AGENDA AND AGENDA NOTES

69th MEETING OF THE TECHNICAL ADVISORY COMMITTEE (TAC) OF NIH

APPENDICES

(Vol.-II)

JULY 21, 2016
AT 1130 HRS
IN CENTRAL WATER COMMISSION
CONFERENCE ROOM [525(S)]
SEWA BHAWAN, R K PURAM
NEW DELHI

NATIONAL INSTITUTE OF HYDROLOGY
ROORKEE-247667

APPENDIX-69.1.1

REVISED COMPOSITION OF TECHNICAL ADVISORY COMMITTEE (with effect from May 2015)

1.	Chairman, Central Water Commission Sewa Bhawan, R.K. Puram New Delhi-110066	Chairman
2.	Member (D&R), Central Water Commission Sewa Bhawan, R.K. Puram NEW DELHI-110066	Member
3.	Chief Engineer (HSO), Central Water Commission Sewa Bhawan, R.K. Puram NEW DELHI-110066	Member
4.	Director National Institute of Hydrology Roorkee-247667	Member
5.	Chairman, Central Ground Water Board Jam Nagar House, New Delhi	Member
6.	DDGM (Hydromet), India Meteorological Department Mausam Bhawan, Lodhi Road, New Delhi-110001	Member
7.	Dr. N K Goel Professor, Deptt. Of Hydrology IIT, Roorkee	Member
8.	Prof. K P Sudheer Department of Civil Engineering IIT Madras IIT P.O. Chennai – 600 036	Member
9.	Prof. K V Jayakumar Department of Civil Engineering National Institute of Technology Warangal – 506 004 (A.P.)	Member
10.	Director Water Technology Centre IARI, Delhi	Member
11.	Dr. N G Srivastava, AGM Pollution Control Research Institute BHEL, Haridwar, Uttarakhand	Member
12.	Prof. Rohit Goyal Department of Civil Engineering MNIT, Jaipur-302017	Member
13.	Office of the Superintending Engineer State Water Data Center Nr WALMI Campus Sector-8, Gandhinagar Gujarat-382008	Member
14.	Dr. Himanshu Kulkarni Advanced Centre for Water Resources Developement and Management (ACWDAM) Plot 4 Lenyadri society, Sus Road Pashan, Pune-411021	Member
15.	Commissioner (PP), Ministry of Water Resources Shram Shakti Bhawan,	Member

	Rafi Marg, New Delhi-110001	
16.	Dr V C Goyal, Scientist F National Institute of Hydrology, Roorkee	Member-Secretary

APPENDIX – 69.2.1

MINUTES OF THE 68th MEETING OF TAC OF NIH

**MINUTES OF 68th MEETING OF
TECHNICAL ADVISORY COMMITTEE OF
NATIONAL INSTITUTE OF HYDROLOGY
HELD ON JULY 21, 2015 AT NEW DELHI**

The 68th meeting of the Technical Advisory Committee (TAC) of the National Institute of Hydrology, Roorkee was held in the Central Water Commission, New Delhi on July 21, 2015. The meeting was chaired by Sh. A.B. Pandya, Chairman, CWC. The list of the participants is given in Appendix -I.

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 gear up to handle new challenges, such as impact of climate change on water resources. He then requested the Member-Secretary to take up the agenda.

Dr V C Goyal, Member-Secretary, also welcomed the Chairman, members and invitees. He then took up the agenda items. He briefed the constitution of the Committee and informed that 8 new members have been nominated by the Chairman, GB of NIH for a term of 3 years. As this was the first meeting of the newly nominated members, he requested all the members to express their views on the research activities at NIH. The views expressed by the Chairman/members are as follows:

Sh. A B Pandya, Chairman, CWC	• Suggested involvement of NIH in (i) paleo-channel study on Saraswati river for isotope fingerprinting, and (ii) exploitation of groundwater resources using nuclear hydrology applications NIH should consider hiring of more storage to upload completed studies on NIH webpage • Research should explore the nitty-gritty of the practicing science (hydrology), which should lead to better engineering practice • Use a uniform format (as used by the WRS Division) for reporting the work programme • Balance has to be struck between research and consultancy projects • Research programme at NIH cannot be self-sustaining. In order to avoid dilution of research focus, NIH should not spread its available resources too thin and not over-stretch on generation of funds through consultancy • Establish a guiding mechanism for peer-review of the requests of externally funded projects, as suggested by Dr Ravinder Kaur of WTC-IARI
Sh. C K Agrawal, Member (D&R),CWC	• Prioritization of studies is needed for timely completion/ delivery of the ongoing research work
Dr. Ravinder Kaur, Director, WTC, Delhi	• Translation research is needed to transfer results for the field and for policy makers • Develop methodology and semi-hightech tools, which are less data hungry and can be easily implemented • Focus on flood and drought studies, especially for ungauged watersheds • Studies required for precise monitoring of agricultural water • Explore MOUs with WTC of Agricultural Universities

	• Develop 'consortia platform' with IITs, NITs, WTCs • Majority of 'internal' studies, seems to be taken up on adhoc-basis, should be limited. NIH has to balance between the basic and applied research. Research studies with priority needs of the country should be taken up • Establish a Project Monitoring Cell (PMC) at NIH to scrutinize, prioritize and oversee implementation of all externally funded projects, including consultancy projects
Dr. Surinder Kaur, DDGM(H), IMD	• NIH should take up studies addressing actual problems, e.g. urban flooding • Projects should be taken up on watershed basis to tackle water quantity as well as quality related issues • Modeling future scenario of water resources is needed to study the impacts of climate change, e.g. on construction of water storage structures
Dr. E. Sampath Kumar, Member, CGWB	• NIH should undertake research studies on overexploitation of groundwater, and impact assessment of artificial recharge schemes • Modeling of coastal area problems
Prof. N K Goel, IIT Roorkee	• There should be mechanism to develop regular interactions between NIH scientists and TAC members • Interface must be developed between NIH scientists and academic institutions • Completed studies should be uploaded on NIH website • Institutional level check is required to ensure that papers are published in reputed and peer-reviewed journals • Excellence in research should be the main focus • Research should lead to better engineering practices
Prof. K P Sudheer, IIT Madras	• Overall coverage of NIH studies is good but in-depth studies are lacking • Focus should be on flood and drought studies, especially in the context of climate change, covering adaptation strategies • List of reputed peer-reviewed journals should be identified • Duration of studies should be reasonable as per requirement of the work, and not unduly over stretched
Prof. Rohit Goyal, MNIT, Jaipur	• There is lot of scope for research on developing state-of-art sensors for ground water level and water quality monitoring • Involvement of students from multi-disciplines in research studies at NIH should be explored
Prof. KV Jayakumar, NIT, Warangal	• Enhance visibility of NIH's work and output • Enhance interactions with academic institutions and involvement of research scholars • Focus on studies related to urban hydrology, environmental flows, wetland hydrology • Combine studies with NITs and IITs to be taken up
Dr. N G Srivastava, AGM, PCRI, BHEL	• Focus is required on hydro-biological aspects of wastewater treatment (e.g. phyto-remediation) • Studies to cover aquatic ecosystem are required
Sh. Bhopal Singh, Dir. Hyd. (S) CWC	• Research work should lead to some products, e.g. Manuals for practicing engineers
Sh. N N Rai, Director (NE), CWC	• Focus needed on flood management aspects • Problem of recurring floods in key basins should be studied • Reliable figures of E-flows should be worked out for different water sectors

ITEM NO. 68.2: Confirmation of the Minutes of 67th Meeting of TAC

The Member-Secretary informed that the minutes of the 67th meeting of the TAC, held on July 15, 2014 at New Delhi, was circulated vide letter no. NIH/RCMU/TAC/34/11 dated July 22, 2014. Since no comments were received from the members, the Minutes were confirmed by the TAC.

ITEM NO. 68.3: Action Taken on the Decisions/Recommendations in the Previous Meeting

The Member-Secretary informed that the suggestions offered during the previous meeting have been noted for compliance.

ITEM NO. 68.4: Status of the Work Programme for the Year 2014-2015

The Member-Secretary briefed about the studies carried out by the Institute during the year 2014-2015. He informed that 67 internal studies and 17 sponsored projects were taken up during the year 2014-15. He also informed that 179 research papers have been published by the Institute during July 2014-March 2015 & April-May 2015. He further informed that 30 training courses/workshops/ symposia were organized during this period. Members appreciated the number of publications brought out by the Institute and number of training/workshop/symposium organized by the Institute.

Some members pointed out abrupt discontinuation of two studies during the work programme of 2014-15, namely "Environmental Flow Assessment of Hemavathi River in Karnataka" under Environmental Hydrology Division, and "Impact of Climate and Land Use Change on Floods of Various Return Periods" under Water Resources Division. Director, NIH, replied that since the PIs of these studies have left the Institute, the studies could not be completed. The TAC opined that in such cases it is the responsibility of the other study team members to complete the ongoing study.

The following studies completed during 2014-2015 were presented during the meeting:

1. Saph Pani- Enchancement of Natural Water Systems and treatment methods for Safe and Sustainable Water Supply in India (Dr N C Ghosh, Sc.G, NIH)
2. Study of Hydro-meteorological Droughts of Chitrakoot Bundelkhand region in India(Dr R P Pandey, Sc.F, NIH)
3. Water Availiability Studies for Sukhna Lake, Chandigarh (Dr Suhas Khobragade, Sc.E, NIH)
4. Glaciological Studies of Phuche Glacier, Ladakh Range, India (Dr R J Thayyen, Sc.D, NIH)

ITEM NO. 68.5: Report the Proceedings of the Working Group Meetings

The Member-Secretary briefed about the 41st and 42nd meetings of the Working Group of NIH, which were held at NIH, Roorkee, during November 26-27, 2014 and March 19-20, 2015, respectively. During these meetings, the Working

Group members reviewed the progress of studies for the year 2014-2015 and also discussed the proposed work programme for the year 2015-2016. He presented the major recommendations of the working group.

TAC noted the proceedings of the Working Group meetings.

ITEM NO. 68.6: Work Programme for the Year 2015-2016

The Member-Secretary briefed about the proposed work programme of the Institute for the year 2015-2016, which was discussed during the 42nd Working Group meeting of NIH. He informed that 75 internal studies and 12 sponsored projects are proposed to be taken up during the current year. Director, NIH, informed that due to some administrative reasons, the RCC meeting of CFMS, Guwahati could not take place so far and shall be held shortly. The TAC authorized the Director, NIH, to consider the proposed studies at CFMS, Guwahati in the forthcoming RCC meeting and report to the TAC in its next meeting.

The TAC approved the proposed work programme of the Institute for the year 2015-2016. The list of studies approved by the TAC for the year 2015-2016 is given in Appendix-II.

ITEM NO. 68.7: Reporting Items

1. Details of the consultancy projects carried out by NIH during the year 2014-2015 were noted by the TAC. Prof K P Sudheer and Prof K V Jayakumar pointed out long delays in completion of the consultancy projects. Director, NIH, replied that the status in many such cases is shown as "ongoing" since the final payment has not been received from the funding agency although the work was completed and final report submitted long time back. The TAC suggested that in such cases the status should be reported as "completed" with a remark that the final payment is pending.

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

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Appendix– I: List of Participants
Appendix– II: Approved Work Programme for the Year 2015-2016

Appendix-I

LIST OF PARTICIPANTS OF THE 68th TAC MEETING OF NIH

1. Sh. A.B. Pandya, Chairman, CWC, New Delhi
2. Sh. C K Agrawal, Member (D&R) CWC, New Delhi
3. Sh. R.D. Singh, Director, NIH, Roorkee
4. Dr. E. Sampath Kumar, Member (SML), CGWB
5. Dr. Ravinder Kaur, Project Director, WTC, ICAR-IARI, New Delhi
6. Prof. N K Goel, IIT, Roorkee
7. Prof. K P Sudheer, IIT Madras
8. Prof. K V Jayakumar, NIT, Warangal
9. Prof. Rohit Goyal, MNIT Jaipur
10. Dr. Surinder Kaur, DDGM(H), IMD, New Delhi
11. Dr. N G Srivastava, AGM, PCRI, BHEL, Haridwar
12. Dr. V C Goyal, Sc.F & Member-Secretary, NIH, Roorkee

INVITEES

1. Dr. Sharad K. Jain, Sc.G, NIH, Roorkee
2. Dr. N C Ghosh, Sc.G, NIH, Roorkee
3. Dr. Rakesh Kumar, Sc.G, NIH, Roorkee
4. Dr. Sudhir Kumar, Sc.G, NIH, Roorkee
5. Dr. R P Pandey, Sc.F, NIH, Roorkee
6. Dr. S D Khobragade, Sc.E, NIH, Roorkee
7. Dr. R J Thayyen, Sc.D, NIH, Roorkee
8. Dr. Jyoti P. Patil, Sc.C, NIH, Roorkee
9. Sh. N.N. Rai, Director, Hydrology (NE), CWC, New Delhi
10. Sh. A K Agrawal, Director, Hydrology (DSR), CWC, New Delhi
11. Sh. M. Raghuram, Director, Hydrology (N), CWC, New Delhi
12. Sh. Bhopal Singh, Director, Hydrology (S), CWC, New Delhi

Appendix-II

APPROVED WORK PROGRAMME FOR THE YEAR 2015-2016

ENVIRONMENTAL HYDROLOGY DIVISION 2015-16

S.N.	Code	Study	Study Team	Duration
Internal Studies				
1.	EH/2015/TS-1	Water Quality Modelling using Soft Computing Techniques	Rama Mehta (PI) C. K. Jain	**2 Years (05/14-05/16)**
2.	EH/2015/TS-2	Himalayan River Water Quality Assessment in a Stretch from Gangotri to Hardwar	Rajesh Singh (PI) C. K. Jain M. K. Sharma S. P. Rai Renoj J. Thayyan J. P. Patra	**3 Years (07/14-06/17)**
Sponsored Projects				
1.	EH/2015/SR-1	Ionic Enrichment Dynamics of Glacial Sediment and Melt water of Gangotri Glacier **(DST)**	M. K. Sharma (PI) C. K. Jain Renoj Thayyan Manohar Arora Naresh Saini Jatin Malhotra Rakesh Goyal Karan Jamwal	**3 Years (04/14-03/17)**
2.	EH/2015/SR-2	Low Cost Technology for Purification of Arsenic and Microbes Contaminated Water using Nanotechnology **(DST)**	Vijaya Aggarwala, IITR (PI) Rama Mehta, NIH (Co-PI)	**2 Years (04/14-03/16)**

GROUND WATER HYDROLOGY DIVISION
2015-16

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

HYDROLOGICL INVESTIGATION DIVISION
2015-16

S. N.	Code	Study	Team	Duration / Status
	Ongoing Internal Studies			
1.	HI/2015/TS-1	Isotopic Studies for the Identification of Different Aquifer Groups and their Dynamics in Upper Yamuna River Plains	Sudhir Kumar (PI) C. K. Jain S. P. Rai S. D. Khobragade P. K. Garg CGWB, Lucknow CGWB, Chandigarh	**2 years** (07/13-06/15)
2.	HI/2015/TS-2	Estimation of Radon Concentration in Waters and Identification of Paleo-groundwater in Part of Punjab Located in Satluj River Basin using Isotopes	S. K. Verma (PI) S. P. Rai (Co-PI) M. S. Rao C. P. Kumar Mohar Singh	**2 years** (10/13-09/15)
3.	HI/2015/TS-3	Interaction between groundwater and seawater along the northern part of east coast of India	M. S. Rao (PI), Sudhir Kumar Pankaj Garg	**2 years** (01/15 - 12/16)
4.	HI/2015/TS-4	Isotopic investigation of benchmark Himalayan glaciers.	M. S. Rao (PI) S.P. Rai, Sudhir Kumar Pankaj Garg	**2 years** (01/15 - 12/16)
5.	HI/2015/TS-5	Assessment of dissolved radon concentration for groundwater investigations in Haridwar district	Pankaj Garg (PI) Sudhir Kumar, M. Someshwar Rao	**1 year** (01/15 – 12/15)
	New Internal Studies			
6.	HI/2015/TS-6	Status Report on Rewalsar Lake, Himachal Pradesh	SD Khobragade (PI) Sudhir Kumar, C. K. Jain	**1 year** (04/15 – 03/16)
7.	HI/2015/TS-7	Lake-Groundwater Interaction Studies for Sukhna Lake, Chandigarh	SD Khobragade (PI) Sudhir Kumar, Senthil Kumar, Pankaj Garg	**3 year** (04/15 – 03/18)
	Sponsored Projects			
8.	HI/2015/SR-1	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates **(MoES)**	S. P. Rai (PI) M. S. Rao Surjeet Singh S. K. Verma C. P. Kumar Sudhir Kumar V. K. Agarwal Rajeev Gupta S. L. Srivastava Vishal Gupta Mohar Singh	**3 years** (06/12-03/16) **Continuing Study**

S. N.	Code	Study	Team	Duration / Status
9.	HI/2015/SR-2	The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India **(IAEA)**	M. S. Rao (PI) C. P. Kumar S. P. Rai	**3 years** (09/12-08/15) **Continuing Study**
10.	HI/2015/SR-3	Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques **(IAEA)**	S. P. Rai (PI) R. V. Kale M. S. Rao C. P. Kumar Sudhir Kumar V. K. Agarwal Vishal Gupta Mohar Singh	**3 years** (10/12-09/15) **Continuing Study**
11.	HI/2015/SR-4	Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains **(IAEA)**	Sudhir Kumar (PI) S. P. Rai S. D. Khobragade C. K. Jain P. K. Garg	**2 years** (05/13-04/15) **Continuing Study**
12	HI/2015/SR-5	Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques **(DST)**	Dr. S. P. Rai (PI) Dr. Sudhir Kumar Rajesh Singh S. D. Khobragade Dr. M. Arora Dr. R. J. Thayyen Sh. P. K. Garg	**5 years (4/15 – 3/20) New Study**

SURFACE WATER HYDROLOGY DIVISION
2015-2016

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

WATER RESOURCES SYSTEM DIVISION
2015-16

S N	Code	Study	Study Team	Duration
	Ongoing Internal Studies			
1.	WRS/2015/ TS-1	NIH_Basin – A WINDOWS based model for water resources assessment in a river basin	M. K. Goel Deepa Chalisgaonkar Sharad K. Jain Prabhash K. Mishra	3 Years (04/13-03/16)
2.	WRS/2015/ TS-2	Assessing climate change impact across KBK region of Odisha	P. K. Mishra Sharad K. Jain Sanjay K. Jain	3 Years (04/13-03/16)
3.	WRS/2015/ TS-3	Glacier change and glacier runoff variation in the upper Satluj river basin	Sanjay K. Jain Sharad K. Jain Renoj J. Thayyen	2.5 Years (10/13-03/16)
4.	WRS/2015/ TS-4	Variability of the Hydro-climatic variables in Punjab Plains of Lower Satluj	M. K. Nema Sharad K. Jain	2 Years (11/13-10/15)
5.	WRS/2015/ TS-5	Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh	Renoj J. Thayyen S. P. Rai Sanjay K Jain Sudhir Kumar	3 years (04/14-03/17)
6.	WRS/2015/ TS-6	Hydrologic Modelling of a part of Satluj Basin using SWAT Model	P. K. Agarwal Sharad K. Jain M. K. Goel Sanjay K. Jain M. K. Nema Tanvear Ahmed	2 -3/4 Years (06/14-3/17)
7.	WRS/2015/ TS-7	Decision Support System for Water Resources Planning in Upper Bhima basin, Maharashtra	D. S. Rathore M. K. Goel, R.P. Pandey Sanjay Kumar Surjeet Singh	2 years (07/14-06/16)
8.	WRS/2015/ TS-8	Modeling of Narmada basin by using the GWAVA model	Sanjay K. Jain Sharad K. Jain T. Thomas (RC-Bhopal) P. K. Mishra P. K. Agarwal M. K. Nema	2.25 years Dec. 2014 – Mar 2017
9.	WRS/2015/ TS-9	Runoff modeling of Shyok River, Karakorum Range	Renoj J.Thayyen Sanjay K.Jain	3 years Dec-2014 to Nov-2017
10.	WRS/2015/ TS-10	Hydrological process and characterization of Lesser Himalayan Catchments	M. K. Nema Sharad K. Jain Sanjay K. Jain Renoj J.Thayyen P. K. Mishra P. K. Agarwal	5 Years 12/14-12/19

	Ongoing Sponsored Studies			
1.	WRS/2015/ SR-1	Glaciological studies of Phuche Glacier, Ladakh Range, India (DST)	Renoj J. Thayyen M K Goel S P Rai	5 Years 1/10-06/15
2.	WRS/2015/ SR-2	Assessment of Environmental flow for Himalayan River (MOES)	Sharad K. Jain Pradeep Kumar P. K. Agarwal P. K. Mishra	1 Year 10/14-09/15
	New Internal Studies			
1.	WRS/2015/ TS-11	Development of Ganga Information Portal	Deepa Chalisgaonkar Sharad K. Jain D. S. Rathore Sanjay K. Jain Sudhir Kumar P. K. Mishra P. K. Agarwal M. K. Nema Furquan Ullah	3 years (04/15-03/18)
2.	WRS/2015/ TS-12	Study of Hydrological Changes in selected watersheds in view of Climate Change in India	L. N. Thakural D. S. Rathore Surjeet Singh Tanvear Ahmed Sanjay K. Jain Sharad K. Jain	3 years (04/15-03/18)

RESEARCH MANAGEMENT AND OUTREACH DIVISION
2015-16

SN	Code	Title of Project/Study, Study Team	Duration
	Ongoing Internal Study		
1.	RMO/2015/TS-1	Participatory development of structure for IWRM Framework in identified sub-basins under Pilot Basin Studies (PBS) program **Team:** V C Goyal (PI), Omkar Singh and R V Kale	DOS: July 2014 DOC: June 2015
2.	RMO/2015/TS-2	Water Conservation and Management in Ibrahimpur Masahi Village of Hardwar District (Uttarakhand) **Team:** Omkar Singh, V.C. Goyal, C.K. Jain, and Rajesh Singh	DOS: Apr 2013 DOC: March 2016
	New Internal Study		
3.	RMO/2015/TS-3	WEAP Model set up for four sub-basins under Pilot Basin Studies (PBS) Programme, jointly with the RCs/CFMSs **NIH HQs:** V C Goyal (PBS Leader), Jyoti Patil and R V Kale **Co-investigators from NIH RCs/CFMSs:** Chandramohan T (RC-Belgaum), Y R S Rao (RC-Kakinada), T R Nayak (RC-Bhopal), B Chakravorty (CFMS-Patna)	DOS: Apr 2015 DOC: Mar 2017
	Sponsored Project		
1.	RMO/2015/SR-1	Customization of WEAP model for application in Ur river watershed in Tikamgarh district of Bundelkhand region. **(Under TIFAC Project)** **Team:** R V Kale (PI), T Thomas- RC Bhopal, Jyoti Patil, Rajesh Agarwal	DOS: Apr 2014 DOC: Sep 2015 (**Ongoing study)**

Proposed Technical Transfer & Outreach Activities during 2015-2016

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

REGIONAL CENTRE, BELGAUM
2015-2016

No.	Title of the Study	Study Group	Duration	Funding	Status
1	Waterlogging and Salinity Studies in NagarjunaSagar Right Bank Canal Command	NV, BKP	2 years (Aug 2012 - Jul 2014) **Report will be submitted by 30th Sept 2015**	Internal	Continued
1	Integrated Water Resources Management (IWRM) on a Pilot Basin – Zuari River Basin, Goa	CMT, BKP, VCG	3 years (Apr 2013 - Mar 2016)	Internal (PBS)	Continued
2	Comparative Analysis of Various Rainfall-Runoff Models for Rivers of Western Ghats	BV, CK & MKJ	3 years (Apr 2013 - Mar 2016)	Internal	Continued
3	Studies on Spring flows and estimation of Groundwater Recharge in Ghataprabha Sub-basin	BKP, NV, SK, RV	2 years (Apr 2013 - Mar 2015) **Extended for one year upto March 2016**	Internal	Continued
4	Application of Geostatistical methods for analyzing sedimentation pattern in river basins of Kerala State	MKJ, and CM	2 years (Sep 2014 – Mar 2016)	Internal	Continued
5	Modeling of sediment yield from river basins of Kerala and Goa, using SWAT model	CMT & BV	2 years (Sep 2014 – Mar 2016)	Internal	Continued
6	Runoff estimation in a catchment using GIS and WEB based tools: A case study	MKJ and BV	1 year (Sep 2014- Aug 2015)	Internal	Continued
7	Impact of Land use/Land cover Changes on Ground water – A Case Study	BKP, BV, SKJ and NV	2 years (Sep 2014 – Mar 2016)	Submitted to MoES for Funding	Continued
8	Impact of Urbanization on Surface and Ground water Quality and Quantity – A Case Study	BKP, SK and NV	2 years (Sep 2014 – Mar 2016)	Internal	Continued

SKJ : Sharad K. Jain
VCG : V. C. Goyal, Scientist F
BKP : Purandara, Scientist E
MKJ : Mathew K. Jose, Scientist D
NV : N. Varadarajan, SRA
SK : Sudhir Kumar, Scientist G
BV : B. Venkatesh, Scientist F
CMT : Chandramohan T., Scientist D
RV : Rajan Vats Scientist B
CK : ChandraKumar S., SRA

REGIONAL CENTRE, JAMMU
2015-2016

S. No.	Title of the Study	Study Team	Duration	Funding
	Ongoing Projects			
1	Impact of land use changes on environmental flows of Tawi river at Jammu	P. Kumar M. K. Nema	03 years	NIH
2	Climate change effects on hydrology of the Tawi basin in Western Himalaya	M. K. Nema P. Kumar R. J. Thayyen	03 years	NIH
3	PBS: Integrated Water Resources Management (IWRM) Study in Tawi River Basin, JK	P. Kumar S. S. Rawat	05 years	NIH
4	Automation of Hydro-Meteorological Network in Jhelum Basin for Flood Forecasting	P. Kumar R. J. Thayyen M. K. Goel Sharad K. Jain	02 years 07 months	NIH
	New Projects			
5	Estimation of sediment yield and identification of areas vulnerable to soil erosion and deposition in a western Himalayan catchment	S. S. Rawat P. Kumar	02 years	NIH
6	Hydrological Investigation of Natural Water Springs of Baan Ganga watershed in Jammu & Kashmir State	S. S. Rawat P. Kumar	03 years	NIH
7	Cryospheric processes in an alpine regime; a case study of Thajwas catchment, Sind sub-basin, Kashmir Valley, India	P. G. Jose R.J. Tahyyen S.P. Rai	03 years	NIH
8	Hydrological Assessment of the floods in the Jhelum river during Sep 2015	P. Kumar S. S. Rawat	02 years	NIH

REGIONAL CENTRE, BHOPAL
2015-2016

Sl. no	Name of the project	Duration	Starting and ending date	Status
1.	Surface and ground water modeling for conju-ncttive use (under Pilot Basin Studies in Bina River Basin in Bundelkhand Region in M.P.)	1¾ years	April 2014 to Dec. 2015	Ongoing Project
2.	Development of DSS for Bina River Basin in Bundelkand Region in M.P. using WEAP Model (under PBS)	2 years	April 2015 to March 2017	New Project
3.	Development of Decision Support System (DSS) Model for Shipra River Basin of MP	3 years	June 2013 to May 2016	Ongoing Project
4.	Integrating hydrology, climate change and IWRM with livelihood issues: Development of methodology and a DSS for water-scarce Bundelkhand region in India	2½ years	May 2013 to Oct. 2015	Ongoing R&D Project
5.	Integrated Drought Vulnerability Assessment for Water Resources Management of the Bina Basin	2 Years	July 2014 to June 2016	New Project
6.	Irrigation Planning and Management for the Command of Harsi Reservoir in Madhya Pradesh	2 ½ years	May 2013 to Oct. 2015	Ongoing Project
7.	Estimation of Revised Capacities of Reservoirs in Chhattisgarh state using Digital Image Processing technique	2 Years	April 2015 to March 2017	New Project

REGIONAL CENTRE, KAKINADA
2015 – 2016

S. No.	Project	Project Team	Duration	Status/ Funding
1	Evaluation of urban storm water network in Hyderabad using SWMM	R.Venkata Ramana, Sc. 'C' (P.I.) Y.R.Satyaji Rao, Sc. 'F' S.V.Vijayakumar, Sc. 'F' V.S. Jeyakanthan, Sc. 'D'	April 2013 to March 2016	Ongoing /Internal
2	Statistical downscaling and assessment of climate change impact on hydrology of Mahanadi river basin	P.C.Nayak, Sc. 'D' (P.I.) Y.R.Satyaji Rao, Sc. 'F' B. Venkatesh, Sc. 'F' T. Thomas, Sc. 'D'	April 2013 to March 2016	Ongoing /Internal.
3	IWRM Studies (2013-2017): Assessment of water availability in the upper Yerrakalva Basin	Y.R.Satyaji Rao, Sc.'F' (P.I) S.V.Vijayakumar, Sc.'F' J.V.Tyagi, Sc. 'G' R.Venkata Ramana, Sc.'C' B. Krishna, Sc.'C'	April 2014 to March 2016	Ongoing /Internal.
4	Identification of submarine groundwater discharge and sea water intrusion zones in Godavari Delta using integrated approach	Y.R.Satyaji Rao, Sc.'F' (P.I) M.S.Rao, Sc.'D' R.Venkata Ramana, Sc.'C'	August 2014 to March 2017	Ongoing /Internal
5	Identification of Ground Water Recharge zones in Vaippar Basin, Tamilnadu using Remote Sensing and GIS techniques	V.S. Jeyakanthan, Sc.'D'(P.I) J.V. Tyagi, Sc.'G' R Venkata Ramana, Sc.'C'	April, 2015 to March, 2017	New /Internal
6	IWRM Studies (2013-2017): Development of hydrological management practice plans for IWRM in the Lower Yerrakalva Basin	S.V.Vijaya Kumar, Sc.'F' (P.I) Y.R.Satyaji Rao, Sc.'F' V.S.Jeyakanthan, Sc.'D'	April, 2015 to March, 2017	New /Internal
7	Development of groundwater level forecasting model using high frequency groundwater level data in the Srikakulam District of Andhra Pradesh	B. Krishna, Sc.'C' (P.I) Y.R.Satyaji Rao, Sc.'F' R Venkata Ramana, Sc. 'C'	April, 2015 to March, 2016	New /Internal

CFMS, GUWAHATI
2015 – 2016

Study No.	Title of the study	Study Team	Duration
NIH/CFMS-G/15-17/	Estimation of Runoff for Kulsi River Basin using SCS Curve Number and Geographic Information System (GIS)	S. K. Sharma G. Tirkey	07/15-03/16 (New Study)
NIH/CFMS-G/15-17/	Application of USLE model for estimation of soil loss in Kulsi River Basin using remote sensing and geographic information system	G. Tirkey S. K. Sharma	07/15 - 03/16 (New Study)

CFMS, PATNA
2015-2016

Sl	Title of the study	Study Team	Duration
1.	Pilot Basin Studies (PBS) for Mahi River Basin in Ghaghra-Gandak Composite Basin	B Chakravorty NG Pandey Pankaj Mani	04/12-03/17 (XII Plan Year)
2.	Development of flood forecasting system based on rainfall information obtained from satellite data	Pankaj Mani Rakesh Kumar	3 year (Started in 2013-14)
3.	Time Series analysis of Monthly Rainfall in Mahi Basin	NG Pandey B Chakravorty Sanjay Kumar	2 year (2014-2016)
4.	Demonstration scheme on Riverbank Filtration in Gagatic plain of Bihar	B Chakravorty NG Pandey	2 year (2015-17)
5.	Spatial and Temporal Distribution of Geochemical Characteristics and Environmental Stable Isotopes in Groundwater of North Bengal	SR Kumar, MS Rao and SWID	1 year (2015-16)

APPENDIX-69.4.1

WORK PROGRAMME OF THE DIVISIONS AT THE H.Q. AND RC/CFMS OF THE INSTITUTE FOR THE YEAR 2015–2016 & 2016-2017

ENVIRONMENTAL HYDROLOGY DIVISION

Scientific Manpower

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

Progress of Work Program for the year 2015-16

S.No.	Study	Study Team	Duration
	Internal Studies		
1.	Water Quality Modelling using Soft Computing Techniques	Rama Mehta (PI) Anju Choudhary	2 Years (05/14-05/16)
2.	Himalayan River Water Quality Assessment in a Stretch from Gangotri to Haridwar	Rajesh Singh (PI) C. K. Jain M. K. Sharma S. P. Rai Renoj J. Thayyan J. P. Patra	3 Years (07/14-06/17)
3.	Status Report on Phytoremediation of Wastewater	Rajesh Singh (PI) C. K. Jain	6 Months (11/15 – 04/16)
	Sponsored Projects		
1.	Ionic Enrichment Dynamics of Glacial Sediment and Melt water of Gangotri Glacier	M. K. Sharma (PI) C. K. Jain Renoj Thayyan Manohar Arora Naresh Saini Jatin Malhotra Rakesh Goyal Shyam Lal	3 Years (04/14-03/17) Sponsored by DST Project Cost: 32.8 lacs
2.	Low Cost Technology for Purification of Arsenic and Microbes Contaminated Water using Nanotechnology	Vijaya Aggarwala, IITR (PI) Rama Mehta NIH (Co-PI)	2 Years (04/14-03/16) Sponsored by DST
	Consultancy Projects		
1.	Water Safety Impact Assessment through Sanitary Improvement of India Mark 2 Hand Pumps in Moradabad Division, Uttar Pradesh	C. K. Jain (PI) Babita Sharma Rakesh Goyal Daya Nand	6 Months (10/14 – 03/15) Extended for 3 months. Sponsored by: UNICEF, U.P. Amount Rs. 12 Lacs (Completed)
2.	Assessment of Ground Water Contamination due to past storage of Spent wash in Kachcha Lagoons and Suggesting Remedial Measures	C. K. Jain (PI) Sudhir Kumar M. K. Sharma Rajesh Singh	3 Months (11/15 – 01/16) Sponsored by: Saraya Distillery, Gorakhpur Amount Rs. 5.7 Lacs Status: Completed
3.	Petroleum Product Contamination at Akolner Village, District Ahmednagar, Maharashtra and Suggesting Remedial Measures	C. K. Jain (PI) Sudhir Kumar B. K. Purendra Anupma Sharma M. K. Sharma Rajesh Singh	One Year (10/15 – 09/16) Sponsored by: MPCB, Mumbai Amount Rs. 54.72 Lacs Status: In progress

Training Course Organized

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

Progress of Studies 2015-16

Study – 1 (Internal Study)

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

2. Study Group:

Project Investigator
Dr. Rama Mehta, Sc. 'D'
Scientific/Technical Staff
Ms. Anju Chowdhary, SRA

3. Type of Study: Internal

4. Nature of Study: Applied Research

5. Date of start: May 2014

6. Scheduled date of completion: May 2016

7. Duration of the Study: Two years

8. Study Objectives:

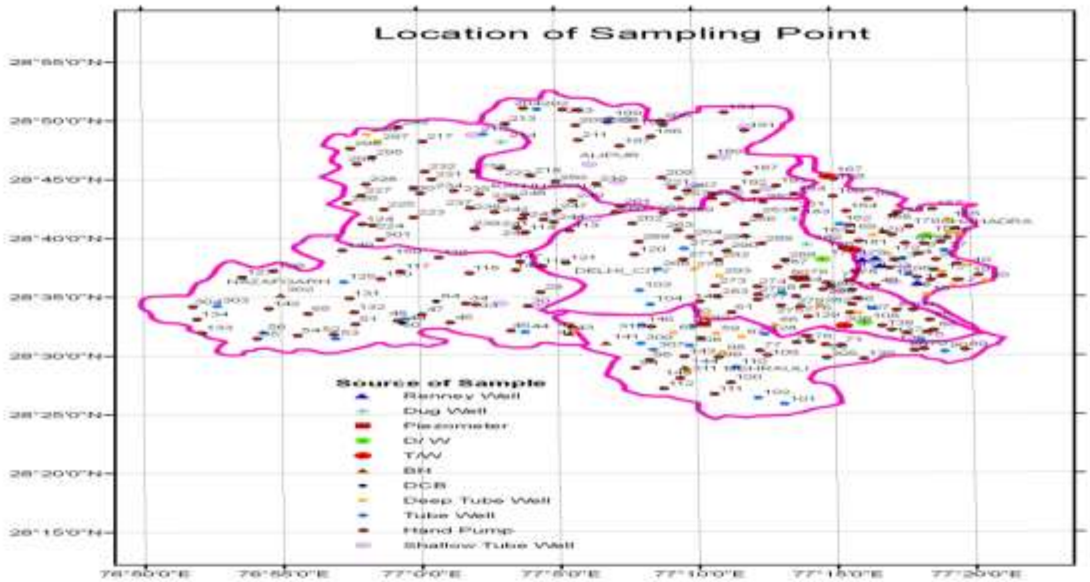
To develop the models for assessment of the quality of water with its quality parameters for Najafgarh, Mehrauli, Delhi City and Shahdara blocks of NCR using conventional and soft computing techniques.

9. Statement of the Problem:

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

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

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



Water quality Modeling for all four administrative blocks viz. Delhi City, Shahdara, Mehrauli & Najafgarh have been done with three different techniques and results have been analyzed with empirical techniques for Water Quality Index during this year.

10. Approved Action Plan / Methodology:

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

Following methods have been employed to calculate the water quality index:

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

11. Timeline:

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

M_FIS technique.								
Testing, evaluation, and comparison with conventional method.								
Result analysis & Report writing								

12. Objectives and achievement during last six months:

Objectives	Achievements
i) Model Development with application of soft computing methods.	Three models (Each model with Empirical method, CCME_ WQIG and Fuzzy Inference Technique) have been developed for Najafgarh block.
Testing, Evaluation and comparison with conventional method.	Results via Fuzzy model have been compared with conventional method and Canadian formula (CCME) for Najafgarh block. Comparative results have to be shown through graphs and performance indices.

13. Recommendation / Suggestion:

Recommendation / Suggestion	Action Taken

14. Analysis & Results:

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

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

16. Deliverables: Technical report and 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: None

20. Study Benefits / Impacts:

Measurable indicators	Achievements
Model development for block Najafgarh with new emerging techniques to get the Water Quality Index for specific use of ground water	Completed
Solution of identified problem	Completed

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

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

23. **Shortcoming/Difficulties:** No

24. **Future Plan:** Developed models can be used to find the present situation of water quality index of these six administrative blocks in NCR region with latest (specifically for eight parameters used in these models) water quality parameters. The report is under writing stage and will be submitted by August 2016 and therefore extension of three months is requested.

Study -2 (Internal Study)

1. **Title of the Study:** Himalayan river water quality assessment in a stretch from Gangotri to Haridwar.

2. **Study Group:**

Project Investigator Dr. Rajesh Singh, Sc. 'C'
Project Co-investigator Dr. C. K. Jain, Sc. 'G', EHD Dr. S. P. Rai, Sc. E, HID Dr. M. K. Sharma, Sc. D, EHD Dr. Renoj J. Thayyan, Sc. D, WRSD Dr. J. P. Patra, Sc. C, SWHD
Scientific/Technical Staff Shri Rakesh Goyal, Tech. Gr. I

3. **Type of Study:** Internal

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

5. **Date of start:** 01.07.2014

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

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

8. **Study Objectives:**

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

9. **Statement of the Problem:**

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

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

10. Approved Action Plan / Methodology:

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

11. Timeline:

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

12. Objectives and achievement during last six months:

Objectives	Achievements
Field investigation, Sample Collection & Analysis	• Analysis of samples collected in November 2015 completed. • Analysis of sediments under progress. • Processing of analyzed data under progress.

13. Recommendation / Suggestion:

Recommendation / Suggestion	Action Taken
Dr. G. P. Juyal, CSWCRTI, Dehradun suggested correlation of contamination with domestic effluents.	Nutrient load will be correlated with domestic effluent discharged in the river

14. Analysis & Results:

- Geo-spatial map showing sampling locations prepared.
- Analysis of samples collected in November 2015 for physico-chemical, bacteriological, and isotopic parameters completed.

- Processing of analyzed data under progress.
- Analysis of sediment samples under progress.

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

16. **Deliverables:** Technical report & research papers

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

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

19. **Data procured or generated during the study:** None

20. **Study Benefits / Impacts:**

Measurable indicators	Achievements
River water quality assessment	Under progress
Nutrient loading	Under progress

21. **Involvement of end users/beneficiaries:** -----

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

23. **Shortcoming/Difficulties:** No

24. **Future Plan:** Final report based on the work done will be submitted by 15th May 2016 and the study will be merged with NMSHE project.

Study – 3 (Internal Study)

1. **Title of the Study:** Status Report on Phytoremediation of Wastewater

2. **Study Group:**

Project Investigator Dr. Rajesh Singh, Scientist 'C', NIH
Project Co-investigator Dr. C. K. Jain, Sc. G, EHD

3. **Type of Study**: Internal

4. **Nature of Study:** Status Report

5. **Date of start:** 01.11.2015

6. **Scheduled date of completion:** 30.04.2016

7. **Duration of the Study:** 6 months

8. **Study Objectives:**

   i) To prepare status report on phytoremediation of wastewater

9. **Statement of problem:**

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

This study aims at developing a document related to phytoremediation techniques based on the published data. It will provide a glimpse of various kinds of scientific work that has been carried out on phytoremediation technique and suggest areas and problems that need to be addressed in the future.

10. Action Plan / Methodology

i) Literature Survey.
ii) Processing of literature survey into status report on phytoremediation

11. Timeline:

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

12. Objectives and achievement during last six months:

Objectives	Achievements
Literature Survey	• Literature survey under progress.
Status Report	• Will be completed by May 2016.

13. Recommendation / Suggestion

Recommendation / Suggestion	Action Taken
1. No Specific comments	

14. Analysis & Results:

- Literature survey under progress and the report will be submitted by May 15, 2016.

15. End Users / Beneficiaries of the study: Planners and Common people

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: None

20. Study Benefits / Impacts:

Measurable indicators	Achievements
Status Report	Under progress

21. Involvement of end users/beneficiaries: NA

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

23. Shortcoming/Difficulties: No

24. Future Plan: The report is under writing stage and will be submitted by May 2016.

Study - 4 (Sponsored Project)

1. **Title of the Study:** Ionic Enrichment Dynamics of Glacial Sediment and Melt water of Gangotri Glacier

2. **Study Group:**

Project Investigator Dr. M. K. Sharma, Sc. 'D'
Co-Investigator Dr. C. K. Jain, Sc. 'G' Dr. Renoj Thayyan, Sc. 'D' Dr. Manohar Arora, Sc. 'D'
Scientific/Technical Staff Sri. Naresh Saini, Scientist B Sri. Jatin Malhotra, SRA Sri. Rakesh Goyal, Tech. Gr. I Sri Shyam Lal, JRF

3. **Type of Study:** Sponsored project by DST, New Delhi, **Budget: Rs 32.80 lacs**

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

5. **Date of start:** April 2014

6. **Scheduled date of completion:** March 2017

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

8. **Study Objectives:**

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

9. **Statement of the Problem:**

Higher level of pollutant load in the lower reaches of River Ganges is as an unresolved problem for the past many decades. There were number of projects launched by the Government of India to address this issue, but failed to achieve the desired result during the past two decades. Contribution of Himalaya rivers originating from snow and glacier fields of higher Himalaya spread across India, Nepal and Tibet, play an important role in controlling the solutes levels in the River Ganges. As these mountain waters with significant amount of snow, glacier meltwaters and rainfall is characterised by low ionic concentrations and play a major role in diluting the high solute load emanating from Ganga plain catchments. Hence any change in the quality and quantity of the Himalayan tributaries of River Ganga under the climate change regime will impact the quality parameters of River Ganga. Understanding of low temperature solute acquisition processes is therefore very important for assessing the solute acquisition and pollutant loading further downstream. Higher sediment load in the glacier fed streams play a significant role in solute acquisition by its interaction with dilute glacial and snow melt waters. Further downstream, higher sediment load due to anthropogenic activities added another dimension to the problem. As Gangotri glacier is the biggest glacier in the region as well as the source of River Ganga, it is imperative to study the dynamics of solute acquisition by dilute glacier waters in interaction with freshly grinded glacier sediments. Hence this study is conceptualised to build the existing knowledge gap on solute acquisition of glacier melt waters during its transit with high sediment load under prevailing low temperature conditions close to the glacier.

10. Approved Action Plan/Methodology:

i) Literature survey through international publications (research papers/ reports)
ii) Reconnaissance survey of Gangotri glacier catchment for site selection.
iii) Collection Suspended sediment samples and meltwater samples from selected sites seasonally.
iv) Chemical analysis for major cations, anions and trace metals in the collected suspended sediment and meltwater.
v) Geochemical analysis of suspended sediments
vi) Study of closed system characteristics and open system dynamics
vii) Dissolution experiments of glacial meltwater-suspended sediment interaction

11. Timeline:

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

12. Objectives and achievement during last six months:

Objectives	Achievements
Chemical analysis of SS and meltwater samples	• Chemical analysis of meltwater sample collected from Gomukh, Bhojwasa and Gangotri from 10 May to 10 October 2015 is under progress.
Open and close system study	• Hydro-chemical data is being processed to study the open and close system characteristics of Gomukh, Bhojwasa and Gangotri.

13. Recommendation / Suggestion:

Recommendation / Suggestion	Action Taken
i) Dr. Ghosh suggested to consider travel time between different sties of the study area while interpretating the results.	Travel time will be measured during field investigation of 2016 and will be considered while interpretating the results.
ii) Dr. Bartarya recommended to incorporate ammonia in the list of parameters analysed.	Included in the analysis

14. Analysis & Results:

i) Processing of measurement of suspended sediment concentration for the suspended sediment samples collected from Gomukh, Bhojwasa and Gangotri completed for the ablation period of year 2015 has been completed.
ii) Sieving of bed sediment samples collected from Gomukh, Bhojwasa and Gangotri is completed.
iii) Chemical analysis of meltwater samples collected from Gomukh, Bhojwasa and Gangotri on Ion Chromatograph is under progress.
iv) Processing of hydro-chemical data to study the open and close system characteristics of Gomukh, Bhojwasa and Gangotri is under progress.

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

16. Deliverables: Technical report and research papers

17. Major items of equipment procured: i) Low Temperature pH Meter ii) Low Temperature EC Meter iii) Deep Freezer

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

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

20. Study Benefits / Impacts:

- Study of low temperature ionic enrichment during interaction between glacial sediment and melt water especially for glaciers with huge supraglacial debris cover.

- Ionic enrichment dynamics of meltwater-glacial sediment interaction under open and close system.
- Provide a strong basis extending studies of solute variability and sediment and pollutant loading further downstream.

21. **Involvement of end users/beneficiaries:** Local people

22. **Specific linkage with Institution and /or end users / beneficiaries**: None

23. **Shortcoming/Difficulties:** No

24. **Future Plan:**

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

Proposed Work Programme 2016-17

Study - 1 (Sponsored Project)

1. Thrust Area under XII Five Year Plan: Water Quality

2. Project Team:

Dr. C. K. Jain, Sc. 'G' - PI
Dr. Manohar Arora, Sc. 'D' - Co-PI
Dr. M. K. Sharma, Sc. 'D'
Dr. P. K. Sachan, Sc. 'C'
Dr. Rajesh Singh, Sc. 'C'
Prof. D. S. Malik, Professor, GKU, Haridwar

3. Title of the Project: Environmental Assessment of Aquatic Ecosystem of Upper Ganga Basin

4. 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.

5. Present state-of-art:

The importance of the Himalayas as a natural storehouse and source of water must be fully acknowledged. The lakes, ponds and wetlands are of special ecological interest in that they provide essential food, animal fodder, fish, wild fowl, medicinal plants, manure, hydro-electricity, irrigation, navigation, and a source of potable water for local populations. The freshwater ecosystems are different in character and exhibit various degrees of trophic evolution, ranging from oligotrophy, through mesotrophy, to eutrophy which is generally understood to be the result of increasing human pressure. Studies need to be carried out on geographical environment, limnology, morphometry, physico-chemical characteristics of water and sediments, biological features, nutrient dynamics, energy flow and trophic status of the freshwater ecosystems to provide a proper basis for judicial management of the water resources.

Ecohydrology, the understanding of the functional interrelations between hydrology and biota at the catchment scale, is fundamental for controlling and restoring ecological processes that will enhance the resistance and resilience of an ecosystem. In this context, two facets of water resources degradation (pollution and the disruption of water and nutrient cycles) are important.

The region is already under water-stress, with the drying up or blockage of many water sources and natural springs. The following immediate actions, appear to be necessary: (a) Initiate a state-wide programme for rejuvenation of Himalayan springs and protection of high-altitude lakes. Provide legislative protection for mountain lakes, natural springs and key water sources and prohibit construction activities along these water-bodies. (c) Inventorise mountain springs (active and dormant) and also do detailed geological mapping to identify the spring recharge zone.

The States which share the Himalayas are also its principal sentinels. Adaptation to Climate Change must become an integral part of their development strategies. The special vulnerabilities of this ecologically fragile region need to be recognized, as much as its rich natural resources in terms of forests, water wealth, biodiversity and tourism potential. While a number of long-term measures are under consideration as part of the National Action Plan on Climate Change, several key and urgent interventions may be considered to prevent the further degradation of the Himalayan Ecology and to preserve their life-sustaining role for millions of our citizens. This not only includes those residing in this region, but also in the entire Indo-Gangetic Plain.

The cities in the Himalayan mountainous zones are increasing in size and in numbers. They are displaying the same degradation that plagues our cities in the plains – growing dumps of garbage and plastic, untreated sewerage, chronic water shortages, unplanned urban growth and heavy pollution from increasing vehicular traffic. This phenomenon will only exacerbate the impact from climate change.

Ecologically sensitive mountainous areas, like the Himalaya, are prone to adverse impacts of global climate changes on account of both natural causes and anthropogenic emissions in other parts of the world as well as those arising out of unplanned developmental activities in the region. Himalayan Ecosystem resources are critical on the face of natural disturbances, anthropogenic activities and climate change. It has important implications for formulation of management strategies and sustenance of dependent human societies. Some of the significant consequences arising out of the global warming on the Himalayan region could relate to a) variability in the volumetric flow of water in the rivers, b) loss in biodiversity, c) unsustainable changes in ecology, d) glacier recession, e) deforestation and degradation, f) conditions for impending natural disasters and g) dislocation of traditional societies dependent vulnerably on the Himalayan ecosystem.

Ganges, Brahmaputra, Yamuna, and other major river systems originate in the Himalayas. Any changes in the Himalayan glacier dynamics and melting are expected to severely affect about 1.3 billions of people. Water quality assessment and studies of in-stream reactions and sediment dynamics play an important role in this context. There are several reasons for this. Because of substantial efforts to reduce point pollution sources the relative effect of non-point pollution has increased. This has increased the need to identify major sources of nutrients and trace elements deposited within the river system.

Traditionally, river water quality monitoring has focused upon surface water concentrations to safeguard drinking water supplies and to characterise the contaminative state of the aquatic environment. However, the monitoring of surface water is hampered by the inherent variability in flow conditions. Changes in water discharge and variations in suspended solid loading have a considerable effect upon pollutant loading, particularly in areas where effluent emissions are irregular. Bottom sediments, on the other hand, provide a much more stable base for contaminative studies and can identify pollution sources that could escape detection by water analysis alone. Therefore, an assessment of both the sedimentary and aqueous phase should be undertaken to adequately characterise the aquatic environment.

Indian Himalayan Region is highly vulnerable both due to geological reasons and on account of the stress caused by increased pressure of population, exploitation of natural resources and other related challenges. These effects may well be exacerbated due to impact of climate change. Climate change is likely to adversely impact the Himalayan eco-system through increased temperature, altered precipitation patterns, episodes of drought and biotic influences. This would not only impact the very sustenance of the indigenous communities in uplands but also the life of downstream dwellers across the country and beyond.

6. 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

7. 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.

8. Cost Estimate:

Budget for NIH

Head/Post	Amount (Rs. in Lakh)					
	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total
Manpower salaries/wages						
JRF (4)	14.400	14.400	16.128	16.128	16.128	77.184
RA-I	5.184	5.184	5.184	5.184	5.184	25.920
Consumables						
Stationary	0.200	0.100	0.200	0.200	0.100	0.800
Consumable/Lab Expendable	4.800	4.900	4.800	4.800	4.800	24.100
Other expenses						
Office expenses	-	-	-	-	-	-
Workshop/Meetings/Trainings	-	-	-	-	-	-
Contingency	1.000	1.000	1.000	1.000	1.000	5.000
Travel & Field						
Travel & Field	3.000	3.000	3.000	3.000	3.000	15.000
Non-recurring Expenses						
Software	1.000	-	-	-	-	1.000
Portable Kits (02)	20.000	-	-	-	-	20.000
Echo Sounders (01)	1.000	-	-	-	-	1.000
Total	***50.584***	***28.584***	***30.312***	***30.312***	***30.312***	***170.004***

Budget for Collaborative Agency

Head/Post	Amount (Rs. in Lakh)					
	1st Year	2nd Year	3rd Year	4th Year	5th Year	Total
Manpower salaries/wages						
JRF	7.200	7.200	8.064	8.064	8.064	38.592
Consumables						
Stationary	0.100	0.100	0.100	0.100	0.100	0.500
Consumable/Lab Expendable	1.000	1.000	1.000	1.000	1.000	5.000
Other expenses						
Office expenses	-	-	-	-	-	-
Workshop/Meetings/Trainings	-	-	-	-	-	-
Contingency	0.500	0.500	0.500	0.500	0.500	2.500
Travel & Field						
Travel & Field	0.500	0.500	0.500	0.500	0.500	2.500
Non-recurring Expenses						
Fish Finder (01)	3.000	-	-	-	-	3.000
Microscope with photography attachment (01)	2.500	-	-	-	-	2.500
Total	***14.800***	***9.300***	***10.164***	***10.164***	***10.164***	***54.592***
Grand Total	**65.384**	**37.884**	**40.476**	**40.476**	**40.376**	**224.596**

9. Work Schedule

- **a. Probable date of commencement of the project:** April 2016
- **b. Duration of the project:** Five Years
- **c. Stages of work & milestone**

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										

GROUND WATER HYDROLOGY DIVISION

Scientific Manpower

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

APPROVED WORK PROGRAMME OF THE DIVISION FOR THE YEAR 2015-16

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 (Project Coord. & Leader) C.P. Kumar, B. Chakraborty, Y.R.S. Rao, Anupma Sharma, Surjeet Singh, Sumant Kumar, Suman Gurjar, S.P. Indwar, R.P. Singh, Anju Choudhury, Sanjay Mittal, Ram Chandar, Staff SW Lab	21/2 year (11/15 – 4/18) **Status: In progress**.	Sponsored by MoWR, RD & GR under Plan Fund.
2. NIH/GWD/ NIH/15-18	Development of Website and e-Portal on "Mitigation and Remedy of Arsenic Menace in India"	C.P. Kumar (PI), Anupma Sharma, Suman Gurjar, Sanjay Mittal	3 years (04/15 – 3/18) **Status**: **In progress**.	Internal Funding.
3. NIH/GWD/ NIH/14-17	Management of Water Resources for Quantity and Quality in Yamuna-Hindon Inter-basin	Anupma Sharma (PI), N.C. Ghosh (Coordinator), Deepak Kashyap, IITR (Technical Consultant)	3 years (12/14 – 11/17) Status: **In progress**.	Internal Funding.
4. NIH/GWD/ NIH/15-16	Alternate water supply management strategies in arsenic affected/ vulnerable areas: Mapping of Arsenic affected zones/regions in Eastern U.P	Sumant Kumar (PI) N.C. Ghosh, Rajesh Singh, R.P. Singh, Suman Gurjar, S.L. Srivastava, Anju Choudhary	1 year (04/15 – 3/16) **Status: In progress.**	Internal Funding.
5. NIH/GWD/ NIH/15-16	Web Enabled "Groundwater Recharge Estimation Model (WE-GREM) ".	Suman Gurjar (PI), N.C. Ghosh, Sumant Kumar, Surjeet Singh, Anupma Sharma	1 year (08/15 – 3/16) **Status: In progress.**	Internal Funding.
6. NIH/GWD/ NIH/16-17	Groundwater fluctuations and conductivity monitoring in Punjab.	Gopal Krishan (PI), N.C. Ghosh, Surjeet Singh, Dan Lapworth (PI from UK) Alan MacDonald (Project Coordinator)	1 year (01/16 – 12/17) **Status: In progress.**	NIH in association with BGS, UK
Proposed New Study				
7. NIH/GWD/ NIH/16-17	Baseline data collection and analysis of Mewat district, Haryana.	N.C. Ghosh (Project Coordinator), Gopal Krishan (PI), Surjeet Singh, C.P. Kumar, Brijesh Yadav (IITR), Lalit Mohan Sharma	1 year (03/16 – 03/17) **Status: New.**	Internal Funding.

		(Sehgal Foundation, Gurgaon)		
8. NIH/GWD/ NMSHE/16-21	Study of river - aquifer interactions and groundwater potential in the upper Ganga basin up to Dabrani.	Surjeet Singh (PI), N.C. Ghosh, R. J. Thayyen, S. P. Rai, Manohar Arora, Gopal Krishan,	1 year (03/16 – 02/21) **Status: New.**	Sponsored by DST under NMSHE.
9. NIH/GWD/ NIH/16-16	Web Enabled "Conjunctive Use Model for Management of Surface and Ground Water using concept of MAR and ASR".	Suman Gurjar (PI), N.C. Ghosh, Sumant Kumar, Surjeet Singh, Anupma Sharma	08 Months (04/16 – 11/16) **Status: New.**	Internal Funding.
10. NIH/GWD/ NIH/16-16	Evaluation of Saryu Nahar Pariyojna(SNP) National Project in Uttar Pradesh.	N. C. Ghosh Gopal Krishan R. P. Singh J. K. Mishra	06 Months (03/16-08/16) Status New study	Sponsored by MoWR, RD & GR.
11./NIH/GWD/16-17	*Country-wide Capacity Building Program on* "Bank Filtration for Sustainable Drinking Water Supply"	N. C. Ghosh, Lead Other Scientists of the division	2 years (02/16 – 12/17) 4 training courses	Sponsored by DST

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

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

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

Project duration : 30 months (November, 2015 – April, 2018).
Sponsored by : MoWR, RD & GR, GoI. Under NIH Plan Fund.

Project team:

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

Objectives of the Project:

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

Methodology

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

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

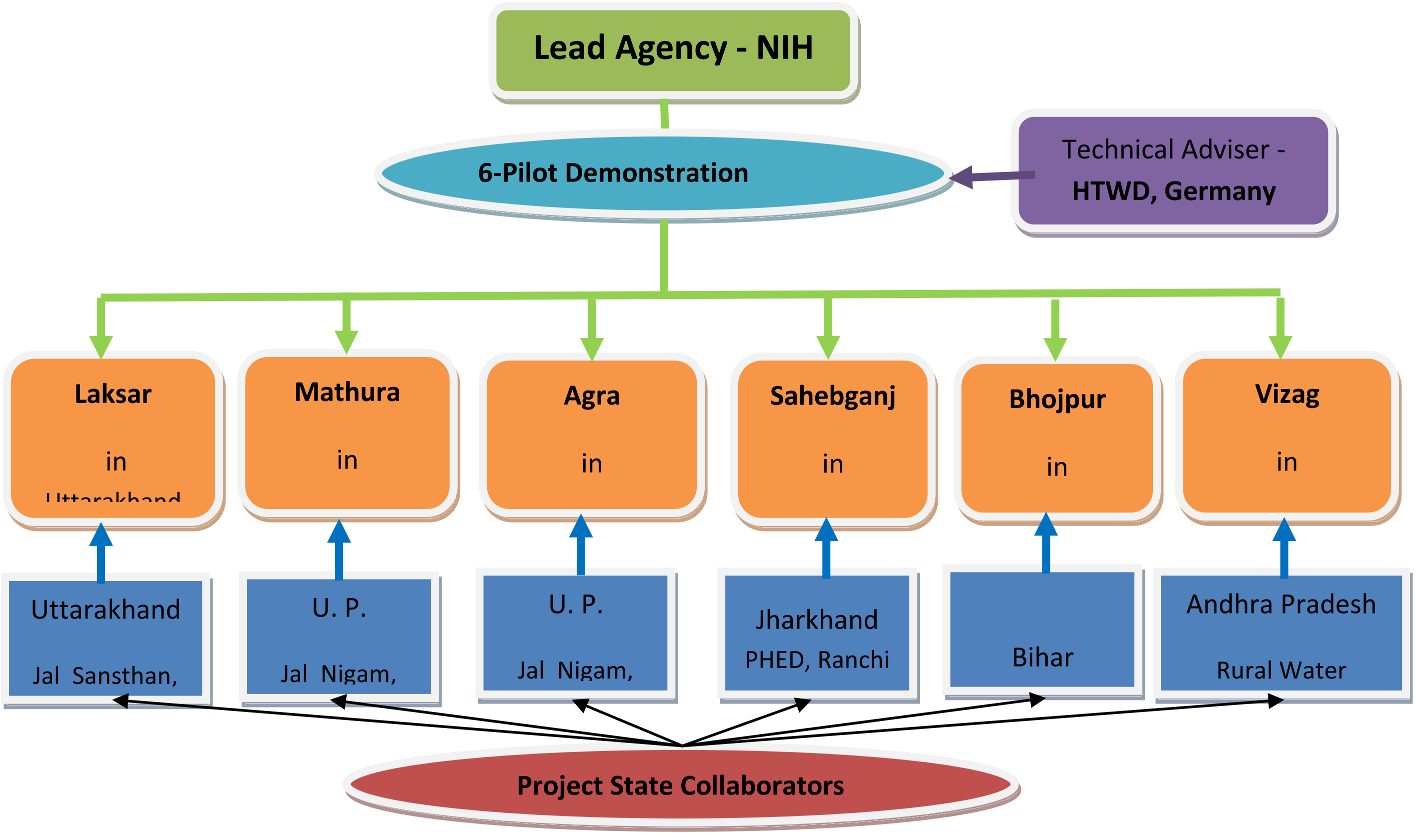


Figure 1 : Involvement of collaborators in different pilot schemes.

Project deliverables

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

Activity Schedule

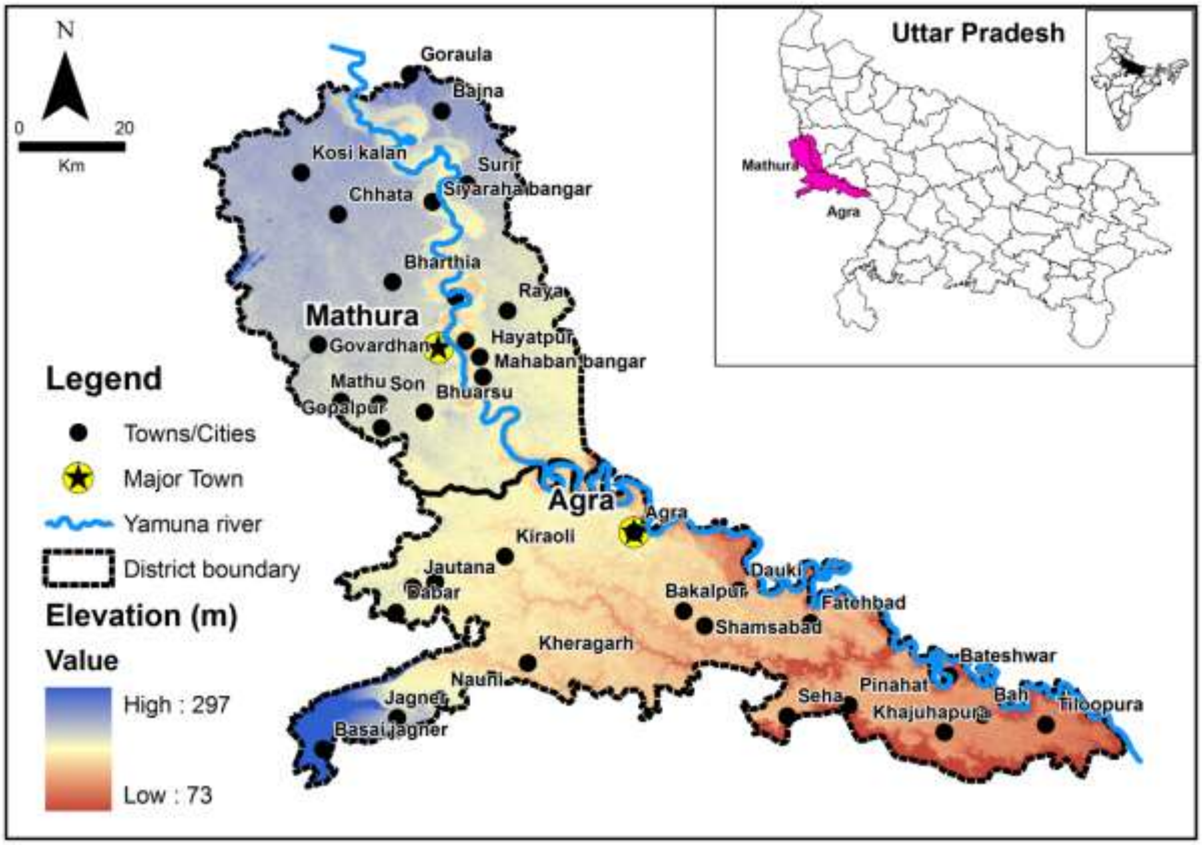
The timeline of different tasks/activities is shown in the following bar diagram.
M* : Month , T (*,*) : Task

Work elements	First Year				Second Year				Third Year	
	M3	M6	M9	M12	M15	M18	M21	M24	M27	M30
Engagement of project personnel (T 1)										
Diagnosis survey										

& site selection (T1.1)										
Site preparation (T 1. 2)										
Baseline data collection (T1. 3)										
Development of scheme, Installation of tube well, flood protection and water supply line, etc. (T 1.4)										
Procurement of pumps & equipment (T 1.5)										
Engagement of field people (T 1.6)										
Sampling campaign and data analysis (T 2.1)										
Operation of pumps and water supply (T2. 2)										
Performance evaluation & risk assessment (T 2.3)										
Interim report (T 2.4)										
Brainstorming workshop (T 2.5)										
Interaction with beneficiaries and utility groups (T 2.6)										
Training & Dissemination (T 3.1)										
Result finalization & Report preparation (T 3.2)										

<u>Progress made so far:</u>

Mathura and Agra



Data Collection

- meteorological data
- river flow data at Agra & Mathura GD site
- soil and land use
- groundwater level data of Agra and Mathura districts
- groundwater quality data of Agra and Mathura districts

Water Sampling

- four times river and groundwater sampling for water quality and isotopic analysis

Soil Sampling

- soil sampling for texture, moisture-retention and water quality analysis at 5 locations near Yamuna river in Agra

Resistivity Survey

- resistivity survey for VES was carried out at 5 locations near Yamuna river in Agra

DGPS Survey

- Differential GPS survey was carried out near Yamuna river in Agra and Mathura

Analysis of Temporal Data

- analysis on rainfall, temperature and river flow data.
- analysis on groundwater quality data collected from GW Deptt., Govt. of UP.

Following particulars are under progress:

- preparation thematic layers.
- analysis on VES.
- testing of water samples for water quality analysis in labs at NIH, Roorkee and ICAR, Dehradun.
- testing of soil samples for texture analysis at NIH laboratory.
- testing of soil samples for water quality analysis at ICAR, Dehradun laboratory.
  Identification of suitable site at Agra and Mathura is in progress.

Progress made for Laksar Site:

Three field visits were made for identification of site in the Laksar area. After survey, three villages namely Kuna khera, Dhandeki, and Mahmudpur were identified for implementing the RBF schemes. There were no suitable locations found at Dhandeki village whereas Muhammadpur has already water supply line. Therefore these two sites were not considered and finally Kuan khera village was selected as there is suitable location and no pipe line supply exists. Two times WQ sampling was done for River and Groundwater in the area and preliminary results suggested that RBF can be implemented with some additional treatment unit. The process for generating borelog data through drilling is under progress.

Site at Kuan Khera Gaon on Bank of Solani River in Laksar

Progress of Bhojpur, Bihar and Vishakapattanam, A.P. sites

Field visit to identify the project sites, a comprehensive field visit along with the officials of the respective State had been undertaken during February, 2016. A number of locations along the river Ganga in Ara (Bihar) were seen and to decide the final site consultation with the PHED, Govt. of Bihar is in progress. Hopeful to decide the site by mid of April and further activity will start thereafter.

For selection of site in Andhra Pradesh, a number of locations along different tributaries in Kakinada and Vishakapattnam were seen and to decide the final location, consultation with the State government officials are in progress. Hopeful to finalize the site before mid of April, 2016. Further activity will start there after.

With regard to the site in Sahebganj (Jharkhand), the visit is yet to take place for selecting the location.

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

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

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

Project team:

Dr. N. C. Ghosh: Project Coordinator
Mr. C. P. Kumar: Project Investigator
Dr. Anupma Sharma: Co-Investigator
Ms. Suman Gurjar: Co-Investigator
Mr. Sanjay Mittal: Co-Investigator

Duration: July 2016 - December 2018

Objectives:

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

Present state-of-art

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

Methodology

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

Research outcome from the project:

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

Present Status:

- Correspondence with Technical Director, NIC was made during April-May 2015 and the list of NICSI empanelled vendors was obtained.
- A proposal was submitted to Director, NIH on 29.5.2015 to obtain administrative approval for (a) registration of domain name "*nih-arsenic.gov.in*", (b) development of website through NIC/NICSI by their empanelled vendor, and (c) hosting the website at NIC.

- However, the administrative approval from Director was not received due to non-availability of required funds during the financial year 2015-2016.
- The study requires funding from Ministry of Water Resources, River Development and Ganga Rejuvenation. Since, no funding and official confirmation were received from the Ministry, the project activities were deferred.
- The study will be initiated only after receipt of funding and confirmation of MoWR ownership (of the developed portal) from Ministry of Water Resources, River Development and Ganga Rejuvenation.

[This project will be taken up after obtaining consent from MoWR, RD & GR]

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

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

Study team:

- Coordinator : Dr N C Ghosh, Scientist-G, GWH Div.
- PI : Dr Anupma Sharma, Scientist-D, GWH Div.
- Study Group: Groundwater Hydrology Division in association with Prof. Deepak Kashyap, IIT Roorkee, as Technical Consultant

Type of study : Internal

Date of start : December, 2014

Duration of study : Three years

Study objectives:

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

Need for study and Specific linkages with Institutions and/or end-users/beneficiaries: Severe water quality degradation issues have affected domestic and irrigation water supply in the fertile Yamuna-Hindon inter-basin. Need to develop strategies for conjunctive management of water resources in the region.

Location map:

Objectives vis-à-vis Achievements:

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

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

List of deliverables

1. Reports
2. Research Papers

Lab facilities used during the study:

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

Future plan:

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

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

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

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

Type of study : Internal

Date of Start : 1st April, 2015

Scheduled Date of Completion : 31st March, 2016

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

Objectives

(i) Baseline data collection & diagnosis survey of the area affected by and vulnerable to arsenic contamination.
(ii) Arsenic risk zone mapping for Ballia district.

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

As of 2008, 3 districts covering 69 villages in 7 blocks in Uttar Pradesh were found affected by arsenic groundwater contamination and people suffering from arsenical skin lesions. The proposed study is undertaken in light of the recommendation given by Inter-Ministerial Group (IMG) on "Arsenic Mitigation" constituted by Ministry of Water Resources, River development & Ganga Rejuvenation and Public Accounts Committee (PAC, eighth report, 16th Lok Sabha) on 'Water Pollution in India'. PAC recommended under Groundwater Pollution: "Alternate sustainable programmes be launched for ensuring supply of arsenic-free water through conjunctive use of surface water and in situ groundwater after thorough scientific studies". The proposed study will be a step forward in understanding the root causes and magnitude of arsenic contamination in eastern U.P. and for attaining sustainable supply of arsenic safe groundwater to affected areas.

Approved action plan

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

Objectives & Achievements

Baseline data collection & diagnosis survey of the area affected by and vulnerable to arsenic contamination	Some baseline data have been collected from U.P Jal Nigam and CGWB, Lucknow (Allahabad unit). Literature review has been done to identify the location or area affected by arsenic in Ballia.
Arsenic risk zone mapping for Ballia district	WQ sampling has been done and chemical analyses are under progress. The data will be fed to Arc-GIS to prepare the risk zone map.

Analysis and Results: Literature survey has been done to understand the causes for occurrence of As in GW. Areas affected by arsenic in Ballia district have been identified through literature. Water Quality sampling was done for As affected three blocks namely Dubhar, Belhari and Bariya. The chemical analyses for major ions, trace metals along with Arsenic are under progress. The relationship of As with other chemical parameters would be established. Borelog data have also been collected from CGWB, Lucknow (Allahabad unit) and analyses of data are under progress.

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

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

Project team

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

Type of study: Internal

Nature of study: Outreach Services.

Duration: August 2015-March 2016

Objectives:

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

Present state-of-art:

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

Methodology:

- A semi-analytical mathematical model to estimate unsteady groundwater recharge resulting from variable depth of water in a large waterbody, influenced by time variant inflows and outflows has been developed by Ghosh et. al. (2015).
- The model has been derived by integrating Hantush's (1967) analytical expression for water table rise due to recharge from rectangular basin into water balance equation of waterbody.
- The model has provision of direct inputs and to calculate of various hydrological components of the water balance equation. These components include evaporation rate, inflow rate, outflow rate, rainfall etc.

- The module has the platform to provide direct values of input variables and also to calculate the variable using mathematical equations. For example, to calculate inflow rate from rainfall, SCS-CN method is used, and to calculate evaporation rate Pan Evaporation Method, Mass Transfer Method and combination of Penman and Priestley-Taylor Method are used.
- The results will be in the form of graphical format, interactive charts and tables.

Progress made so far:

- Development of Web-enabled Groundwater Recharge Estimation Model (WE-GREM) is completed.
- A comprehensive help module is under development.

References:

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

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

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

Study objectives:

1. To characterize multi-year variability in groundwater level and SEC using high frequency groundwater measurements within nested shallow and deep piezometers
2. To prepare a status report on groundwater issues in Punjab

Statement of the problem:

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

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

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

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

Methodology:

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

Action plan:

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

Study Benefits /Impact:

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

Specific linkages with Institutions: BGS, UK

Annexure - 1

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

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

Progress

- The contract document from BGS, UK has been received and travel grant is sanctioned. But the field work will be conducted from NIH, grant.
- The field work for downloading the data will be conducted in few days and results will be shown in coming working group meeting during October, 2016.

Future plan

- Field work for downloading the conductivity and water level data
- The hydro-meteorological data will be collected from state departments

NEW STUDIES

7. PROJECT REFERENCE CODE: NIH/GWHD/NIH/2016-17

Title of the study : Baseline data collection and analysis of Mewat district, Haryana

Study Team :
NIH, Roorkee, India
Dr. N. C. Ghosh (project coordinator)
Dr. Gopal Krishan (PI)
Dr. Surjeet Singh (co-PI)
Er. C.P. Kumar (co-PI)
IIT-Roorkee
Dr. Brijesh Yadav (PI)
Sehgal Foundation, Gurgaon
Sh. Lalit Mohan Sharma

Type of study : Applied Research

Date of start (DOS) : March, 2016

Scheduled date of completion: March, 2017

Location : Mewat District, Haryana

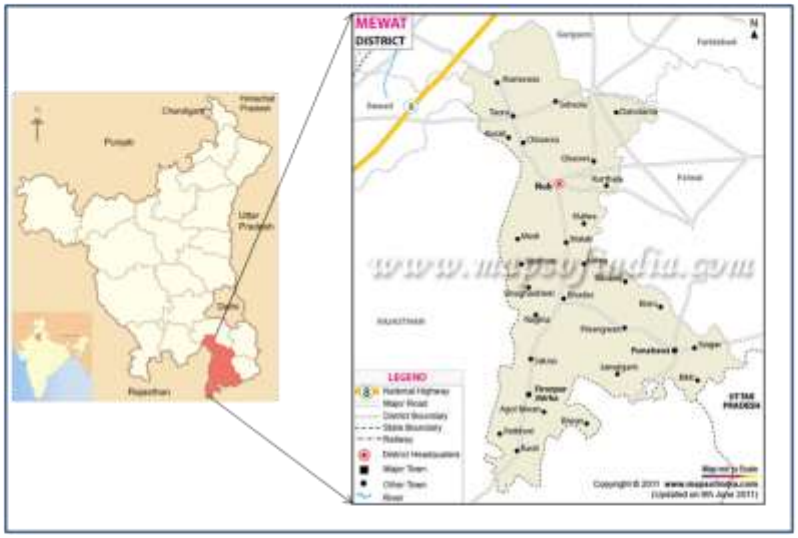
Study objectives:

1. To collect baseline hydrological, hydrogeological and water quality data of Mewat district
2. To analyze and identify the problems and groundwater recharge sources using isotopes

Statement of the problem:

The water-logging and deteriorating ground water quality of Mewat district, Haryana has affected the Ferozpur Jhirka, Nagina, Nuh, and Punhana blocks severely. The reasons for this are considered to be due to low rate of groundwater withdrawal and salinity of groundwater. The net annual withdrawal is very less as compared to the recharge. These natural as well as anthropogenic factors, therefore, result ponding of water in the depression areas, both on surface and sub surface, creating almost water logging conditions. In the areas, where water level is shallow, groundwater brings salts upward by capillary action and these dissolved salts are left at the surface due to evaporation. Such salts affected lands are seen in blocks of Nuh, Malab, Akaira and parts of Punhana block.

The origin of salinity in soils and in groundwater in shallow and deeper aquifers and its growth in space and time is not well understood. Considering this, the present study will be carried out mainly in the Mewat district of Haryana. The district covers an area of 1859.61 sq km and comprises of 5 blocks (Ferozpur Jhirka, Nagina, Nuh, Taoru and Punhana) and out of which 2 blocks namely Ferozpur Jhirka and Taoru are over exploited and Punhana block is critical.



Map of Mewat district

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

Methodology:

In order to investigate the changing groundwater conditions (quality and quantity), water and soil samples will be collected and analyzed for salinity, alkalinity and major anions F, Cl, NO_3 & SO_4 and cations Ca, Mg, Na. K. Analysis of stable isotopes of groundwater will be carried out to investigate the groundwater dynamics. Aquifer geometry, water quality, water table and isotopic details will be integrated to interpret the changing groundwater conditions and water quality. The results will be provided in thematic maps for the user organizations for suitable management practices to overcome the deteriorating quality and improving the sustainability.

Action plan:

Year	**Mar. 2016 to Mar., 2017** (Annexure 1)	**Remark**
Mar. 2016 to Mar. 2017	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 Annexure 1

Study Benefits /Impact:

- Problems to be identified
- Continuing the present work in PDS

Specific linkages with Institutions: IIT-Roorkee, Sehgal Foundation-Gurgaon

Annexure - 1

Activity Schedule for the Baseline Data Collection and Analysis in Mewat, Haryana (Quarter-wise from Mar. 2016 to Mar. 2017)

Activity	1st	2nd	3rd	4th
Collection of data from various agencies (NIH/Sehgal Foundation)	♦	♦	♦	♦
Collection of water and soil samples	♦		♦	
Analysis of samples (IIT-Roorkee)		♦	♦	
Interim Report/Technical publication(NIH-IIT-Sehgal Foundation)		♦		
Final Report/Publication(NIH- IIT-Sehgal Foundation)			♦	♦

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

IPR potential and issues: Nil

Major items of equipment needed: None

8. PROJECT REFERENCE CODE: NIH/GWHD/NMSHE/2016-21

Title of the study	:	Study of river - aquifer interactions and groundwater potential in the upper Ganga basin up to Dabrani
Study Team	:	Dr. Surjeet Singh, Sc-D (PI) Dr. N. C. Ghosh, Sc-G Dr. R. J. Thayyen, Sc-D Dr. S. P. Rai, Sc-E Dr. Manohar Arora, Sc-D Dr. Gopal Krishan, Sc-C
Type of study	:	Sponsored by DST under NMSHE
Date of start (DOS)	:	March, 2016
Scheduled date of completion:		February, 2021
Location	:	Bhagirathi Basin up to Dabrani (Uttarkashi)

Study objectives:

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

Statement of the problem:

Surface and ground water interactions and their dynamics in hilly terrain are complex in nature, which mainly depend on topography, river hydraulics, aquifer geometry, geological and hydraulic setups. It is difficult to demarcate the influent and effluent stretches of a river in topographically varying river-aquifer system. Further, in hilly terrain geometry and horizontal extent of aquifer are changeable and hence difficult to ascertain. Groundwater recharge in the snow dominated area/season is governed by the snow cover extent and duration. Reduction in both the snow cover extent and duration in association with increased winter temperature is an identified climate change response of the western Himalayan region. It is in those contexts, the study is envisaged.

Understanding of groundwater dynamics in Himalayan region is quite difficult because of difficulty in approachability to high altitudes, complex geology, highly undulated terrain conditions, lack of habitation and groundwater development, and most importantly lack of groundwater data availability. A number of studies, carried out so far, have focused on the surface water availability and variability assessment. Groundwater, being an integral part of the hydrological cycle, cannot be excluded from the interactions with stream flow, glacier and snowmelt recharge.

Weathered material along the hill slopes and sediment deposits in the valley portions form enough space to accommodate the water from snowmelt and rainfall recharge. Because of tectonic activities in Himalayas, fractures are developed in the rocks which act as conduits for groundwater movement and recharge. Further, many sedimentary rocks, porous and permeable soils and rocks form potential aquifers that may receive and hold enough water from snowmelt. At the soil-snow interface, there is high pressure due to the overburden material of snow/glacier deposits. As this pressure increases, temperature also increases at this interface. Therefore, there exist strong chances of snowmelt recharge at the soil-snow interface which could be a continuous process of snowmelt recharge to groundwater even in the winter season. Reduced winter precipitation and steep rise in winter temperature during the past three decades is being considered as possible climate change signal in the western Himalayan region. This has been resulted into reduced winter cover duration in the high altitude region, which possibly could alter groundwater recharge regimes and local springs and base flow. Hence, understanding of cryosphere-GW interaction including magnitude of snowmelt at the soil-snow interface and recharge to groundwater is a matter of research and needs investigations.

To bridge the knowledge gap on these issues, a comprehensive study on the stream/river and groundwater flow interactions and dynamics including potential assessment emerging from snow and glacier melt recharge are necessary to answer the question of groundwater development prospect in the hilly areas as well as base flow regimes of the mountain streams.

End Users/ Beneficiaries: DST, UJS

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

Baseline Data/Information on the Study Area & Results of Previous Studies: Existing data and information already available with NIH and other line departments will be collected.

Methodology:

- 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.
- Developments of lithologs & aquifer characterization.
- Collection of water samples & monitoring of groundwater levels.
- Analysis on the stream-aquifer interactions and dynamics processes.
- Estimation of groundwater recharge & water potential.

Action Plan & Timeline:

Activity	1st year		2nd year		3rd year		4th year		5th year	
	I	II	I	II	I	II	I	II	I	II
Reconnaissance survey & selection of sites for piezometer development										
Literature survey										
Preparation of various thematic layers (geology, soils, snow cover, drainage, monitoring network, etc.)										
Development of piezometers										
Field measurements & sample collection and analysis										
Analysis of results & interpretations										
Key findings										
Dissemination of outputs										
Submission of final report										

Data Requirements:

- Geological maps
- Meteorological data
- River flow data
- Groundwater levels, etc.

List of Deliverables:

- Reports
- Research papers
- Training Workshops

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.

Major Items of equipment needed: GPS, Portable WL Indicator, EC & pH meter.

9. PROJECT REFERENCE CODE: NIH/GWHD/NIH/2016-16

Title of the study **:** Web Enabled "Conjunctive Use Model for Management of Surface and Ground Water using concept of MAR and ASR"

Project team

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

Type of study **:** Internal

Nature of study **:** Outreach Services.

Duration **:** April 2016 - November 2016

Objectives:

- To develop a comprehensive user friendly web-enabled "*Conjunctive Use Model for Management of Surface and Ground Water in a recharge basin using concept of MAR and ASR*".
- To provide a platform to users and professionals for calculating time-varying depth of water in , and groundwater recharge from, a recharge basin consequent to the pumping in the vicinity of the basin for recovery of recharged water .
- To visualize the output in graphical as well as tabular format.
- To host the module in the public domain as an extension of WE-GREM for its large uses by stakeholders and groundwater professionals.

Methodology:

- An analytical model to determine the recharge rate due to interaction of different hydrological components in a recharge basin including pumping in the vicinity of the basin has been developed.
- The model has been developed based on water balance of recharge basin that includes inflow to the basin, outflow from the basin, and rainfall over the basin, evaporation from the basin and groundwater recharge from the basin. For estimation of different hydrological components processed based equation have been used for example SCS-CN method is used for inflow, Standard models like Pan Evaporation, Mass Transfer, combination of Priestley-Taylor and Penman are used for Evaporation, analytical method Hantush (1967) is used for groundwater recharge and for pumping Thesis(1935) well response function is used.
- The developed model will be converted into a web-enabled and user friendly interface.
- The interface will be an extension to the WE-GREM.

Deliverables:

- Web-enabled system for calculating time-varying depth of water in , and groundwater recharge from, a recharge basin consequent to the pumping in the vicinity of the basin for recovery of recharged water.

Results will be in the form of charts, tables and graphs.

10. PROJECT REFERENCE CODE: NIH/GWD/INT/16-16

Title of the Project: Evaluation of Saryu Nahar Pariyojna(SNP) National Project in Uttar Pradesh.

Type of study: Sponsored by MoWR, RD & GR

Nature of study: R&D

Duration: March 2016 - August 2016

Study Team: N. C. Ghosh, Gopal Krishan, R. P. Singh & J. K. Mishra

Government of India
Ministry of Water Resources,RD&GR
PP Wing - R&D Division
1st Floor, Wing 4, West Block–I, R.K. Puram, New Delhi-110066
Tel/Fax : 011-26104082, E-mail:watmd-mowr@nic.in

No. 26/31/2016-R&D/382-398 **Dated:** March 01, 2016

Office Memorandum

Sub: Evaluation study of Saryu Nahar Pariyojna (SNP) National Project in Uttar Pradesh on Scientific lines.

The Approval of the competent authority is hereby conveyed for conducting evaluation study of Saryu Nahar Pariyojna (SNP) National Project in Uttar Pradesh on Scientific lines for the following aspects as given below:

No.	Component of Study	Agency/Organisation
1.	**Ground Water** a. The status of ground water in the SNP command. b. To quantification of Ground Water availability for Irrigation on sustainable basis in SNP command. c. Present status/future scenario of salinity and water logging in SNP command due to canal irrigation & measures for its restoration. d. The viability of using solar pumps for extracting Ground Water from shallow well for irrigation.	**NIH to take up the Study**: Regional Director, CGWB, Lucknow to provide requisite data/ assist NIH in conducting the Ground water studies.
2.	**Surface Water** a. Actual/present carrying capacity of Saryu Link Channel (SLC) & Saryu Main Canal (SMC) and maximum discharge they may pass in present stage. Loss of capacity. b. Assessment of water availability for SNP system from Ghagra, Saryu and Rapti etc. c. Assessment of crop water requirement of SNP command on 10-daily basis and checking the same with the water availability.	**CWC to take up the study:** Uppar Ganga Basin Organisation, CWC, Lucknow to co-ordinate with the Irrigation Department, Govt. of Uttar Pradesh for making available the requisite data/ information for the study to CWC (HSO/PAO/IMO/Designs, N&W/PMO).
3.	**Economic Evaluation** Present Cost-Benefit Ratio of SNP on actual benefits from the scheme.	
4.	Updating of CWC/NRSE 2009 report may also be updated in the CWC	

2. The study will be carried out in-house in CWC/NIH.
3. The organizations in CWC/NIH responsible for doing study may request the requisite field data from UGBO/CGWB/State Govt. To avoid delay, communication may be made through e-mail/phone.
4. The units in CWC may forward the outcome of the study to PPO for compilation of report.
5. A committee chaired by Economic Advisor, MoWR,RD&GR and represented by Chief Engineer PPO/PAO, CWC, Regional Director, CGWB, Lucknow, Dr. N.C. Ghosh Scientist-G of NIH and assisted by Director, R&D will monitor the progress/outcome and submit the report within three months to the Ministry.

o/c

1/3/16
(S K Gangwar)
Director (R&D)
09650675666

11. PROJECT REFERENCE CODE: NIH/GWD/INT/16-17

Title of the Project: *Country-wide Capacity Building Program on* "Bank Filtration for Sustainable Drinking Water Supply".

Type of study: Sponsored by DST, Govt. of India (Rs.36.4 lakhs for four Training Courses)

Nature of study: Outreach Activity

Duration: February 2016 - December 2017

Study Team: N. C. Ghosh & other scientists of the Division

Objectives:

(i) To develop, strengthen and upscale competence on bank filtration technique and its allied aspects in the Country for attaining drinking water security;

(ii) To create a platform of knowledge repositories on bank filtration in the Country, and develop a network to connect & interact with trained personnel for exchanging knowledge.

Methodology:

A total of 4 training courses, each of 5-day duration, will be organized at Roorkee in two years. In each year, there will be two training courses; one for the states representing Indo-Gangetic and Brahmaputra & Barrack basin covering all eight north-eastern states, West Bengal, Bihar, Jharkhand, Uttar Pradesh, Uttarkhand, Himachal Pradesh, and Delhi and other one for the all other states namely peninsular states, Odisha, Maharastra, Goa, Gujarat, M.P., Chhatisgarh, Punjab, Haryana, Rajasthan and Jammu & Kashmir and same will be repeated for the second year to increase more competent persons in each state. Few persons will also be included from R & D and Academic Organizations. A total of about 35 participants in each training course with two participants from each state and 5 from R & D and Academic Organization will be included in each training course.

Deliverables:

- Upscale Process for competence building on "Bank Filtration"
- Services for knowledge dissemination and up-gradation on "Bank Filtration"
- Compiled report on conducted training courses including feedback analysis.

HYDROLOGICAL INVESTIGATION DIVISION

Scientific Manpower

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

APPROVED WORK PROGRAMME FOR 2015-2016

S. No.	Study	Team	Duration/ Status
	INTERNAL STUDIES		
1.	Isotopic Studies for the Identification of Different Aquifer Groups and their Dynamics in Upper Yamuna River Plains	Sudhir Kumar (PI); C K Jain; SP Rai; SD Khobragade; P. K. Garg; CGWB, Lucknow & Chandigarh)	**2 years** (07/13-06/15) **Continuing Study**
2.	Estimation of Radon Concentration in Waters and Identification of Paleo-groundwater in Part of Punjab Located in Satluj River Basin using Isotopes	S. K. Verma (PI) S. P. Rai (Co-PI) M. S. Rao C. P. Kumar Mohar Singh	**2 years** (10/13-09/15) **Continuing Study**
3.	Interaction between groundwater and seawater along the northern part of east coast of India	M. S. Rao (PI), Sudhir Kumar Pankaj Garg	**2 years** (01/15 - 12/16) **Continuing Study**
4.	Isotopic investigation of benchmark Himalayan glaciers.	M. S. Rao (PI) S.P. Rai, Sudhir Kumar Pankaj Garg	**2 years** (01/15 - 12/16) **Continuing Study**
5.	Assessment of dissolved radon concentration for groundwater investigations in Haridwar district	Pankaj Garg (PI) Sudhir Kumar, M. Someshwar Rao	**1 year** (01/15 – 12/15) **Continuing Study**
6.	Status Report on Rewalsar Lake, Himachal Pradesh	SD Khobragade (PI) Sudhir Kumar, C. K. Jain	**1 year** (04/15 – 03/16) **New Study**
7.	Lake-Groundwater Interaction Studies for Sukhna Lake, Chandigarh	SD Khobragade (PI); Sudhir Kumar; Senthil Kumar; Pankaj Garg	**3 year** (04/15 – 03/18) **New Study**
	SPONSORED PROJECTS		
8.	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates	S. P. Rai (PI); M. S. Rao; Surjeet Singh; S. K. Verma; C. P. Kumar; Sudhir Kumar	**3 years** (06/12-03/16) **Continuing Study**
9.	The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India	M. S. Rao (PI) C. P. Kumar S. P. Rai	**3 years** (09/12-12/15) **Continuing Study**
10.	Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques	S. P. Rai (PI) R. V. Kale M. S. Rao C. P. Kumar Sudhir Kumar	**3 years** (10/12-04/16) **Continuing Study**

S. No.	Study	Team	Duration/ Status
11.	Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains	Sudhir Kumar (PI); S. P. Rai; S. D. Khobragade; C. K. Jain; P. K. Garg	**2 years** (05/13-03/16) **Continuing Study**
12	Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques	S. P. Rai (PI); Sudhir Kumar; Rajesh Singh; S. D. Khobragade; M. Arora; Dr. R. J. Thayyen; Sh. P. K. Garg	***To be under taken under NMSHE project***

CONSULTANCY PROJECTS

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

R & D STUDIES:

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

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

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

Project Team:

(a) Project Investigator: Sudhir Kumar (PI)

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

Duration : July 2013 to June 2015

Study Objectives: Objectives of the study are

i. To identify the various aquifers present in alluvial tract of the Upper Yamuna Plains.
ii. To identify the source of recharge of different aquifers, and the interaction between various aquifers.
iii. To investigate the continuity of aquifers on both the sides of the river Yamuna,
iv. To determine the groundwater dynamics in different identified aquifers, and
v. To estimate the groundwater velocity and replenishment potential of the deeper aquifers

The results shall be presented during the meeting.

The study has been completed and report preparation is under progress.

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

Title of the Study	:	**Estimation of Radon Concentration in Waters and Identification of Paleo-groundwater in Part of Punjab Located in Satluj River Basin using Isotopes**
Study Team	**:**	S. K. Verma (PI), S. P. Rai (Co-PI), M. S. Rao, C. P. Kumar, and Mohar Singh
Type of Study	:	Internal
Date of Start	:	October 2013
Date of Completion	:	September 2015

Study Objectives:

- To measure radon concentration in water
- To identify the paleo-groundwater in the study area

The study has already been completed and was presented in the last working group meeting. Report is being finalised.

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

Title of the study : Interaction between groundwater and seawater along the parts of East Coast of India

Study Team:

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

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

Type of Study : Internally funded

Budget : Rs. 26,82,000/-

Date of Start : April, 2015 (Revised Oct, 2015)

Date of Completion : March 2017 (Revised Sep, 2017)

Study Area:

The study area covers the Coastal region of West Bengal and Odisha. Major problem of the area is either intrusion of seawater or discharge of fresh groundwater to sea.

Study Objectives:

The objectives of the study are:

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

Statement of the Problem

India has over 8000 km length of shore line with people living over 250 million within 50 km width of the coast and groundwater is an important resource in this region. Increasing population density, industrial growth, irrigation expansion, falling water levels is causing continuous depletion of freshwater resource whereas, factors like monsoon variability, climate change, sea-level change, episodic cyclones etc., are causing short & long term variability in the freshwater availability and thereby variability in the seawater-groundwater interface zone in the coastal zone of India. Mapping of fresh and saline groundwater zones and the operative processes along this zone help to protect the groundwater resource from getting it salinized. The present project is intended to provide a regional map of seawater-groundwater interaction zone of coastal West Bengal and Odisha using salinity and isotopic mapping.

Action Plan

First Year (Oct, 2015 to Sep, 2016)

Sl. No.	Work Element	1st Qtr (Oct'15-Dec'15)	2nd Qtr (Jan'16-Mar'16)	3rd Qtr (Apr'16-Jun'16)	4th Qtr (Jul'16-Sep'16)
1	Field work for water sampling and data collection	✓		✓	
2	Sample analysis		✓		✓
3	Data interpretation, interim report, publications			✓	✓
4	Training programme/workshop				✓
5	First Year Report				✓

Second Year (Oct, 2016 to Sep, 2017)

Sl. No.	Work Element	1st Qtr (Oct'16-Dec'16)	2nd Qtr (Jan'17-Mar'17)	3rd Qtr (Apr'17-Jun'17)	4th Qtr (Jul'17-Sep'17)
1	Field work for water sampling and data collection	✓		✓	
2	Sample analysis		✓	✓	
3	Data interpretation, interim report, publications			✓	✓
4	Training programme/workshop				✓
5	Final Report				✓

Objectives vis-à-vis Achèvements

Objectives	Achievements
Mapping the salinity variation and stable isotopic composition in the coastal groundwater	First field work was completed in the month of November, 2015. The samples for isotopic analysis are being analysed in the Nuclear Hydrology Laboratory and the results are expected by the 2nd week of April
Mapping the dissolved radon in groundwater and its implication to fresh groundwater discharge to sea or sea-water intrusion	An inventory of radon concentration in groundwater was done during field work of Nov 2015. The data will be interpreted in conjunction with the isotopic data on getting the water samples analyzed on mass-spectrometer.
Mapping the groundwater-seawater interaction regions vis-à-vis the operating hydrological process (SGD/Seawater intrusion)	---

Future Plan: Field visit for sampling on the basis of the inventory sampling. Collection of archival data and isotopic/chemical analysis of water samples that will be collected during the 2nd field visit.

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

Title of the Study	**:**	**Isotopic investigation of benchmark Himalayan glaciers**
Study Team	**:**	M. S. Rao, (PI), Sudhir Kumar (Co-PI), Prof. A. L. Ramanathan, JNU (Technical Collaborator)
Type of Study	:	Internally funded
Budget	:	Rs. 32.68 lakhs
Date of Start	:	April, 2015
Date of Completion	:	March 2017
Study Objectives	**:**	

The objectives of the study are:

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

ii) Assessment of spatial variability in isotopic & chemical characteristic of glacial environment

iii) Use of isotope technique to understand the accumulation and ablation of (Himalayan) glaciers

Statement of the Problem

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

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

Study Area:

In 2002, DST, Government of India and the the International Commission on Snow and Ice (ICSI), UNESCO, has included Chhota Shigri glacier as a bench mark glacier in the Himalayan glaciers as it satisfied most of the required criteria of bench mark glacier which includes glacier size, altitudinal range to detect ELA variability, well defined catchment, simple geometry, easily accessible, well defined accumulation area, single tongue, insignificant mechanical processes such as avalanches, relatively debris free and smooth surface, etc. Chhota Shigri is a 9km long glacier located in Lahol Spiti Valley of Himachal Pradesh in the geo-coordinate between 32^{0}11'-32^{0} 17'N and 77^{0}29'-77^{0} 33'E. It comes in the Chandra river basin on the northern ridge of Pir Panjal range in the Lahaul-spiti valley of Himachal Pradesh. The total area of this glacier is 15.7km^2 with catchment area of 34.7 km^2 and is distributed over altitude range 4050m -6263 m a.s.l. This glacier is influenced alternatively by Asian Monsoon in summer and mid-latitude westerlies in winter. Thus it has two distinct accumulations i.e. summer and winter. The geology of the catchment is dominated by Rohtang gneiss.

Brief Methodology

The study involved sampling of melt water of glacial channels, snow cores, precipitation and their isotopic analysis. The collected water samples is analyzed to LMWL and in understanding the effect of local weather in modification of isotope systematic of the snow accumulation & melting.

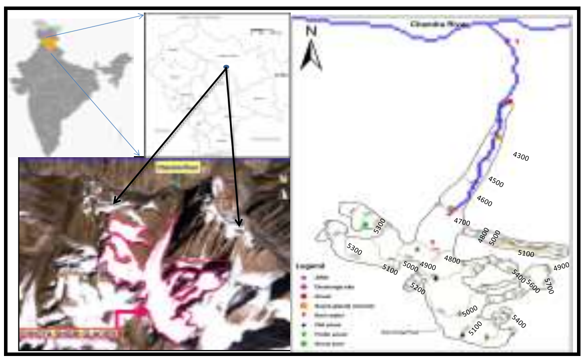


Fig: Location details of Dokriani Glacier in Himachal Pradesh, India;

Results:

Collected Sample type	Elevation (m above msl)
Fresh & old snow	4900-5190
Meltwater a)From supra glacial channels b) From snout c) glacial discharge	 4710-4392 3910
Snow core (4 m; 50 cm interval)	5196
Individual rain samples (July-September)	

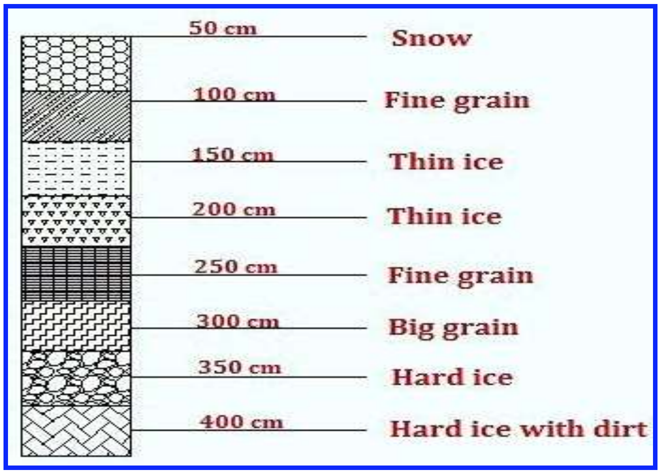


Fig: Stratigraphy record of the raised snow core.

Table: Isotopic results of the analyzed samples

Sample type	Elevation	$\delta^{18}O$ (‰)	δD (‰)
Snow core (400 cm)	5196	-11.22	-70.96
Fresh Snow FS_1 FS_2 FS_3 FS_4	 5190 9100 5000 4900	 -19.23 -14.6 -14.83 -9.11	 -151.92 -110.42 -112.85 -65.47
Old Snow OS1 OS2	 5100 4900	 -8.82 -10.57	 -56.55 -72.74
Rain water July-Sept July	 3877 4756	 -4.25 -4.51	 -21.37 -37.22

Objectives	Achievements
Generating the primary isotope data on snow, glacial cores and on glacial discharge of benchmark Himalayan glaciers	Completed for Dokriani Glacier
Assessment of spatial variability in isotopic & chemical characteristic of glacial environment	Completed
Use of isotope technique to understand the accumulation and ablation of (Himalayan) glaciers	Partially completed.

Future Plan:

The samples collected as on date have been analyzed. The facility to raise ice core of length 10m or more is not available in NIH. The purchase process to procure long corer cannot be initiated at this stage as the project period is completing. Therefore, with the analyzed data and archival data the final report will be prepared. The final report will be submitted by June, 2016

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

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

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

Type of Study : Internal

Date of Start : January 2015

Date of Completion : December 2015

Study Objectives:

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

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

The study has been completed and the report is being finalised.

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

Title of the Study: **Hydrological Aspects of Rewalsar Lake, Himachal Pradesh (Status Report)**

Project Team: Suhas Khobragade (PI), Sudhir Kumar, C. K. Jain, V. K. Agrawal, and Satya Prakash

Type of Study: Internal Study

Budget: 3.27 Lakh

Date of start: April, 2015

Duration: 1 year

Date of completion: March, 2016

Study Objectives:

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

Study Area:

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

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

Statement of Problem:

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

Brief Methodology:

The envisaged objectives will be achieved through:

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

Action Plan:

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

Objectives vis-à-vis Achievements

Sr. No.	Objective	Achievement
1.	To determine the environmental status of the lake	Water quality assessment has been carried out for monsoon and post monsoon seasons. Pre-monsoon sampling is proposed in May, 2016.
2.	To identify major problems of the lake	Done

3.	To identify major management issues of the lake	Done
4.	To review current research status and research needs for lake	Have been done based on the present understanding of the problems
5.	To review the data availability scenario and identify data gaps vis-a-vis identified research needs	To be completed after pre-monsoon sampling of May 2016.

Results and Analysis:

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

Isotopic analysis of the lake and surrounding ground water has also been carried out. The values of $\delta^{18}O$ for the lake are observed to vary in the range of -1.79 ‰ to -1.53 ‰ while corresponding δD values range between -12.65 ‰ and -10.85 ‰. The surrounding groundwater shows different isotopic characteristics than the lake water. The values observed in the lake are highly enriched compared to the surrounding groundwater due to evaporation effect.

Sedimentation in the lake has been determined using Cs-137 technique. Sediment core was collected from the lake and was analysed for Cs-137 activity. The results are shown in Fig. 2. Based on the analysis, rate of sedimentation for the Rewalsar lake comes out to be 0.82 cm/year.

However, analysis of water quality data particularly the high DO values, fail to explain dying of fish during summer. Further analysis of water quality was suggested including analysis of heavy metals for analysis of seasonal variation and particularly the summer water quality. Accordingly, sampling was carried out again for winter season during January, 2016 and the detailed results, including analysis of the heavy metals, shall be presented in the working group meeting.

Further, it was proposed to be a one year study initially. However, since it is now planned to carry out the summer season sampling during May-June, 2016, it is proposed that the study may be extended by another six months.

Future Plan: As per activity schedule

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

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

Study Team: Suhas Khobragade (PI), Sudhir Kumar, Senthil Kumar, P Garg, Sh. V. K. Agrawal and Satya Prakash

Type of Study: Internal

Budget: 59.59 lakh

Duration: 3 years

Date of Start: April, 2015

Date of Completion: March, 2018

Statement of Problem:

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

Study Objectives:

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

Brief Methodology:

The envisaged objectives will be achieved through –

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

Action Plan/Timeline:

Sl. No.	Work Element	First Year	Second Year	Third Year
1.	Recruitment of project staff	√		
2.	Literature Review	√	√	√
3.	Collection and compilation of all available	√		

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

Objectives vis-à-vis Achievements

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

Results and Analysis:

Analysis of the water balance indicate that depending upon the water levels of the lake, the seepage losses from the lake in a water year (July-June) can vary from 0 (zero) to 175 Ham. Higher is the post monsoon water level reached by the lake, more would be the seepage losses. At levels of 1956.3 m and below, the losses would be almost zero or negligibly small. However, for further detailed analysis continuous monitoring of the daily water level data of the lake, and the two piezometers located just upstream and downstream of the lake is being carried out since July, 2015 using automatic water level recorders installed at these three locations.

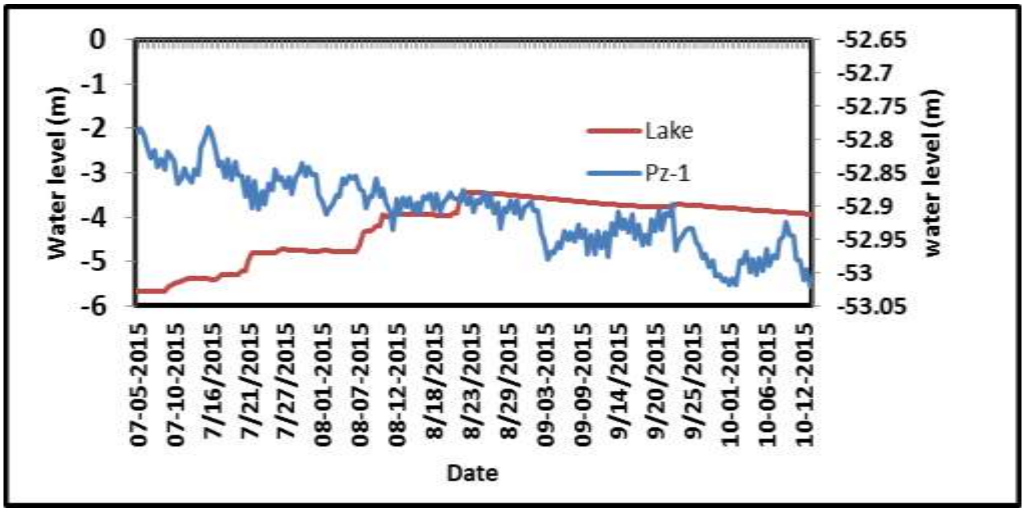


Fig. 1(a): Variation of Pz-1 water level vis-à-vis lake water levels

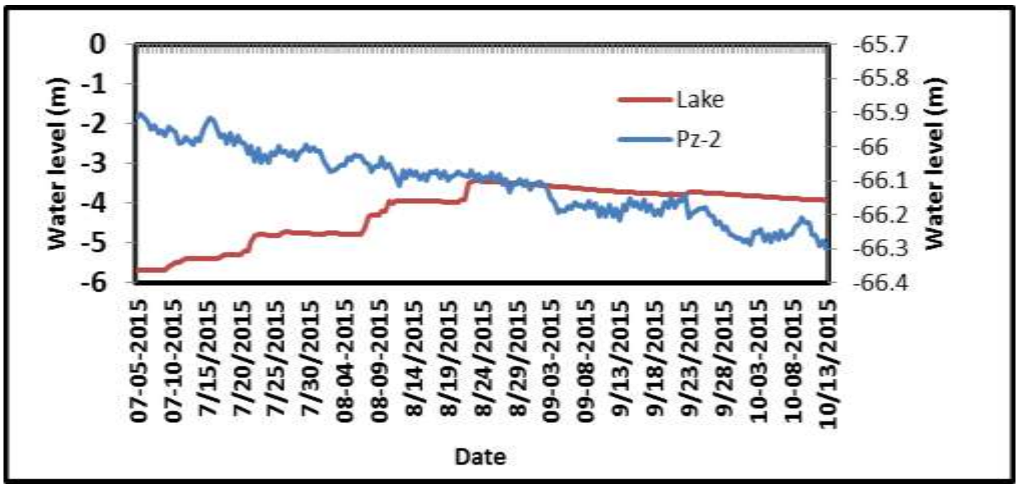


Fig. 1(b): Variation of Pz-2 water level vis-à-vis lake water levels

More detailed results shall be presented in the working group meeting

Future Plan:

(i) Long term monitoring of water level data.
(ii) Installation of additional piezometers in the U/S & D/S of lake.

SPONSORED PROJECTS

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

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

Study Team : S. P. Rai (PI), S. K. Verma, S. Khobragade, Surjeet Singh, Sudhir Kumar, V. K. Agarwal, Rajeev Gupta, S. L. Srivastava, Vishal Gupta, Mohar Singh

Type of Study : Sponsored

Funding Agency : MoES, Government of India

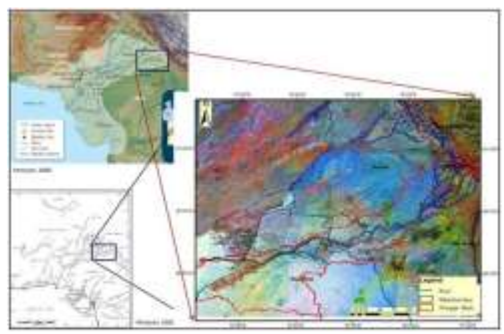
Budget : Rs. 210 Lakh (NIH component Rs. 35 lacs)

Date of Start : June 2012

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

Location Map:

The study area covers the North Western India. However, Ghaghar basin has been selected to carry out detailed investigations, which covers the states of Himachal Pradesh, Punjab, Haryana and Rajasthan.



Land use: Agriculture dominated

Major problem of the area is declining of groundwater levels at a very fast rate, but at few places groundwater level is raising also.

Study Objectives

- Isotopic characterization ($\delta^{18}O$ and $\delta^{2}H$) of groundwater, stream and rain water
- Groundwater dating using Tritium and Carbon-14
- Delineation of flow direction and recharge zones
- Identification of recharge source and zones of groundwater in the study area

Statement of the Problem

India is largest agricultural user of groundwater in the world. The last 40 years have seen a revolutionary shift from large scale surface water management to widespread groundwater abstraction, particularly in the northwestern states of Punjab, Haryana and Rajasthan. As a result of this, groundwater depletion of this region has become under the vulnerable condition and a hotspot for groundwater management. The groundwater depletion rates in the states of northwestern India are reported highest in the world. This unmanaged use of groundwater becomes more challenging due to increasing demands from population and industrial developments under the climate change scenario. There is a major task to replenish the groundwater depletion through rainfall recharge. Therefore, this study is proposed to study groundwater dynamics in the region.

Action Plan

Activity	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**11th**	**12th**	**13th**	**14th**	**15th**	**16th**
Selection of study area	♦															
Literature survey	♦	♦	♦	♦	♦											
Collection of previous years data	♦	♦	♦	♦	♦											
Identification of data gaps	♦	♦	♦													
Selection of sites for stable isotope (δ^2H and $\delta^{18}O$) analysis	♦	♦	♦													
Selection of sites for radio-isotope (^3H and ^{14}C) analysis	♦	♦	♦													
Site selection and installation of raingauges	♦	♦	♦													
Measurement of δ^2H and $\delta^{18}O$ of rain, river and groundwater		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦			
Sample collection and Measurement of ^3H activity of groundwater, rain and river		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦		
Sample collection and measurement of ^{14}C activity of groundwater										♦	♦	♦	♦	♦	♦	
Measurement of radon in groundwater								♦	♦	♦	♦	♦	♦			
Preparation of geological and hydrogeological maps of the study area				♦	♦	♦	♦	♦								

Activity	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th
Preparation of water table and flow direction map on the basis of previous years data		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦			
Interpretation of isotopic data					♦	♦	♦	♦	♦	♦	♦	♦	♦	♦		
Estimation of natural recharge to groundwater												♦	♦	♦	♦	
Impact of climate change on groundwater										♦	♦	♦	♦	♦	♦	
Identification of recharge zones									♦	♦	♦	♦	♦	♦	♦	
First Draft Report														♦		
Second Draft Report															♦	
Final Report																♦

Objectives vis-à-vis Achèvements

Objectives	Achievements
Isotopic characterization ($\delta^{18}O$ and $\delta^{2}H$) of groundwater, stream and rain water	Pre-monsoon & post-monsoon samples of groundwater, river and canal have been collected and laboratory analysis completed.
Groundwater dating using the tritium and Carbon-14	About 40 samples Tritium dating completed and analysis of 20 samples is in progress. 25 groundwater samples collected for carbon and dating and CFCs, SF6 dating. The samples were sent to UK for analysis. The results of C-14 has been received, however CFC results are awaited.
Delineation of flow direction and recharge zones	Water level data and tritium data are used to delineate the flow direction and recharge zones of groundwater.
Identification of recharge source and zones of groundwater in the study area.	$\delta^{18}O$, $\delta^{2}H$ and tritium data of groundwater and other sources have been analysed and source identification of the groundwater is in progress. Identified recharges sources for shallow groundwater

Analysis and Results:

Variation of Groundwater Level Data

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

Isotopic Composition of Rainfall, River and Canal Water

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

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

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

The spatial variation of $\delta^{18}O$ values of groundwater of shallow depth show that $\delta^{18}O$ varying between -4‰ and -12‰. The enriched $\delta^{18}O$ values are found in the upper part of the catchment while depleted values in the middle and lower part of the catchment. The depleted isotopic signature of groundwater in the middle and lower part indicates recharge to groundwater from canal water. The environmental tritium activity has been measured for groundwater at different locations and it is found to vary between 0.3 TU and 8 TU. The tritium value of groundwater samples collected from shallow depths near Chandigarh and Rajpura area are varying from 5.2 TU to 6.1 TU and near Patiala and Samana it is about 4.2 TU. 20 groundwater samples for dating using 14C, CFCs and SF6 has been send to UK for measurement.

The electrical conductivity (EC) of Ghaghar river and canal water is found in the range of 400 μS/cm to 450 μS/cm and 200 μS/cm to 220 μS/cm, respectively. The canal and river water samples show low salt values than the desirable value of Indian & WHO Standards (782 μS/cm). EC of groundwater ranges between 230 μS/cm and 10500 μS/cm in shallow aquifer, 260 μS/cm to 3900 μS/cm in middle aquifer and 420 μS/cm to 9500 μS/cm in deep aquifer, respectively. In shallow aquifer, EC ranges 250 μS/cm to 2000 μS/cm in upper reaches of study area, 500 μS/cm to 1000 μS/cm in middle part of study area and 1000 μS/cm to 10500 μS/cm in lower part of study area. The southern part of the basin is more saline. This is reason that groundwater level is raising upwards in southern part of the study area. The hydrochemical analysis of groundwater of study area has been analysed and details results will be present in working group meeting.

There is marked variation in isotopic and chemical composition of groundwater which indicates complex system of recharge. At several places significant recharge from canal has been observed. Details of the findings will be presented in working group meeting.

Future Plan

- Estimation of volume of water withdrawn due to pumping (under progress)
- Groundwater Age dating using Tritium, ^{14}C and CFC (C-14 analysis completed and CFC samples under analysis)
- Preparation of final report

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

Title of Study: **The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India**

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

Type of Study : Sponsored

Funding Agency : IAEA, Vienna

Budget : € 15,000.00

Date of Start : September 2012

Date of Completion : December 2015

Study Objectives :

The objectives of the study are:

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

The study has been completed and was presented in the last working group meeting. The report has been submitted to IAEA.

10. *PROJECT REFERENCE CODE: NIH/HID/IAEA-2/2012-15*

Title of the Study : **Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques**

Study Team : S. P. Rai (PI), R. V. Kale, M. S. Rao, C. P. Kumar, Sudhir Kumar, V. K. Agarwal, Vishal Gupta, Mohar Singh

Type of Study : Sponsored

Funding Agency : IAEA, Vienna

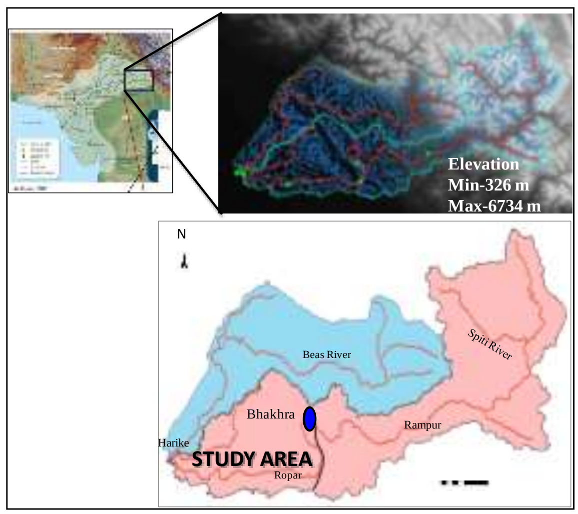
Budget : 5000 Euro per year

Date of Start : October 2012

Date of Completion : April 2016 (request for extension up to December 2016)

Location Map

The study area falls in the Punjab state of India. Groundwater levels in Punjab have reached to most critical condition. As per report of Central Ground Water Board, Government of India (2009), 80% area of Punjab state falls under over-exploited zone. With onset of Green Revolution during 1960s, the state rapidly adopted the green revolution technology and resulted in increased demand for irrigation water. The requirement of irrigation was met through development of irrigation canal network and development of tube wells. Between 1960 and 1999, the food grain production of Punjab increased from 3.16 to 22.22 million tones. During this period, number of tube wells increased from 0.60 million to 1.1 million, leading to over-exploitation of groundwater in most parts of the state. The concentrated pumping has affected the natural groundwater conditions and flow regime.



Study Objectives

- To develop thematic maps based on isotope and related information relevant to the evaluation and assessment of the quality of surface water
- Comparative study of recession characteristics of Satluj River with conceptual and isotopic model
- To assess the potential and limitations of the tracer techniques for routine application in hydrological studies

Statement of the Problem

The importance of Satluj river in Indian context is better understood from the fact that it continues to play a major role in the socio-economic development of north-western part of the country. The dependency of the states of Himachal Pradesh, Punjab, Haryana and Rajasthan on the resources of Satluj river for the sustenance and growth of agricultural and hydroelectric power sector is ever growing. In addition to several micro and mini projects, several mega projects are under way, particularly in the upper part of Satluj Basin. The runoff of Satluj river receives major contribution from snow/glacier, rainfall-runoff and groundwater/baseflow. The assessment of rainfall derived runoff and snow and glacier melt runoff have been carried out. However, contribution of the baseflow to river flow was overlooked and no major attempt has been made to assess the impact of baseflow contribution on discharge and quality of the river. Therefore, this study will be a first approach to understand the groundwater and river interaction in this part of the Satluj catchment.

Action Plan

Activity Schedule (Quarterwise: 2012-13, 2013-2014 and 2014-2015)

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

Objectives vis-à-vis Achèvements

Objectives	**Achievements**
• To develop thematic maps based on	○ Isotopic characterization ($\delta^{18}O$ and

isotope and related information relevant to the evaluation and assessment of the quality of surface water	δ^2H) of groundwater, stream and rain water ○ Groundwater dating using tritium ○ Delineation of flow direction and recharge zones using water level and tritium data ○ Hydro-chemical analysis of groundwater
• Comparative study of recession characteristics of Satluj River with conceptual and isotopic model	○ Isotopic technique has been used to separate out different component of hydrograph ○ Modelling approach has been attempted to separate out the baseflow component of stream discharge ○ Comparison of both study is under progress
• To assess the potential and limitations of the tracer techniques for routine application in hydrological studies	○ Assessment of potential of tracer techniques are under progress

Analysis and Results

Isotopic Composition of Precipitation

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

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

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

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

Isotopic Composition of River

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

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

Isotopic and Chemical Composition of Groundwater

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

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

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

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

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

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

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

In the present study, baseflow separation has been carried out using following non-tracer based methods, (i) Local Minimum Method, (ii) One Parameter Digital Filter, (iii) Eckhardt Digital, and (iv) Modified Eckhardt Digital Filter The partitioning of stream flow has been carried out using the isotopic modeling techniques. The results as well as their analysis will be presented in more details during WG meeting.

Future Plan

- Interpretation of isotope and chemical data
- Preparation of final report

11. *PROJECT REFERENCE CODE:* NIH/HID/IAEA-3/2013-15

Title of the Study : **Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains**

Study Team : Sudhir Kumar (PI), S. P. Rai, Suhas Khobragade, C. K. Jain, P. K. Garg

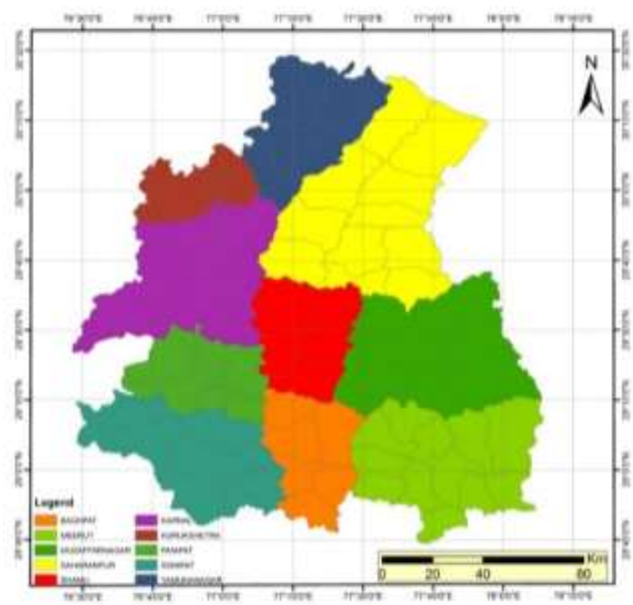
Funding Agency : IAEA, Vienna

Budget : €28,500

Duration : May 2013 to April, 2015

Location Map:

Study Objectives:



i. To identify the various aquifers present in alluvial tract of the Upper Yamuna Plains.
ii. To identify the source of recharge of different aquifers, and the interaction between various aquifers.
iii. To investigate the continuity of aquifers on both the sides of the river Yamuna,
iv. To determine the groundwater dynamics in different identified aquifers, and
v. To estimate the groundwater velocity and replenishment potential of the deeper aquifers.

Statement of the Problem:

Alluvial aquifers are primarily composed of thick unconsolidated Quaternary deposits made up of alternating sequences of sand, silt and clay in various proportions. The major part of water demand in these areas is catered from groundwater which is by and large copiously available because of potential nature of aquifers as well as adequate recharge from rainfall. Western part of the Upper Yamuna Plains has a good irrigation canal network of Western Yamuna Canal, which originates from Hathnikund Barrage in Yamunanagar District of Haryana. The unconfined aquifers in the study area are expected to be recharged by the seepage from canal network and irrigation return flow apart from the rainfall, which is the major source of recharge. The canal water originates at higher altitudes in the Himalayas has different isotopic composition ($\delta^{18}O$ and δD) as compared to the groundwater locally generated in the Upper Yamuna Plains.

Deeper aquifers in the area are supposed to be recharged from the Bhabhar zone, the coarse material deposited as alluvial fans on the margin of Himalayas. Groundwater velocity in the deeper aquifers is expected to be very slow, thus groundwater dating (^{14}C) should give an idea about the groundwater flow direction as well as groundwater velocity in the deeper Aquifers. If there is vertical recharge through the semi-confining layers, the same should be easily detected by Tritium dating.

Thus, isotope based investigations can help understanding the surface water and groundwater interactions, aquifer-aquifer interactions, groundwater dynamics and identification of recharge sources and recharge areas of deeper aquifers for taking better management strategies**.**

Objectives vis-à-vis Achievements:

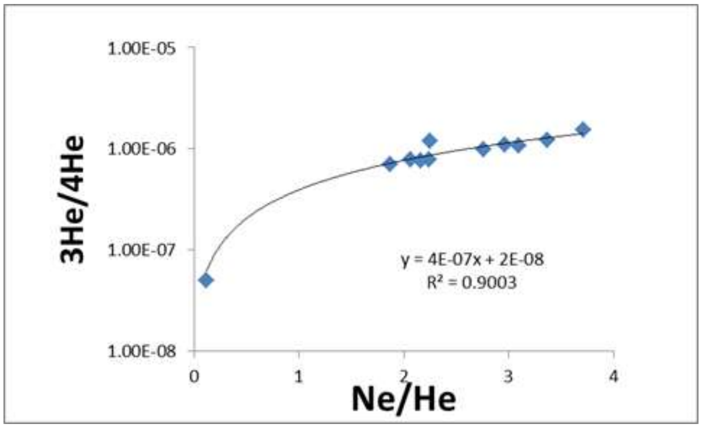
S. No.	Objective	Achievement
1	To identify the various aquifers present in alluvial tract of the Upper Yamuna Plains.	The aquifers have been identified
2	To identify the source of recharge of different aquifers, and the interaction between various aquifers.	Partially achieved
3	To investigate the continuity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

Present Status:

1. Most of the data available with CGWB has been collected.
2. Groundwater sampling from 21 wells ranging in depth from 100-420 m have been collected from UP side. 28 samples from shallow wells tapping the Ist aquifer have also been collected.
3. Analysis of groundwater and river/canal/rainfall samples for chemical and stable isotope analysis is under progress.
4. Carbon-14 and carbon-13 analysis of 14 samples has been completed
5. Noble gas analysis for 12 samples has been completed
6. Thirty One samples locations from Haryana have been collected which includes 10 locations for IIIrd aquifer, 6 locations from IInd aquifer and 15 locations from Ist aquifer
7. Construction of aquifer geometry based on available data / information has been completed

Results:

1. Deeper groundwater (Aquifer-III) in the south western part of UP side is the not being vertically recharged.
2. Good correlation between Terrigenic Helium and age of groundwater
3. Oldest ground water in the area estimated to be more than 1,00,000 years based on Helium dating.
4. There is a high temperature zone in the south and south western part of UP side study area
5. The results achieved shall be presented during the working group meeting.



Future Plan:

Activity	**Apr'16-Jun'16**
Final draft report and discussion on outcome during the meeting to be hosted by IAEA + final report submission	Report to be submitted

ITEM NO. 44.4 PROPOSED WORK PROGRAM OF THE DIVISION FOR THE YEAR 2016-17

As per the approved work program of the Hydrological Investigations Division for the FY 2015-16, 3 Internal studied, 3 sponsored projects and 8 consultancy project shall continue during the FY 2016-17. Moreover, it is proposed to start three new studies (2 internal and 1 sponsored,) w.e.f 01.04.2016.The proposed work program of the division during FY 2016-17 is given at Annexure-II.

Type of study/Project	***Continuing in Studies***	***New studies proposed***	***Total***
Internal Studies	3	2	5
Sponsored Projects	3	1	4
Consultancy Projects	8		8
Total	14	3	17

The details of the proposed new internal studies and the sponsored projects to be under taken during the FY 2016-17 are given below:

INTERNAL STUDIES:

PROJECT REFERENCE CODE: NIH/HID/INT/2016-18

Title of the Study: **Radiocarbon dating of deeper groundwater of Indo-Gangetic Basin**

Study Team: : Dr Sudhir Kumar, Sc. 'G'& Head, H. I. Division and Dr M. Someshwar Rao Sc. 'D'(PI)

Funding Agency : Internally Funded

Budget : Rs. 15.95 Lakh

Duration : $2^1/_2$

Date of Start : Apr, 2016

Date of Completion : Mar, 2019

Study Objectives **:**

The objectives of the study are:

i. Development of ^{14}C dating system
ii. Preparing manual of 'Procedure of Radiocarbon dating analysis in NIH'
iii. Dating old groundwater as inferred from tritium dating using ^{14}C dating technique and re-interpretation of the data.

Preamble:

Radiocarbon dating of groundwater has a special place in groundwater hydrology because of its applicability over a dating range from few hundred years to several tens of thousands years over which alternative dating tools are either not available or are order of magnitude costlier than ^{14}C dating and that (costly) alternative dating tools are available only in few laboratories across the world. The radiocarbon age data is useful in identification of paleo-waters, groundwater flow direction in deeper aquifers, hydraulic connectivity between deep & overlying aquifers etc. NIH has developed its radiocarbon dating glass line in the year 1998-1999 and has been used in dating a few important groundwater systems including paleo-groundwater in Krishna Delta region. Due to wear & tear in past 15 years, the glass line performance has deteriorated substantially, chemicals have expired their shelf life, primary standards procured from IAEA got exhausted and vacuum seals of vacuum line lost its vacuum holding strength. Therefore, a fresh new radiocarbon dating line will be developed to restart ^{14}C dating in NIH. Over the past 15 years, in various investigations, NIH has discovered old groundwater in western UP, Punjab, Haryana, NCT- Delhi, in coastal aquifers and in other parts of the country. Groundwater at these sites was found of age beyond the applicable upper age limit of tritium dating technique. Most of these sites and those that will be observed in due course of investigations that will be found beyond the upper age limit of tritium dating technique will be examined using the proposed radiocarbon dating system and the observed results will be used in refining the previous interpretation. With this pre-amble it is proposed to develop radiocarbon dating line and examine old groundwater system that were identified in the past investigations and those which will be observed in the future research studies.

Research outcome from the project:

- Upgraded ^{14}C radiocarbon dating system
- Procedure Manual for radiocarbon dating analysis in NIH
- Radiocarbon ages of old groundwater which could not be dated in previous project due to non-availability of radiocarbon dating technique
- Radiocarbon dating of important water samples in the ongoing projects in NIH.

Cost estimates:

a. Total cost of the project : Rs. 27,50,000/-
b. Source of funding: Internal
c. Sub Headwise abstract of the cost

Sl. No.	**Sub-head**	**Amount (in Rupees)**			
		1st Year	2nd Year	3rd Year	Total
1.	Salary:	3,00,000	3,30,000	3,60,000	9,90,000
2.	Travelling expenditure	1,50,000	1,50,000	1,30,000	4,30,000
3.	Minor Equipments & imported items	2,00,000	1,00,000	1,00,000	4,00,000
4.	Consumables	60,000	1,00,000	80,000	2,40,000
5.	Misc. expenditure	50,000	50,000	40,000	1,40,000
6.	Workshops		2,50,000	3,00,000	5,50,000
	Sub- Total:	7,60,000	9,80,000	10,10,000	27,50,000

Justification for Sub-head-wise abstract of the cost

Salary: One Resource Person will be recruited to assist PI in fabrication, installation and calibration of 14C dating line. He will also support PI in procurement of standards and chemicals, groundwater sampling and radiocarbon dating of the collected water samples.

Travelling Expenditure: This includes travel from NIH, Roorkee to study area once in each year for collecting samples, for visit to other laboratories for inter-laboratory comparison, travel to Delhi/Ambala etc in purchase and fabrication of 14C dating line items and for any travel related to this project.

Minor Equipment & imported items : The study involves development of custom made glass line for carbon dioxide preparation from water samples, gas storage units, Dewar flasks, purchase of units for generating vacuum & vacuum/pressure measurement units & gauge, imported glass valves, imported chemicals, radiocarbon standards & ‘O’-rings, G-4 sintered discs, gas absorption units & storage cylinders, clamps, jacks, holders, etc

Consumables: Teflon vials, chemicals, glassware, plastic ware, filters, other laboratory consumables and stationary.

Miscellaneous Expenditure: For fabrication of items using NIH workshop facility and for any unforeseen expenditure for smooth execution of the project

Work Schedule: Three years (Apr’16 to Mar’19)

Sl. No.	Work Element	Months					
		1-6	7-12	13-18	19-24	25-30	30-36
1	Procurement of imported items and items from within India for	✓	✓				

	fabrication & development ^{14}C line						
2	System installation, calibration and running of dummy samples		✓				
3	Sample collection & radiocarbon dating		✓	✓	✓	✓	
4	Interim report		✓		✓		
5	Workshop				✓		✓
	Final report						✓

PROJECT REFERENCE CODE: NIH/HID/INT/2016-18

Title of the Study : Isotopic Investigations in parts of Upper Yamuna River Basin

Study Team : S. K. Verma (PI), Sudhir Kumar, S P Rai, Mohar Singh Vishal Gupta

Type of Study : Internal

Duration of study : Two years

Date of Start : April 2016

Date of Completion : March 2018

Study Area : Parts of Upper Yamuna Basin

Study Objectives:

- To assess radon concentration in groundwater
- Isotopic (δ^2H & $\delta^{18}O$) characterization of groundwater
- To study strontium in deep groundwater
- To indentify the geothermal zones and its impact on isotopic composition

Present state-of-art:
During the last 40 years large scale groundwater abstraction, particularly in the north western states of Punjab, Haryana & Uttar Pradesh has taken place due to increase in irrigation requirements. As a result of this, groundwater depletion of this region has become under the vulnerable condition and a hot spot for groundwater management. The groundwater depletion rates in the states of northwestern India are reported highest in comparison to other parts of world. There is a major task to replenish the groundwater depletion through rainfall recharge. In this connection, NIH has initiated an isotopic investigations in parts of upper Yamuna river basin through a project entitled “Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains” funded by IAEA. The preliminary investigations carried out under this project indicated that the temperature is more than 30 ^{0}C in some parts of Western Uttar Pradesh. Therefore, the detailed isotopic investigations are required to investigate the source and cause of this thermal groundwater occurring in parts of Western Uttar Pradesh.

Methodology:

In order to study the radon concentration in the study area at different locations, groundwater samples from shallow as well as deeper aquifers will be collected for in-situ radon measurement. Spatial variation of radon concentration in groundwater will be studied. The groundwater samples from shallow/deeper aquifers for existing hand pumps, open wells and tube wells will also be collected for stable isotopes & strontium analysis to study their variations. The hydro-geological data will also be collected for the study area in order to study the hydro geological features to be linked with the radon concentration in groundwater.

Research outcome from the project:

i. Generation of data base for radon concentration, strontium & stable isotopes (δ^2H & $\delta^{18}O$)
ii. Publication of report and research papers

Cost estimate:

a) Total cost of the project: 6,50,000/-
b) Source of funding: Internal
c) Sub head-wise abstract of the cost

Sl. No.		Amount (in Rupees)		
	Sub-head	2016-2017	2017-2018	Total
1.	Salary			
2.	Travelling expenditure	1,00,000.00	1,00,000.00	2,00,000.00
3.	Infrastructure/Equipment	50,000.00	50,000.00	1,00,000.00
4.	Experimental charges	1,00,000.00	1,00,000.00	2,00,000.00
5.	Misc. expenditure	75,000.00	75,000.00	1,50,000.00
	Grand Total:	3,25,000.00	3,25,000.00	6,50,000.00

Justification for Sub-head-wise abstract of the cost: as above
Travel (Rs. 2,00,000/-): The fund is required for travelling to the study area for survey for selecting sites, sample collection for pre-monsoon and post monsoon seasons
Experimental Charges: An amount of Rs. 2,00,000/- will be required for procurement of chemicals, glasswares and plastic wares required for analysis of water samples.
Infrastructure/Equipment: Rs. 1,00,000/- will be required to procure small instruments like EC, pH meter etc.
Miscellaneous expenditure (Rs. 1,50,000/-): The fund is required for hiring of daily wages worker and other contingencies etc.

Quarterly Break up of cost estimate for each year:

Year: 2016-2017

Sl.No.	Sub-head	Amount (in Rupees)			
		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1.	Salary	-	-	-	-
2.	Travelling expenditure	25,000.00	25,000.00	25,000.00	25,000.00
3.	Infrastructure/Equipment	-	25,000.00	-	25,000.00
4.	Experimental charges	25,000.00	25,000.00	25,000.00	25,000.00
5.	Misc. expenditure	-	25,000.00	25,000.00	25,000.00
	Sub- Total:	50,000.00	1,00,000.00	75,000.00	1,00,000.00
	Grand Total	3,25,000.00			

Work Schedule:

d. Date of commencement of the project: April 2016
e. Duration of the project: April 2016 to March 2018 (2 years)
f. Stages of work and milestone:

Action Plan

Sr. No	Activity	April 2016 to March 2018							
		1st Q	2nd Q	3rd Q	4th Q	1st Q	2nd Q	3rd Q	4th Q
1.	Review of literature, Collection of hydro-geological data/information for the study area etc.	♦	♦						

2.	Preparation of index map of study area, selection of locations/sites for experimental works etc.	♦	♦						
3.	Collection of water samples for radon measurement, stable isotopes and strontium analysis & Analysis of radon		♦	♦	♦	♦			
4.	Lab. analysis of groundwater samples for stable isotopes and Strontium		♦	♦	♦	♦	♦	♦	
5.	Interpretation of isotopic data						♦	♦	
6.	Preparation of interim report/Part-1				♦				
7.	Final report								♦

Data requirements & Expected source:

- Information of wells located in the study area along with location map (CGWB and/or any other state organization)
- Lithologs of wells (CGWB and/or any other state organization)
- Water level data of the wells (CGWB and/or any other state organization)

List of deliverables: Data base on radon concentration, strontium and stable isotopes (δ^2H & δ^{18}O).

IPR potential and issues: Nil

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

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

Major items of equipment needed: None

SPONSORED PROJECT

PROJECT REFERENCE CODE: NIH/HID/SPON/2016-21

Title of the Study:	**Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques**
Study Group:	
(a) PI :	Dr. S. P. Rai, Sc. 'E',
(b) Co-PI:	Dr. Sudhir Kumar, Sc. 'G', Rajesh Singh, Sc. 'B', S. D. Khobragade, Sc. 'E', Dr. M. Arora, Sc. 'D', Dr. R. J. Thayyen, Sc. 'D' and Mr. P. K. Garg, Sc. 'B'
Staff:	Mr. Vipin Agrawal (SRA), Rajeev Gupta (SRA), Raju Juyal (RA), Mr. Vishal Gupta (RA), Mr. Mohar Singh (Sr. Tech.)
Type of Study	DST, Govt. of India
Budget:	Rs. 1.77 Crores
Duration:	5 Years
Date of Start:	April 2016
Date of Completion	March 2021

Budget:

Study Objectives:

- **a)** Isotopic characterization of precipitation and identification of sources of vapour
- **b)** Runoff generation processes in headwater region of Ganga using isotope and modeling
- **c)** Spatial and temporal variation of snow and glacier melt in Ganga and its major tributaries.
- **d)** Contribution of transient groundwater and its role in sustainable flow of Ganga.
- **e)** Groundwater dynamics in 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 serious environmental degradation and climate change. Continuing climate change is predicted to lead to major 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 dramatic affected, although not the same in terms of rate, intensity, or direction in all parts of the region. Therefore, a thorough understanding of hydrological processes operating all along the Himalayan region is a fundamental requirement.

Studies conducted worldwide during last few decades have established that stable oxygen and hydrogen isotope ratios provide useful tools for hydrological investigations in mountainous area. Classical approach used to study the hydrological processes can be strengthened through tracing isotopic signature of water molecules. Since, primary input of water on land is precipitation. The isotopic signatures of source and subsequent partitioning into stream flow, subsurface flow, spring/groundwater recharge processes, etc., though occurring on a local scale and over small time intervals get integrated both temporally and spatially as water from different parts of the catchment originating at different times accumulate and mix through operative hydrological processes, provide valuable information about different hydrological processes. Therefore, isotopes of well-mixed environmental reservoirs, such as the atmosphere, glacial melt, streams and aquifers, often represent an integration of source inputs to the system that extend over large spatial scales. Thus, isotopes indicate, record, integrate and trace water movement and hydrological process from small geographic scales (meters to hectares) and short temporal scales (minutes to hours) to large spatial scales (regions and the globe) and long temporal scales (decades to centuries). The partitioning of the different component of stream runoff can be done. Therefore, isotopic data on water sources at different spatial and temporal scales can be used to calibrate hydrological models, to provide internal quantitative check on the assumptions of various hydrological models.

It can be achieved through investigating stable isotopic composition (oxygen isotopes - ^{16}O and ^{18}O; and hydrogen isotopes-^{1}H and ^{2}H or D) of water molecules in different components of hydrological cycle in conjunction with volume and flux data. Environmental radio tracers (^{3}H, & ^{14}C etc) will be use to trace the residence time, flow velocity and age of the groundwater along with stable isotopes also. Study area for the present study will be upto Rishikesh

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

Study Area: Study area covers upper Ganga basin up to Rishikesh

Methodology:

- Field investigations of the study area
- Hydro-geological investigations of the study area using the past data
- Stable isotopic analysis of precipitation, glacier, river and groundwater
- Tritium and Carbon-14 dating to determine the age of the groundwater
- Delineation of drainage and preparation DEM using remote sensing and GIS
- Application of SNOWMOD and SRM models
- Analysis of the results

Action plan & time line: (Quarter wise, for 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 of sample for stable and radio isotope		√	√	√	√	√	√	√		
Compilation of data, interpretation and analysis					√	√	√	√	√	
Organisation of training course				√		√		√		

and workshop										
Preparation of final report										√

Data requirement & Expected source:

Meteorological data (i.e., rainfall, maximum minimum temperature, sunshine hours, relative humidity, solar radiation etc), Discharge data and hydrogeological data are required. Meteorological data would be purchased from IMD. The geological information's will be collected from the GSI/CGWB and state groundwater cell. The discharge data will be collected from CWC. Isotope and other related data will be generated in the field and lab.

List of deliverables:

Reports and papers will be delivered on following aspects

1. Understanding of Runoff generation processes in head water region of Ganga basin.
2. Assessment and snow/glacier melt contribution in mountainous region of Ganga basin with time and space
3. Role of groundwater contribution in sustaining the discharge of Ganga river and its tributaries.
4. Development of methodology for the sustainable development of springs through understanding the mechanism of recharge and discharge processes of the springs
5. Identification of source of precipitation

IPR potential and issues: NIL

Involvement of End Users/beneficiaries:
The beneficiaries of the study would be the water resource planners and managers of water resources of the study area apart from the academicians.

Specific linkages envisaged with Institutions and/or other NGOs: Sharing of data with central and state government organization and NGOs of the study area

Major items of equipment needed: None

SURFACE WATER HYDROLOGY DIVISION

Scientific Manpower

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

Work Programme for the year 2015-2016

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

1. NIH/SWHD/NIH/12-15

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

Study Group:

Dr. A.K. Lohani, Scientist 'G' Surface Water Hydrology Division, PI Data Collection, Data Processing, Data Analysis, Simulation, Interpretation of results etc.
Dr. Surjeet Singh, Scientist 'D', Ground Water Hydrology Division, Co-PI Data Collection, Data Processing, Simulation
Rahul Jaiswal, Scientist 'C' & Ganga Plains Regional Centre, Bhopal, Co-PI Data Collection, Data Processing, Simulation Officers from Water Resources Department, Chhattisgarh
D. K. Sonkusale, Water Resources Department, Raipur- Data Collection
Akilesh Verma, Water Resources Department, Raipur- Data Collection

Type of study: Internal

Date of Start: April 1, 2013

Date of Completion: September, 2015

Statement of Problem

The management of water resources requires integration of large volumes of disparate information from diverse sources. An efficient and easy to use framework is required to couple this information with hydrological modelling tools for assessment and evaluation that allow broad, interactive participation in water resources planning and decision making process and effective methods of communicating results to a broader audience. Better and useful information needs to be made available to a larger number of participants in more open and participatory decision making and this information is to be effectively integrated into decision making processes. It is a challenge to integrate new information technologies with traditional methods of analysis and to put these tools to work in practice. A Decision Support System (DSS) helps in attaining this objective. DSS (planning) developed under Hydrology Project-II pertains to a decision support system for integrated water resources development and management. The proposed study will demonstrate the implementation steps and applicability of the DSS (P) for a selected basin.

Objectives:

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

The Study Area

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

Analysis and Results:

Already the MIKE-HYDRO Model has been setup for the basin and interim report has been submitted. Data related to existing cropping system and irrigation is not yet provided by the State Water Resources Department. However, the study has been carried out by considering the cropping pattern generally adopted in that region. The study has been completed by considering various cropping scenarios and water availability cases.

Action Plan

Task	Apr. -Sep. 2013	Oct.-Mar. 2013	Apr.-Sep. 2014	Oct. 2014-Feb. 2016	Status
Identification of the study basin	═══				**Identifying the basin in consultation with Chhattisgarh WRD**
Data Collection & Processing	═══				**Completed**
Rainfall-Runoff Modelling using NAM	═══	═══			**Completed**
Implementation of Mike Basin		═══	═══		**Completed**
Scenario generation using DSS(P)			═══	═══	**Completed**

Deliverables

Reports and research papers

2. NIH/SWHD/NIH/13-15

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

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

Study Group Dr. Sanjay Kumar, Sc-D, PI
Dr. Sharad Jain, Sc-G & Head WRSD, Co-PI

Date of Start: April 2013

Schedule date of Completion: March 2016

Objectives of the study:

The objectives of the study are:

1. To estimate uncertainty in river discharge observations.
2. To estimate uncertainty in the stage-discharge (rating) relationship.
3. To estimate uncertainty in stage- discharge relationship using slope as a parameter (back water effects).

Statement of the problem:

The uncertainty in the river discharge measurement and estimation is caused by different sources of errors. These mainly includes uncertainty in (a) observations of river stage and discharge used to parameterize the rating curve, (b) presence of unsteady flow conditions, and (c) interpolation and extrapolation errors of the rating curves. The study will provide a framework for analyzing and quantifying the uncertainty in the (i) river flow data (ii) stage-discharge relationship and (iii) stage-slope-discharge relations (for backwater effects) based on the ISO documents GUM (Guides to the expression of Uncertainty in Measurement), HUG (Hydrometric Uncertainty Guidance), ISO 773, 5168, 7066 and 768. The study will also examine various hydraulic factors controlling the flow at a cross section in the river and provides an understanding of independent variables that describes relations among stage, discharge and other parameters specifically discharge measurement under back water effects.

Methodology:

Statistical methods/tools and the procedures described in various ISO documents (GUM, HUG) will be used for the estimation of river discharge uncertainties. The uncertainty in discharge measurement (assuming velocity area method) will be quantified as per the ISO 748 which provides the magnitude of these errors at 95% confidence level. The GUM defines the law of propagation of errors for combining uncertainties from several sources and HUG described it for different types of mathematical expressions generally used in hydrometry. This is illustrated by considering the quantity Q as a function of several measured quantities x, y, z. The error δQ in Q due to errors δx, δy, δz…. in x, y, z…., respectively, is given by

$$\delta Q = \frac{\partial Q}{\partial x}\delta x + \frac{\partial Q}{\partial y}\delta y + \frac{\partial Q}{\partial z}\delta z + \cdots$$

The uncertainty of a discharge measurement determined from a stage-fall-discharge rating function (as opposed to a gauged discharge which is determined from a current meter) shall be evaluated using statistical equations based on law of propagation of errors described above. Let

X_{rd} be the uncertainty in the recorded discharge, the above error equation is then modified for uncertainty in discharge compution using stage-fall-discharge relationship as

$$X_{rd}=\pm(X_{\alpha}{}^{2} + \beta^2 X^2 h_{u/s-h0} + \gamma^2 X^2{}_{hu/s-hd/s})^{1/2}$$

In practice, X_α is the standard error of the mean relation ($S_{mr)}$. $Xh_{u/s-h0}$ is the standard error of upstream gauge and $X_{h\ u/s-h\ d/s}$ is the standard error of fall between the u/s and d/s gauges.

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

Cost estimate for the FY 2015-16 (completed)

a. Total cost of the project:
b. Source of funding: Internal
c. Sub head-wise abstract of the cost

S.N.	**Sub-head**	**Amount (in Rupees)**
1.	Salary	24,60,000.00
2.	Travelling expenditure (domestic/international)	100,000.00
3.	Infrastructure/Equipment	100,000.00
4.	Experimental charges	00.00
5.	Misc. expenditure	50,000.00
	Grand Total:	27,10,000.00

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

In the year (2015- 16), technical services of Sc 'G' and Sc 'D' will be utilized for the achieving the targets. Domestic and international travel for attending various meeting of OSO and BIS related to revising the ISO 9123 document. Availing/procuring computing facilities in the institute and miscellaneous contingencies.

Quarterly Break up of cost estimate for each year (FY 2015-16)

S.N.	**Sub-head**	**Amount (in Rupees)**			
		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1.	Salary	615000.00	615000.00	615000.00	615000.00
2.	Travelling expenditure	25,000.00	50,000.00	25,000.00	00.00
3.	Infrastructure/Equipment	25,000.00	75,000.00	00.00	00.00
4.	Experimental charges	00.00	00.00	00.00	00.00
5.	Misc. expenditure	10,000.00	20,000.00	10,000.00	10,000.00
	Sub- Total:	6,75,000.00	7,60,000.00	6,50,000.00	6,25,000.00
	Grand Total	**27,10,000.00**			

Note:

(i) The above table has to be prepared for each year of the project period

(ii) PI has to submit the revised table to the Finance Officer for the subsequent year (on or before 15th March of current year) considering the actual expenditure incurred during the current year

Action plan and timeline and progress:

S.N.	**Major Activities**	**1st Year**	**2nd Year**	**3rd Year**

1	Literature review including related various ISO standards						
2	Estimation of uncertainty in river discharge measurements (Interim Report-1)						
3	Estimation of uncertainty in stage-discharge (rating) relationship using slope as a parameter (back water effects) (Interim Report-2)						
4	Estimation of uncertainty in stage-discharge (rating) relationship. (Interim Report-3)						
5	Preparation of final report						

Progress:

(i) The comments from experts (nominated by SC1 member bodies) on the working draft of the ISO 9123 were discussed in a meeting held on 26Th May, 2015 in Tokyo, Japan. Accordingly collated comments and decisions taken in the meeting were communicated to member bodies for necessary actions.

(ii) A revised Draft International Standard (DIS) has been prepared incorporating the suggestions/comments of the experts and submitted to BIS/ISO (18th January, 2016) for further review of the member bodies.

3. NIH/SWHD/NIH/13-16

Title of the study: **Evaluation and modeling of hydrological support system for Watersheds of Garhwal, Uttarakhand hills.**

Study Group: Dr. Avinash Agarwal, Scientist 'G' (PI),
Dr. Manohar Arora, Scientist 'D', (Co PI),
RK Nema (PRA)

Type of study : Internal

Date of Start: Nov 2013

Schedule date of completion: Oct 2016

Role of team members

1. **Dr. Avinash Agarwal (PI):** Field visits, collection of electronic data, processing and plotting of data. Analysis of rainfall, runoff spring flow data. Development of implement able technology for water availability and transfer. Progress, presentation and final reporting.
2. **Dr. Manohar Arora (Co PI):** Field visits. Assessing in collection of electronic data and in development of implement able technology for water availability analysis. Presenting theb progress of work when required. Transfer of technology
3. **Sh. R K Nema (PRA):** Field visits. Collection of tabulated data. Keeping the record of skilled and unskilled daily wages. Proper running of all field instrument and observatory. Visits of the sites for its proper up date. Assessing in transfer of technology

Location of study area

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

Objectives of the study:

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

Statement of the problem:

The monitoring continued with a network of instrumentation for watersheds (Chandrabhaga, Danda) with Rainfall (08 locations), runoff (3 locations), AWS One location for rainfall, temperature, humidity, wind speed & direction incoming radiation, pan evaporation and soil moisture (different depths), soil temperature (two depths). Daily spring flow of around twenty locations in each watershed is measured. The spring flow models will be developed considering topographic and hydrologic information. A long term spring flow record for springs is developed for climatic variability of the springs and for evaluation of spring flow with time.

Recommendation and suggestions in previous meeting of working group

Discussions were held with following comment/recommendation.	
▪ NIL	▪

Analysis of results

Objectives of the study were completed and presented in 43 working group meeting. Data collection will be continued till October 2016. Report preparation is in progress.

List of deliverables	Hydro-meteorological data, papers and report for small watershed of Uttarakhand.
Major items of equipment procured	Nil
Lab facilities used during the study	Nil
Data procured and /or generated	Soil data of UP and Uttarakhand (procured) Spring flow (generated)
Study benefits/impacts	Hill habitat, State Government and other agencies.
Specific linkage with institutions and/or end-users/ beneficiaries	Village wise interactive workshops in the watershed are proposed
Shot comings/ difficulties	Nil
Future plan	Report writing and data collection

4. NIH/SWHD/NIH/13-16

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

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

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

Objectives of the study:

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

Statement of the problem:

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

Study area:

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

Present state of art:

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

Fig. 1: study area

Methodology

SWAT, one of the most recent models developed by the USDA, is used to analyse and quantify the monthly water balance of the Yerrakalva river basin. The model has been chosen as SWAT is an integrated river basin scale, physically based, continuous-time, long-term simulation, distributed watershed model. Also, its suitability to different parts of the world has been well established. The SWAT model uses physically based inputs such as weather variables, soil properties, topography, land use characteristics and land-management practices occurring in the catchment. The hydrologic cycle as simulated by SWAT is based on the water balance equation. Model outputs all water balance components (surface runoff, evaporation, lateral flow, recharge, percolation, sediment yield, etc.) at the level of each watershed and are available at daily, monthly or annual time steps.

Work schedule:

(a) Date of commencement of the project: April 2014
(b) Duration of the project: Two Years

Progress

SWAT was set up for the study basin by dividing the basin in to 19 sub-basins. The Yerrakalva reservoir located in basin was also incorporated in the model set up.
The model was calibrated and validated using monthly flows observed at Ananathapalli gauging site. The monthly water balance was computed for each of the sub-basin as well as for the entire basin.

The study is complete.

Research Outcome from the project:

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

5. NIH/SWHD/NIH/14-15

Title of the study: **Hydrological modelling of Brahmani Baitarani river basin using eWater Source platform**.

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

Duration of study: 3 Years (April 2014 to March 2017) : Ongoing

Type of study: Internal.

Location map

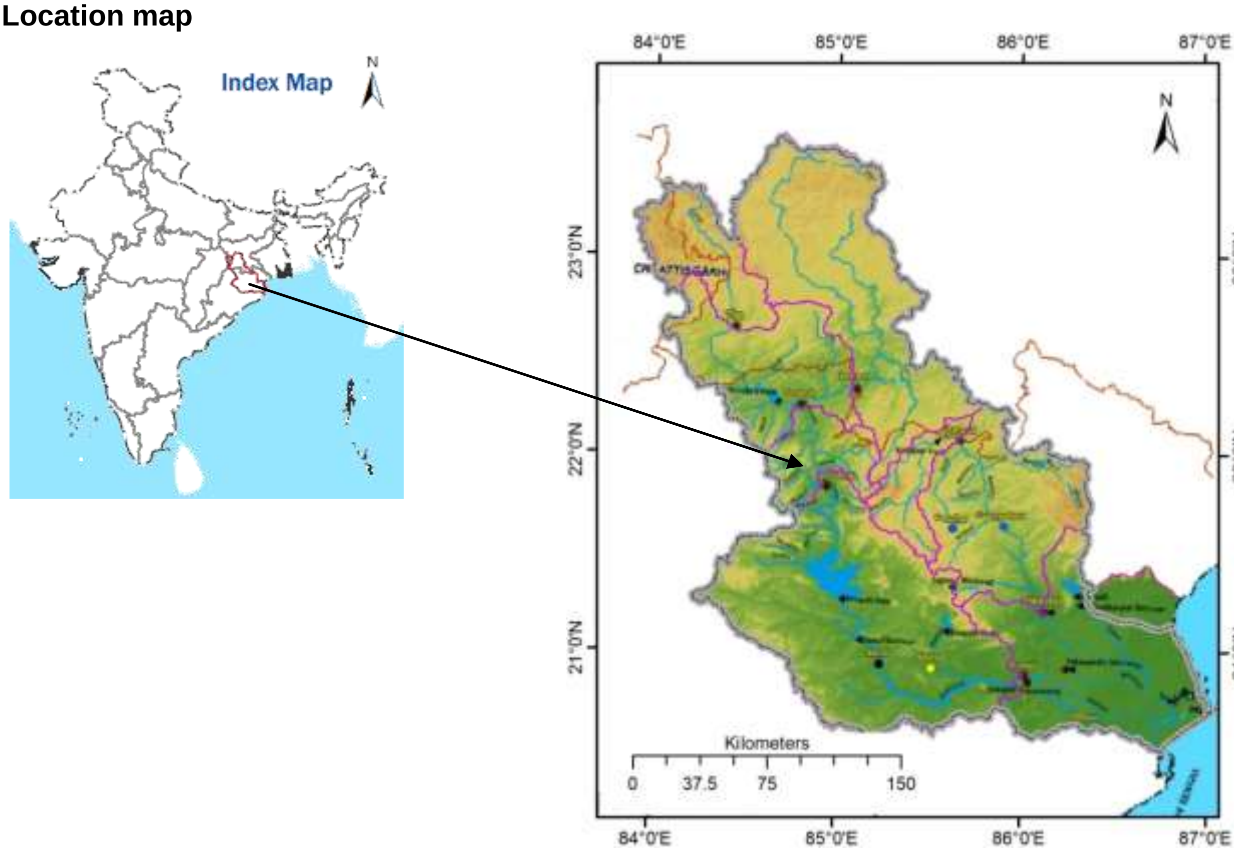


Fig. 1: Location map of study area.

Study objectives:

a) Statistical and trend analysis of rainfall and river discharge in Brahmani Baitarani river basin.
b) Development of rainfall runoff model for Brahmani Baitarani river basin using eWater source platform.
c) Investigation of implications of different rainfall inputs on rainfall–runoff simulation.
d) Test the applicability of the eWater source modelling platform in Brahmani Baitarani river basin by generating hydrological time series.

Statement of the problem

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

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

Approved action plan and timeline

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

Role of team members

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

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

Brief Methodology

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

Historical rainfall and flow data of the Brahmani Baitarani river basin are collected and time series of monthly, seasonal and annual values of rainfall and discharge will be analyzed using statistical methods. Trend analysis will be performed to determine whether or not there have been any significant changes in rainfall and discharge over this catchment. The analogue year's plots are used to identify years with near normal, above normal and below normal conditions, using the long term mean of the variables. Further, the daily rainfall data of .25°×.25° obtained from IMD for the period 1901 to 2013 and ET data from Terrestrial Hydrology Group, Princeton University from 1948 to 2008 are used for rainfall runoff modelling.

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

Different methods are available to obtain the daily rainfall time series for conceptual rainfall–runoff models, depending on data availability, time constraints etc. The implications of different rainfall inputs on the calibration and simulation of rainfall–runoff models will be analysed. First, the simulated runoff resulting from single lumped daily rainfall series for each catchment obtained from three methods: single rainfall station, thiessen average, and average of interpolated rainfall surface will be compared. Secondly, runoff generated from catchment modelling using daily/monthly rainfall series and modelling with smaller functional units within a sub catchment will be compared. The source platform includes set of optimisation tools for calibration of various model parameters. These high-level optimisation features include: Shuffled Complex Evolution (SCE-UA), multi-objective complex evolution (MOCOM-UA), Rosenbrock and other optimisation algorithms; predefined and user defined custom objective functions; option for custom optimisation problems such as regional calibration. Some of these techniques will be applied to calibrate the model. Finally, the calibrated model will be used to simulate hydrological time series for various time periods and will be compared with observed time series to test the applicability of the eWater source modelling platform in Brahmani Baitarani river basin.

Results achieved with progress/present status

During the previous four months catchment modelling of Brahmani Baitarani river basin in eWater source platform being developed. The rainfall runoff model is being setup with daily rainfall data of .25°×.25° obtained from IMD and ET data from Terrestrial Hydrology Group, Princeton University. The model calibration is being carried out with gauged sub catchments represented by a small proportion of the basin. Various objective functions viz. NSE Daily, NSE Monthly, NSE Monthly & Bias Penalty, NSE Daily & Flow Duration, NSE Daily & log Flow Duration, Minimise Absolute Bias, NSE Daily & Bias Penalty etc. are used to for calibration model. Further optimization algorithm like Shuffled Complex Evolution (SCE), Uniform Random Sampling (URS), Rosenbrock, SCE then Rosenbrock etc are evaluated for their performance. It is observed that SCE and SCE then Rosenbrock provide beat modelling efficiency. However, in case of SCE then Rosenbrock, the variability among different simulation runs are found to be minimum. Comparison of simulated discharge obtained from various model viz. GR4J, Sacramento and SimHyd with observed discharge are shown in Figure 2. It is found that the GR4J model has performed better in comparison to other model for this basin. Further it has only four parameters to calibrate, which also reduces uncertainty. Further, the exercise with available daily point rainfall data is being carried out.

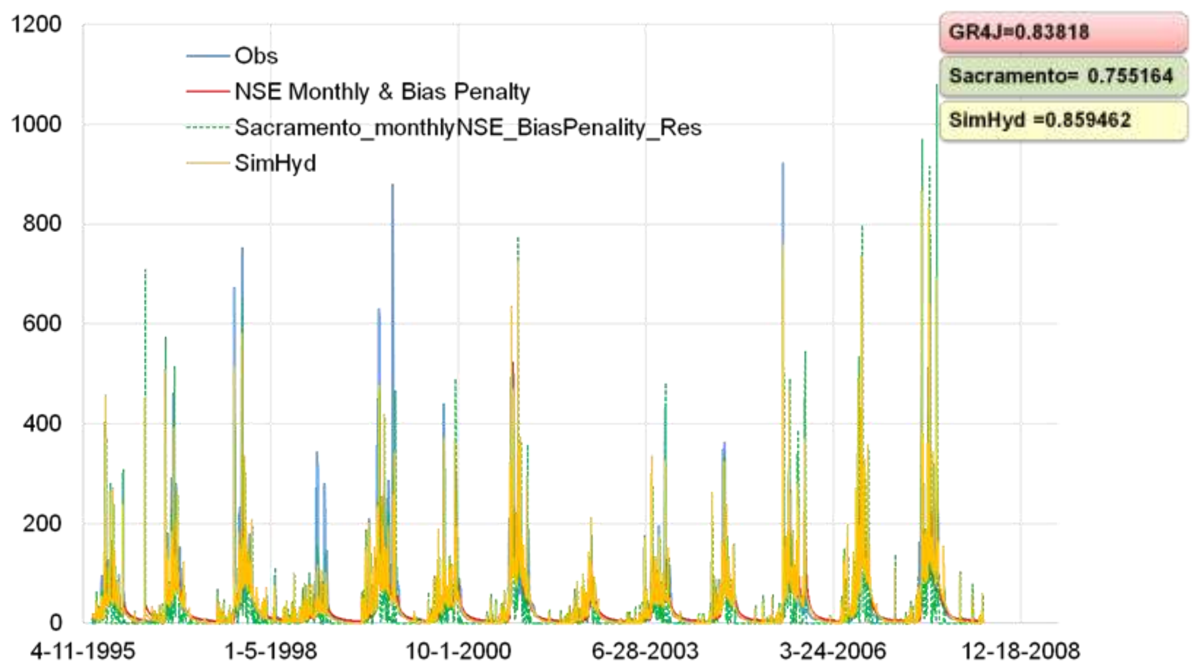


Fig. 2: Observed and simulated discharge.

Action taken on comments of previous working group meeting

There were no specific comments.

List of deliverables

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

Data collected/generated

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

Involvement of end users/beneficiaries

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

6. NIH/SWHD/NIH/14-17

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

Study Group:

1. Dr. Archana Sarkar, Sc D, SWHD (PI)
2. Sh. N.K. Bhatnagar, PRA, SWHD
3. Dr. Vaibhav Garg, Sc C, IIRS, Dehradun
4. Dr. Rakesh Kumar, Sc G & Head, SWHD

Type of study: Internal

Date of start: April 2014

Scheduled date of completion: September, 2017

Study area

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

Uttarakhand has a total area of 53,484 km^2, of which 93% is mountainous and 65% is covered by forest. Most of the northern part of the state is covered by high Himalayan peaks and glaciers. Uttarakhand lies on the southern slope of the Himalaya range, and the climate and vegetation vary greatly with elevation, from glaciers at the highest elevations to subtropical forests at the lower elevations. The highest elevations are covered by ice and bare rock. Below them, between 3,000 and 5,000 metres (9,800 and 16,400 ft) are the western Himalayan alpine shrub and meadows. The temperate western Himalayan sub-alpine conifer forests grow just below the tree line. At 3,000 to 2,600 metres (9,800 to 8,500 ft) elevation they transition to the temperate western Himalayan broadleaf forests, which lie in a belt from 2,600 to 1,500 metres (8,500 to 4,900 ft) elevation. Below 1,500 metres (4,900 ft) elevation lie the Himalayan subtropical pine forests. The Upper Gangetic Plains moist deciduous forests and the drier Terai-Duar savanna and grasslands cover the lowlands along the Uttar Pradesh border in a belt locally known as Bhabhar. These lowland forests have mostly been cleared for agriculture, but a few pockets remain.

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

Objectives of the study

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

Statement of the problem

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

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

Approved action plan and timeline

Year	April - June	July-Sept	Oct-Dec	Jan-March
2014-15	Additional rainfall data procurement, data processing	Additional rainfall data procurement, data processing	Trend Analysis of historical rainfall data	Interpretation of results and preparation of interim report-1
2015-16	Downloading APHRODITE data.Trend Analysis of historical rainfall data (different rainfall intensity	Downloading of TRMM satellite data and processing of downloaded data	Statistical analysis and comparison of data from different sources	Interpretation of results and preparation of interim-2

	series)			
2016-17	Comparison of rainfall data from different sources using a hydrological model	Comparison of rainfall data from different sources using a hydrological model	Comparison of rainfall data from different sources using a hydrological model	Preparation & Submission of Final Report

Progress

Objectives	Achievements
April 2015- March 2016	
1. Trend Analysis of historical rainfall data (different rainfall intensity series)	Completed
2. Downloading of TRMM satellite data and processing of downloaded data	Completed
3. Statistical analysis and comparison of data from different sources	Partially completed
4. Interpretation of results and preparation of interim-2	In progress

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

Analysis and results

Data Used
Daily rainfall gridded data from APHRODITE and TRMM for 10 stations in Uttarakhand.

Results

TRMM daily rainfall data for ten stations namely, Almora, Bageshwar, Haridwar, Joshimath, Munsiyari, Pithoragarh, Rudraprayag, Rudrapur, Tehri, and Uttarkashi has been downloaded and processed. Annual and seasonal trend analysis has been carried out with TRMM data. Comparison of data from different sources (observed, APHRODITE & TRMM) is being carried out.

Expected adopters
State Water Resources Dept and other agencies.

Deliverables
Research papers and report

Data procured and/generated during the study
Daily rainfall data at 50 rain gauge stations around Uttarakhand State with varying length.

Future plan
As per the approved action plan.

7. NIH/SWHD/NIH/14-17

Title of the Study: **Monitoring and Modelling of Streamflow for the Gangotri Glacier**

Study Group : Dr. Manohar Arora Sc 'D'
Dr. Rakesh Kumar Sc 'G' & Head SWHD

Role of Team Members:

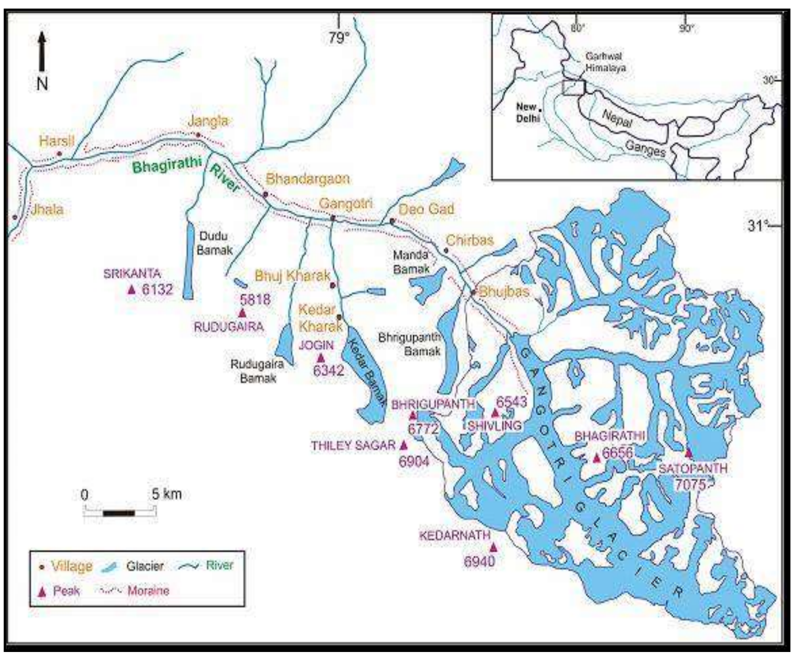
1. Dr. Manohar Arora, (PI): Conduction field investigations, analyzing data/information, report preparation and overall responsible for the study completion.
2. Dr. Rakesh Kumar, (Co-PI): Guidance in development of methodology, modelling and structuring of report.

Type of Study : Sponsored

Date of start : 01.5. 2014

Scheduled date of completion: 31.03.2017

Location Map:



Objectives: The objective of this study includes:

- Continuous observations of meteorological, hydrological and suspended sediment data for the melt season to determine monthly and seasonal specific water and sediment yield from the study glacier.
- To study the melt water storage and drainage characteristics of the glacier and to simulate daily streamflow using a conceptual hydrological model using observed meteorological and hydrological data.
- Modeling the role of glacier in catchment runoff variation.
- Modeling the catchment runoff variation under different climatic scenarios.

Statement of the problem: The study involves collection and analysis of hydro-meteorological and discharge data of the glacier site. The second step is to develop and apply a snow melt model for stream flow generation and identification of different runoff components. The third step is to model role of glacier in catchment runoff variation and catchment runoff variation under different scenarios.

Approved action plan:

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

Objectives vis a vis Achèvements:

Objective	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 collected in summer 2015 was processed and analysed. The results were presented before the Working Group Experts
To study the melt water storage and drainage characteristics of the glacier and to simulate daily streamflow using a conceptual hydrological model using observed meteorological and hydrological data.	The melt water storage and drainage characteristics for the year 2014 have been completed.
Modeling the catchment runoff variation under different climatic scenarios	It is proposed to run SNOWMOD and HBV Light for the catchment upto discharge site. The snow cover area is being determined and the percentage of basin in different aspect is also determined. This information will be used for the calibration and validation of the model. The climatic scenarios have been generated.

Recommendations of Working Group/TAC/GB:
The study may be continued for long term to link with climate change.

Adopters of the results of the study and their feedback:
The study is a sponsored study and the results will be disseminated by DST.

List of deliverables:
Major items of equipment procured: Nil

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

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

Specific linkages with Institutions/beneficiaries: The data collected is also being shared with the authorities of Gangotri National Park. The details of sediment concentration are being communicated to the downstream Dam authorities.

Shortcomings/Difficulties: The study involves four months of extensive field work and maintenance of construction site etc. Without the support of project staff it is difficult to manage data collection.

Future Plan: The study will be conducted for long term. The Himalayan glaciers are poorly monitored. There is very little or sparse data of Himalayan Glaciers The collected data will be used for climate change studies.

8. NIH/SWHD/NIH/14-17

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

Study Group:

1. Sh. Digambar Singh, Sc C, SWHD
2. Dr. A. R. Senthil kumar Sc E, SWHD
3. Dr. Manohar Arora, Sc D, SWHD

Date of start: 1 June 2014

Duration of the study: 3 Years

Type of Study: Internal

Objectives of the study:

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

Brief methodology:

Evaporation model

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

Development of climate scenarios

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

Results achieved with progress/present status

It was observed that wind speed shows sinusoidal behavior on yearly basis whereas sunshine duration decreases in the later part of the year. The temperature parameters viz: average, maximum and minimum increases during summer and recedes during winter. The humidity variability creates a trough in the summer months. From these graphs the behavior of the parameters controlling the evaporation is studied.

A sensitivity analyses of two major parameters controlling evaporation i.e. temperature and sunshine duration shows that there is a linear increasing trend as we increases the parameters. It also depicts that incoming radiation has major control in the evaporation.

Evapotranspiration is also determined by the Thornthwaite (0.140,0.513,1.180,2.541,3.917,3.193,2.455,1.672,2.314,1.854,0.895,0.299) and Turc method (1.358,2.483,3.139,3.534,3.664,3.548,3.327,2.934,2.370,1.757,1.367)

Action plan and timeline

Year	April - June	July-Sept	Oct-Dec	Jan-March
2014-15	Literature review, Data collection and compilation	Literature review, Data collection, compilation and processing	Development of model for evaporation by empirical and soft computing techniques	Development of model for evaporation by empirical and soft computing techniques
2015-16	Development of model for evaporation by empirical and soft computing techniques	Development of climate scenarios from SDSM/PRECIS	Development of climate scenarios from SDSM/PRECIS	Development of climate scenarios from SDSM/PRECIS
2016-17	Simulation of evaporation by considering the climate scenarios	Simulation of evaporation by considering the climate scenarios	Simulation of evaporation by considering the climate scenarios	Writing of final report

Data requirements

a. Maximum and minimum temperature
b. Rainfall
c. Humidity
d. Pan evaporation

Deliverables:

i) Future series of rainfall, maximum and minimum temperature and humidity
ii) Trend of future evaporation
iii) Comprehensive report giving data, maps and results
iv) Research papers

9. NIH/SWHD/NIH/15-16

Title of the Study: Generalization and parameter estimation of GEV distribution for flood analysis

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

Objectives of study

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

Statement of problem and brief methodology

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

The objective is intended to possibly unify both type 2 and type 3 GEV distributions in a single GEV and suggest both a simple and optimization method for estimation of its parameters with its illustration on measured and published International data.

Achievement/progress:

The report is complete with finalization of writing in progress, and will be submitted by this month.

Adopters of the results of study and their feedback

Practitioners, field engineers, and academic personals.

10. NIH/SWHD/NIH/15-16

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

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

Objectives of study

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

Statement of problem and brief methodology

Solution to problems concerning abrupt change in discharge is required to deal with the surges and bores in channels. In the case of two surges or bores travelling from opposite direction, analytical results yielding direct solution is of help to users as it will avoid iterative solution.

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

Achievement/progress:

The report is complete with finalization of writing in progress, and will be submitted by this month.

Adopters of the results of study and their feedback

Practitioners, field engineers, and academic personals.

Deliverables

Research report detailing the developed equation and research papers in International Journals with illustrative of ease in application in comparison to existing methods.

11. NIH/SWHD/NIH/15-16

Title of the Project: **Flood and Sediment studies in Himalayan Basin using MIKE-11 Model**

Project team:

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

Objectives

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

Date of Start: year 2015

Schedule date of Completion: year 2018

Present state-of-art

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

Methodology

Steps of the methodology are:

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

Analysis and Results:

Collection of data/information related to cloud burst and sediment is in progress. Flood simulation model has been setup for following cases in MIKE-11 software:

1. Cloud burst
2. GLOF

However to carry out sedimentation modeling MIKE-Hydro-River software with rainfall-runoff module, hydrodynamic module, Flood module and Sediment module etc. is required for the study. For the procurement of the software already the process is initiated.

Adopters of the results of the study and their feedback:

Agriculture department of the concerned region

Research outcome from the project

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

12. NIH/SWHD/NIH/15-16

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

Study Group:

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

Type of study: Internal

Date of start: April 2015

Scheduled date of completion: March 2018

Study area

The Sharda Valley in Uttrakhand has a vast potential for Water Resources Development, which was not tapped at all during the initial three decades of planned development. The region is mythological abode of Gods; the pilgrim route to Holy Mansarover passes along the Sarda Valley. The river Sharda (or Kali) form the international boundary between India and Nepal, towards the north, from a point called Bramhadeo, about 5 km upstream of Tanakpur. River Sharda originates in the region of Higher Himalayas, near Indo-Tibetan border, from the Glacier of Zaskara range, at about 5250 M. In the upper reaches, in the hills, it is called Mahakali. The river emerges into plains at Bramhadeo and it is called Sharda. The study area extends between 29°0'–30°38'N and 79°28 – 81°7'E covering an area of about 15280 Sqkm, with elevation ranging from 250 to 7000m above msl. About 1732 Sqkm of the total area of the basin is under glacier landscape. The Main River generally flows in north-south direction and is met with by a number of major tributaries from Indian side, namely, Dhauliganga, Goriganga, Sarju and Ladhia. The major tributary from the Nepal side is Chameliya. The Sharda river finally joins the Ghaghra (Karnali) River as its right-bank tributary in Uttar Pradesh. The Sharda Valley in Uttrakhand has a vast potential for Water Resources Development. The Tanakpur Hydroelectric Project (120MW) was commissioned in 1992 by the NHPC with a barrage on the Sharda River near the town of Tanakpur in the district of Champawat. Mahakali (Sharda in

India) is one of the five major river basins of Nepal which is shared with India and of which about 34 per cent of total basin area lies in Nepal. The hydroelectric potential of the valley on the Indian side of the river as assessed by UP Irrigation Department is over 3000 MW; and the power potential of the main Sharda river is assessed as 2000 MW. Therefore, accurate estimation of the basin runoff (including snowmelt runoff) is of extreme importance.

Objectives of the study

i. Preparation of basin maps including DEM and estimation of snow cover area using remote sensing data
ii. Calibration of conceptual snowmelt runoff models namely, SRM and SNOWMOD for Sharda River basin upto Tanakpur.
iii. Development and training of black-box models (ANN models) for simulation of runoff including snowmelt runoff of the Sharda River basin upto Tanakpur.
iv. Inter-comparison of various models.
v. Investigation of the impact of likely future changes in climate on stream flow using downscaled GCM scenarios in the study area.

Statement of the problem

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

Potential climate change and its unfavourable impacts on hydrologic systems pose a threat to water resources throughout the world. The effect of climate on hydrology in tropical Asia has many facets. The Himalayas, which act as a mountain barrier on the earth, where polar, tropical and Mediterranean influences interact, play an important role in maintaining and controlling the monsoon system over the Asian continent. In the Himalayas, the storage of precipitation in the form of snow and ice (in glaciers) over a long period provides a large water reservoir that regulates annual water distribution. The majority of rivers originating in the Himalayas have their upper catchments in snow covered areas and flow through steep mountains. If there is any climatic variability in the Himalayas, the impacts could be felt in regions downstream. Therefore, besides reasonably accurate estimation of the runoff, there is an imperative need to study the impact of climate change on the runoff regime of the Sharda basin in view of its huge water resources potential including uses for hydropower, irrigation etc.

Approved action plan

S. No.	Work Element	First Year				Second Year				Third Year			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Collection of information and Hydro-meteorological Data												
2	Preparation of base maps												
3	Downloading MODerate resolution Image Spectral radiometer (MODIS) snowcover data products for the study area												

4	Analysis and interpretation of weekly MODIS snowcover data and preparation of snow cover maps												
5	**Preparation & Submission of Interim Report-I**												
6	Input data preparation for SRM Model												
7	Calibration and Validation of SRM Model												
8	Input data preparation for SNOWMOD Model												
9	Calibration and Validation of SNOWMOD Model												
10	Input data preparation for ANN Models												
11	Training and Validation of ANN Models												
12	Preparation & Submission of **Interim Report-II**												
13	Inter-comparison of Models												
14	Downscaling of GCM outputs for the study basin												
15	Preparation of Input data for conceptual model for changed climate scenarios												
16	Simulation of conceptual snowmelt runoff model with changed climate scenarios												
17	Preparation & Submission of Final Report												

Progress

Objectives	Achievements
April 2015- March 2016	
1. Collection of information and Hydro-meteorological Data	Completed
2. Preparation of base maps	Completed
3. Downloading MODerate resolution Image Spectral radiometer (MODIS) snowcover data products for study area	Completed
4. Analysis and interpretation of weekly MODIS snowcover data and preparation of snow cover maps	Completed

Analysis and results

Data Used
SRTM DEM data and SOI toposheets

Results
The MODIS data products, namely, MOD10A2 have been downloaded from the NASA's National Snow and Ice Data Centre website http://www.nsidc.org through the ftp server from DAAC (Distributed Active Archive Centre). The MODIS snow products downloaded for the present study is provided in Hierarchical Data Format (HDF-EOS) which is standard format for EOS Data Information System (EOSDIS). 04 nos. MODIS scenes (h24v05, h24v06, h25v05,

h25v06) were required to cover the whole study area, as the watershed boundary was falling on the corner of the each scene. Thus total 740 {4(47+46+46+46) = 740} MOD10A2 scenes were procured for snow cover mapping in the Sharda basin for the period Oct’2006 to Sept’2010. There are two type of Scientific Data Sets (SDS) available in MOD10A2 products, namely "Maximum_Snow_Extent" and "Eight_Day_Snow_Cover". The maximum snow extent for the period is contained in the "Maximum_Snow_Extent" SDS that shows where snow was observed on one or more days in the period. Particular Days in the eight-day period when snow was observed are shown in the "Eight_Day_Snow_Cover" SDS. The SDS "Maximum_Snow_Extent" has been used in the present study as it gives better information about the actual snow accumulation in eight days period. Using ERDAS IMAGINE software, the HDF-EOS images with HDF format have been converted to .img format which is compatible with the ERDAS software and makes visualization and processing of the images easier. The projection system that comes with MOD10A2 scenes is sinusoidal projection with WGS84 datum. This sinusoidal projection has been re-projected to Geographic Lat/Long (WGS84) with WGS84 datum. Image-to-image registration of the MODIS scenes was not carried out as all the scenes were found to be accurately geo-referenced. These 04 nos. re-projected MODIS images were mosaiced using the ERDAS imagine software to get a single image of the study area. The mosaiced MODIS image covering the whole study area has been re-projected to WGS_1984_UTM_Zone_44N as our study area falls in this zone. This MODIS image has been used to get the snow cover area. Finally, snow cover maps have been prepared for the period 2006-10 for the Sharda Basin.
Figure 1 shows the spatio-temporal distribution of the Snow cover area in the Sharda basin for the year 2006-10. Figure 2 show the monthly distribution of the Snow cover area in the Sharda basin for the period 2006-10. It can be shown that snow cover starts building from September upto February and then starts depleting from March onwards till August. Accumulation is maximum from December to March due to low temperature and snowfall in high altitude areas. Similarly, SCA is minimum from July to September because of monsoon and high temperature and follows the same trend for each of the study year. The mean monthly maximum Snow cover in the basin was during the month of February (34.2%) and minimum during July (3.7%) for the period 2006-10. In all the maximum snow cover was in Feb’2007 (35.7%) and minimum in July’2008 (2.8%).

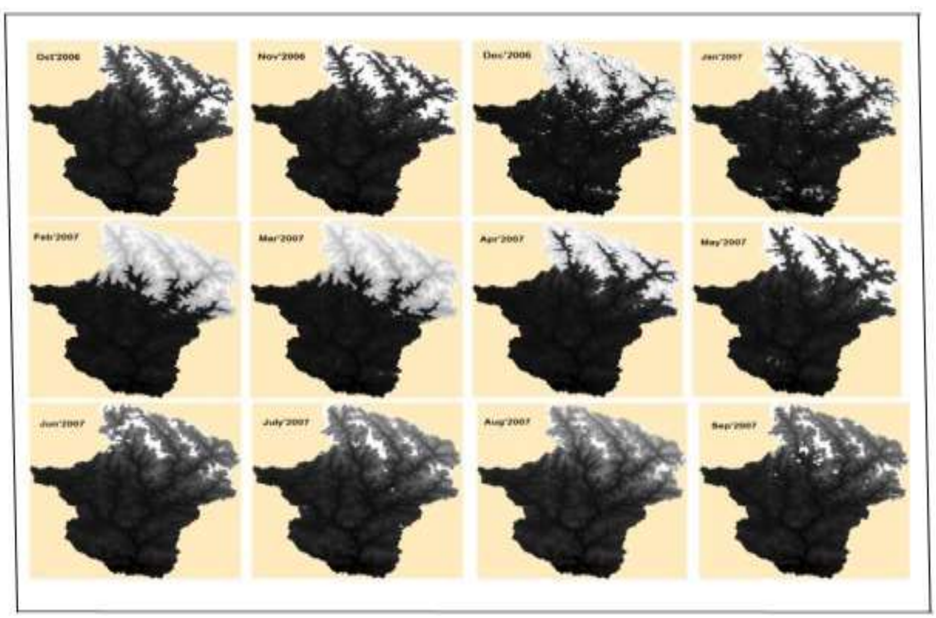


Figure 1: Sequential Snow cover in Sharda basin as seen in MODIS Images for the period Oct’2006–Sep’2007

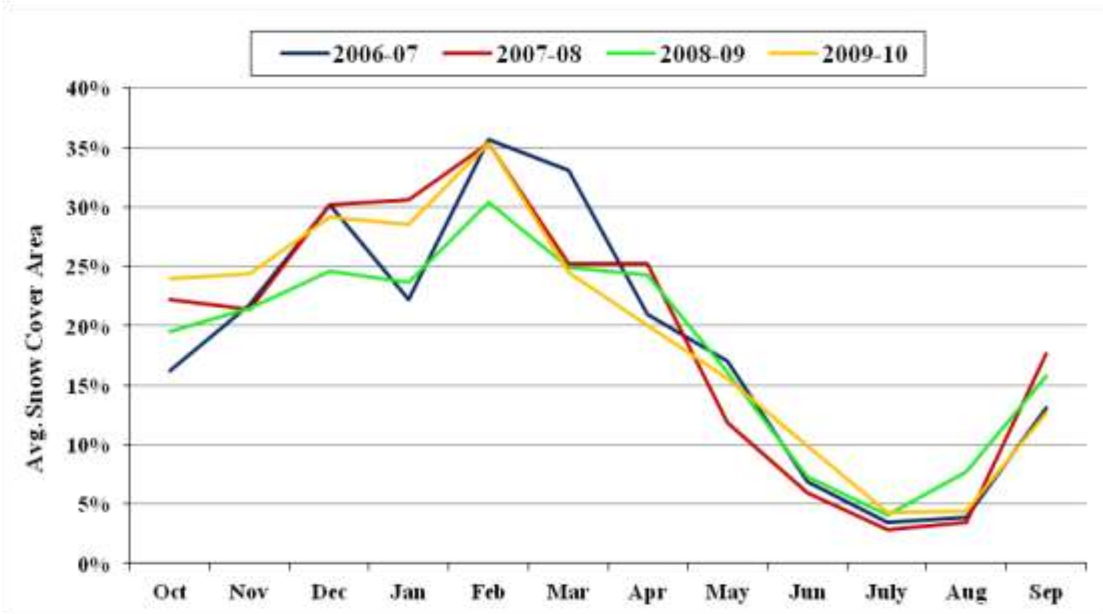


Figure 2: Monthly distribution of SCA in Sharda basin

Expected adopters

State Water Resources Department and other agencies.

Deliverables

Research papers and report

Data procured and/generated during the study

Nil

Future plan

As per the approved action plan.

13. NIH/SWHD/NIH/15-18

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

Study Group:

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

Date of start: 1 April 2015

Expected date of completion: 31 March 2018

Duration of the study: 3 Years

Type of Study: Internal

Objectives of the study:

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

Brief methodology:

Sediment yield model

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

Climate Scenarios

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

Computation of sediment yield under different scenarios

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

Revision of elevation-area-capacity table

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

Results achieved with progress/present status

The data of land use, soil type, rainfall, wind velocity, relative humidity, temperature, solar radiation, potential evaporation, runoff and sediment yield at outlet, runoff and sediment inflow to storage structures located in the catchment and elevation-area curve of the storage structures in the catchment are required for setting up of SWAT model to simulate the sediment yield. The sediment yield at the entrance of the Pong Dam is available from 1987 to 2009. For setting up SWAT model to simulate the sediment yield, the sediment yield at Pandoh reservoir is also required. The data of sediment yield at the upstream of the Pandoh reservoir is not available. The sediment yield at Mandi is available from 1996 to 2006. The trap efficiency of Bhakra for the period from 1962 to 2003 is 99.34 % and the trap efficiency of Pong reservoir is 97.11. Considering the average of the trap efficiencies of the two reservoirs is to be the trap efficiency of Pandoh and the sediment yield at the Pandoh dam is calculated from the sediment yield at Mandi. This data will be used in the simulation of SWAT model.

14. NIH/SWD/NIH/15-18

Title of the study: Study of regional drought characteristics and long term changes in Supplemental irrigation water requirement in seonath basin in chattisgarh

Project team:

Name of PI: Dr. R.P. Pandey, Scientist F; Surface Water Div., NIH Roorkee
Name of Co-PI: Dr. Rakesh Kumar, Scientist G, Surface Water Div., NIH Roorkee

Type of study: Internally Funded

Project Duration: 2-years

Date of start: April 2015

Scheduled Date of Completion: March. 2017

Objectives of the study:

The primary objectives in this study are as follows:

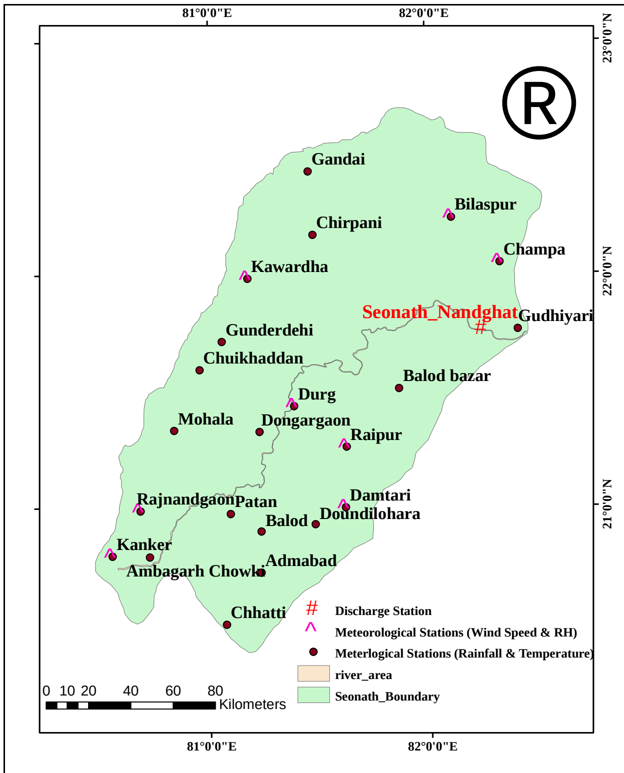
(1) To analyse long-term rainfall and streamflow data for assessment of regional drought characteristics
(2) To assess the climatic variability in terms of long term trend in climatic variables.
(3) To assess long-term changes in evapotranspiration and sensitivity analysis of ET to different climatic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

Study Area : Seonath Basin in the Chhattisgarh State

The study selected for this study is Seonath River Basin in the state of Chattisgarh. The Seonath River is the longest tributary of the Mahanadi River basin draining three districts of Chhattisgarh namely Durg, Rajandgaon and Bilaspur. The Basin is located between latitude $20^0$16' N to 22^0 41' N and Longitude $80^0$25' E to $82^0$35' E. The drainage area of the Seonath river basin is 30,860 Sq km. The mean annual rainfall in the basin varies from 1005 mm to 1255 mm. Seonath river basin comprises 25% of the upper catchment of the Mahanadi basin.

The study area (Seonath river basin) falling in Chhattisgarh State faces frequent droughts.

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



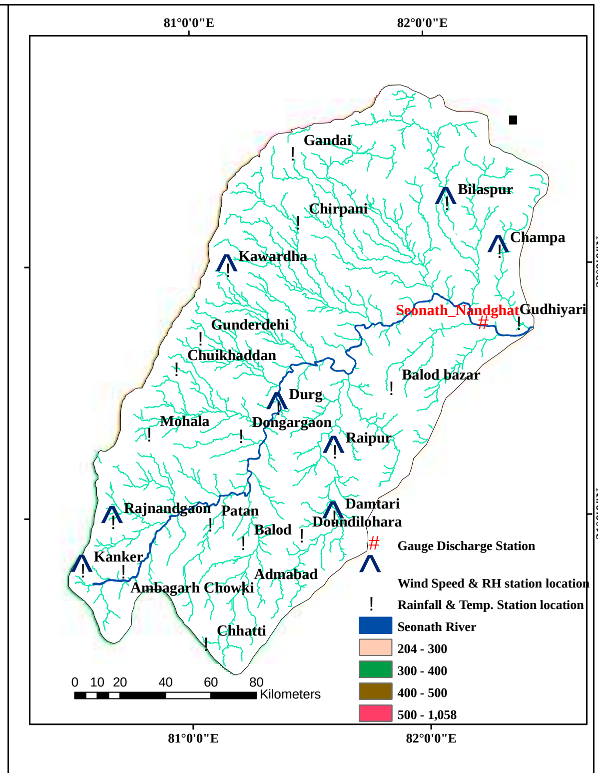


Figure 1a: Location of Meteorological stations in Seonath basin

Figure 1b: DEM and Drainage network

Proposed Methodology

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

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

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

Progress of Work

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

a. The daily meteorological data [Rainfall, Temperature (maximum, minimum and mean)] of 24 stations have been collected from IMD, Pune for 51 years (1960-2010). Observed data on wind speed and relative humidity is available only for eight stations. The pan evaporation data is available only for one station viz., Raipur. The location of the stations and digital elevation model (DEM) of basin are shown in Figure 1a &1b.

b. The discharge data for the same period at the single outlet namely Nandghat, has been obtained from State Data Centre, Department of Water Resources, Raipur (Chhattisgarh).

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

The composite maps have been prepared to illustrate the location of different meteorological stations located within Seonath River Basin and DEM. The maps of land use and soil type (Figure 2a & 2b) have been prepared. . The major land use of the basin is for agriculture except in Raipur district which shows major settlement; therefore the basin is described as an agriculture basin (Figure 2a) The main soil types found in the basin are sandy clay covering 72.28% of the basin area followed by silt loam 17.29% of the basin area (Figure 2b).

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

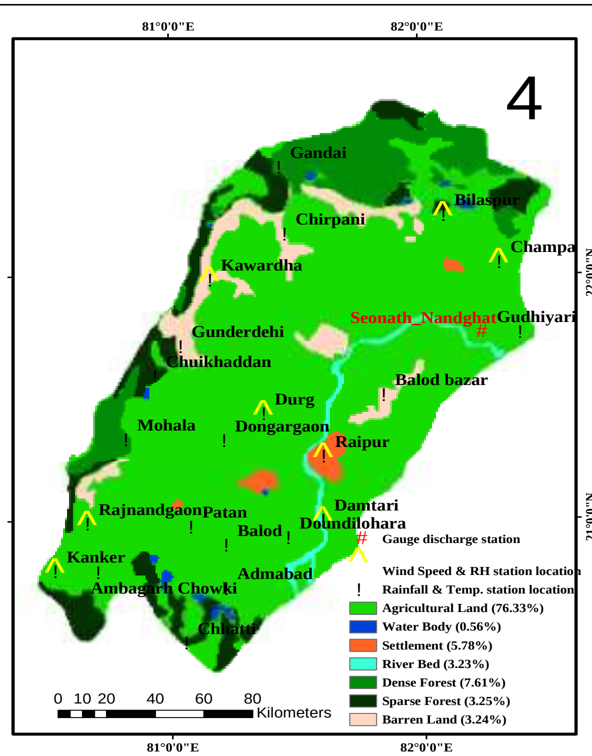


Figure 2a: Land Use/Cover Map

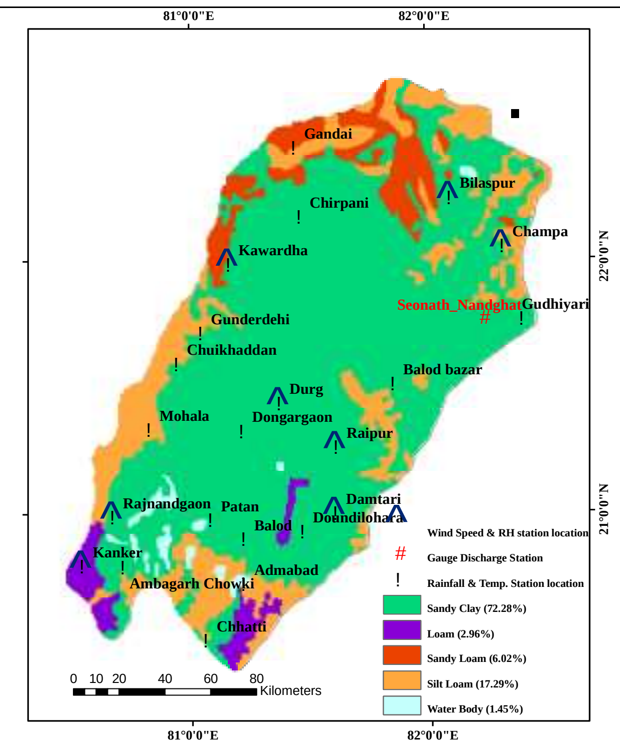


Figure 2b: Soil Type Map

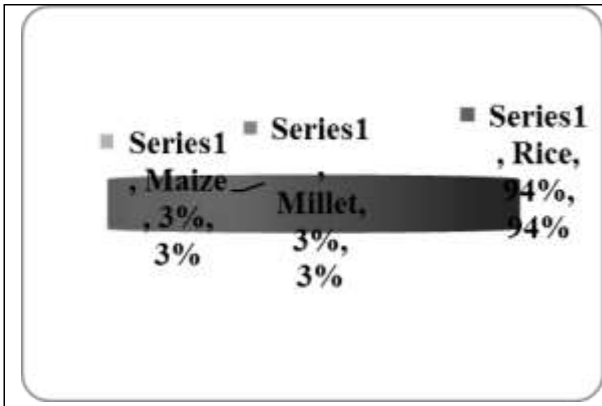


Figure 3a: Kharif season crops in Seonath river basin. ***(Source: Directorate of Economics and Statistics, Chhattisgarh)***

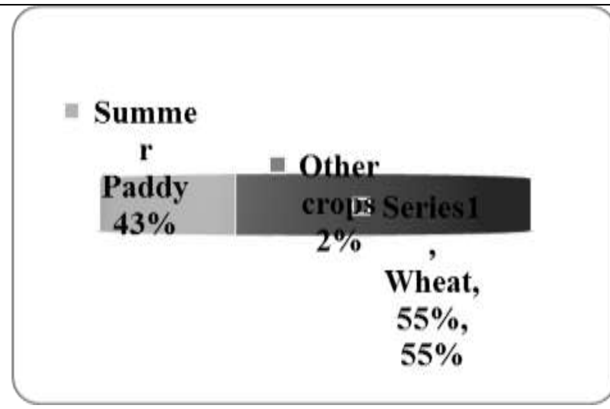


Figure 3: : Rabi season crops in Seonath river basin. ***(Source: Directorate of Economics and Statistics, Chhattisgarh)***

(iii). Assessment of trends in climatic variable:

The daily data of rainfall, maximum and minimum temperature, relative humidity and wind speed have been collected from India Meteorological Department (IMD), Pune, and State Data Centre, Department of Water Resources, Raipur (Chhattisgarh) from 1960-2010 (51 years). For rainfall, maximum temperature and minimum temperature data is available for 24 stations whereas for wind speed and relative humidity, data is only available for eight stations. The detail information about the stations has been presented in Chapter 3. These data has been used to check the trend and variability on annual and seasonal time scale viz. summer (March-May), winter (November to January) and monsoon (late June to October) for Seonath River Basin falls in Chhattisgarh State

a. **Homogeneity Test:** Double Mass Curve analysis has been carried out to check the homogeneity/consistency in the annual and monthly rainfall data series.

b. **Dependency Test (Autocorrelation coefficient):** The dependency of different meteorological parameters has been computed using lag-1 serial correlation coefficient. In this study, almost all the series are found to be non-correlated except few of the series are correlated (Figure 4).

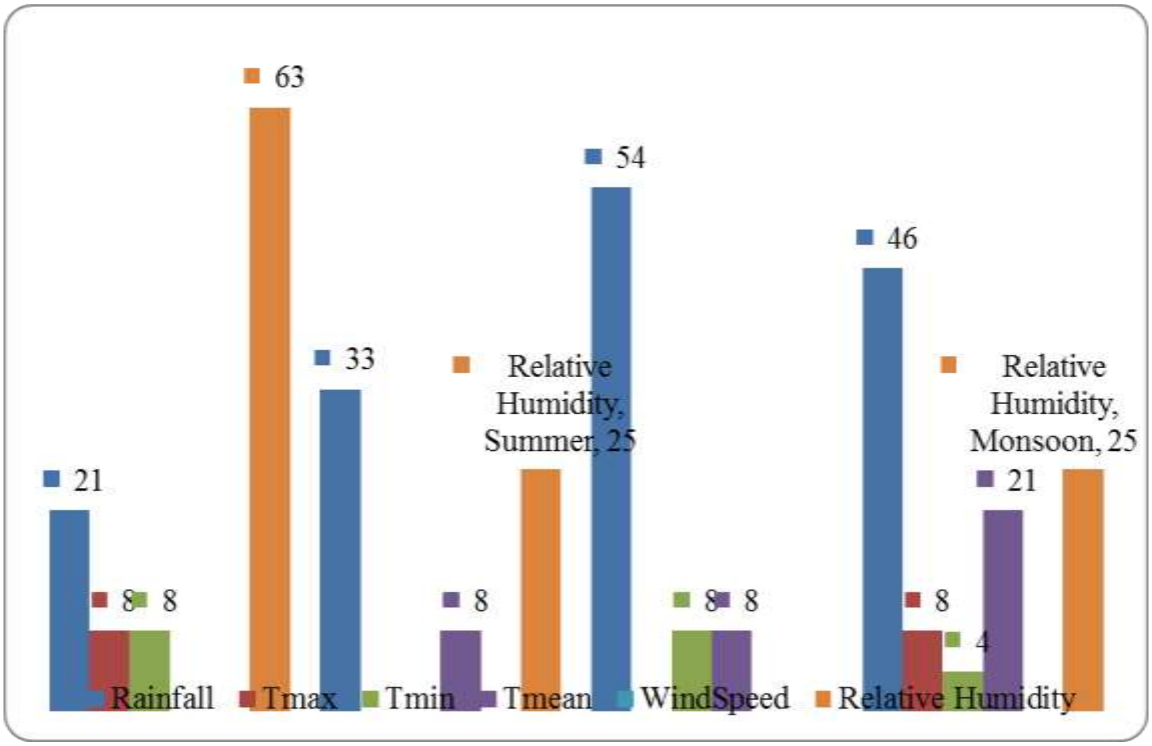


Figure 4a: Percentage of Stations correlated for different climatic parameters (Annual and Seasonal)

(iv). Statistical Test for Trend and Variability Analysis

The Mann-Kendall test **(Non-parametric)** (Yu and Neil, 1993; Douglas et al., 2000; Yue et al., 2003; Burn et al., 2004, Singh et al., 2008a, b) is used to detect monotonic (increasing or decreasing) trend in rainfall data. In addition to recognize whether a trend exists, the trend magnitude has been assessed by Sen's Slope Estimator (β), and expanded by Hirsch et al. (1982). To estimate trend magnitude Theils-Sen's slope (β) approach is used in this study. Flowchart (Figure 4b) presents methodology for trend and variability analysis of meteorological variables.

Some trends may not be evaluated to be statistically significant while they might be of practical interest and vice versa. For the present study, change percentage has been computed by approximating it with a linear trend. That is change percentage equals median slope multiplied by the period length divided by the corresponding mean, expressed as percentage (P_c) followed by Yue and Hashino (2003). The percentage change is estimated by following formula.

$$P_c = \frac{\beta * L}{\mu} \quad (1)$$

Where, P_c = Percentage Change, β = Slope Magnitude, L = Length of the year and μ = Corresponding mean.

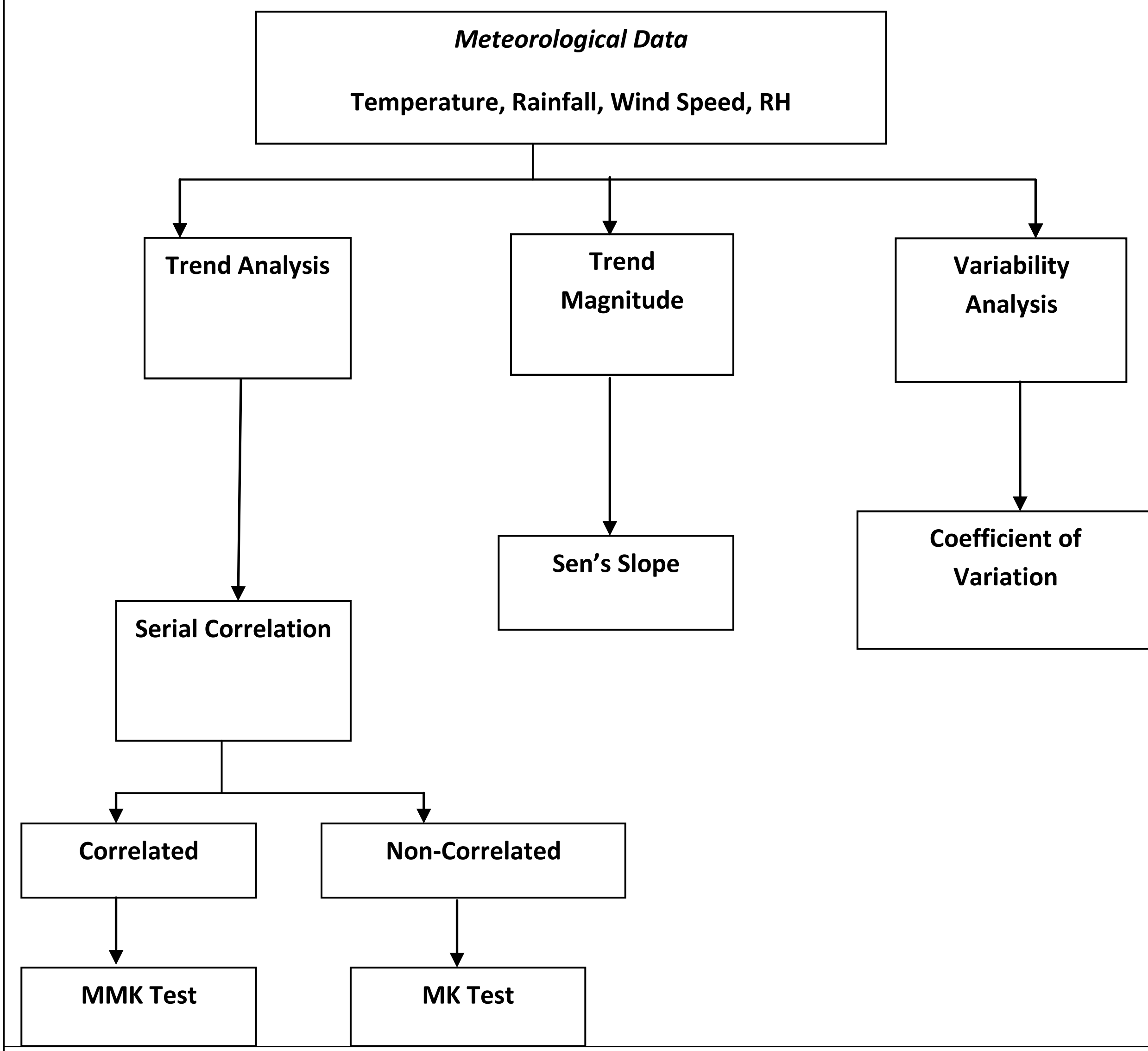


Figure 4b: Flowchart presenting methodology for trend and variability analysis of meteorological variables

Spatial Distribution of trends of rainfall is shown in Figure 4c

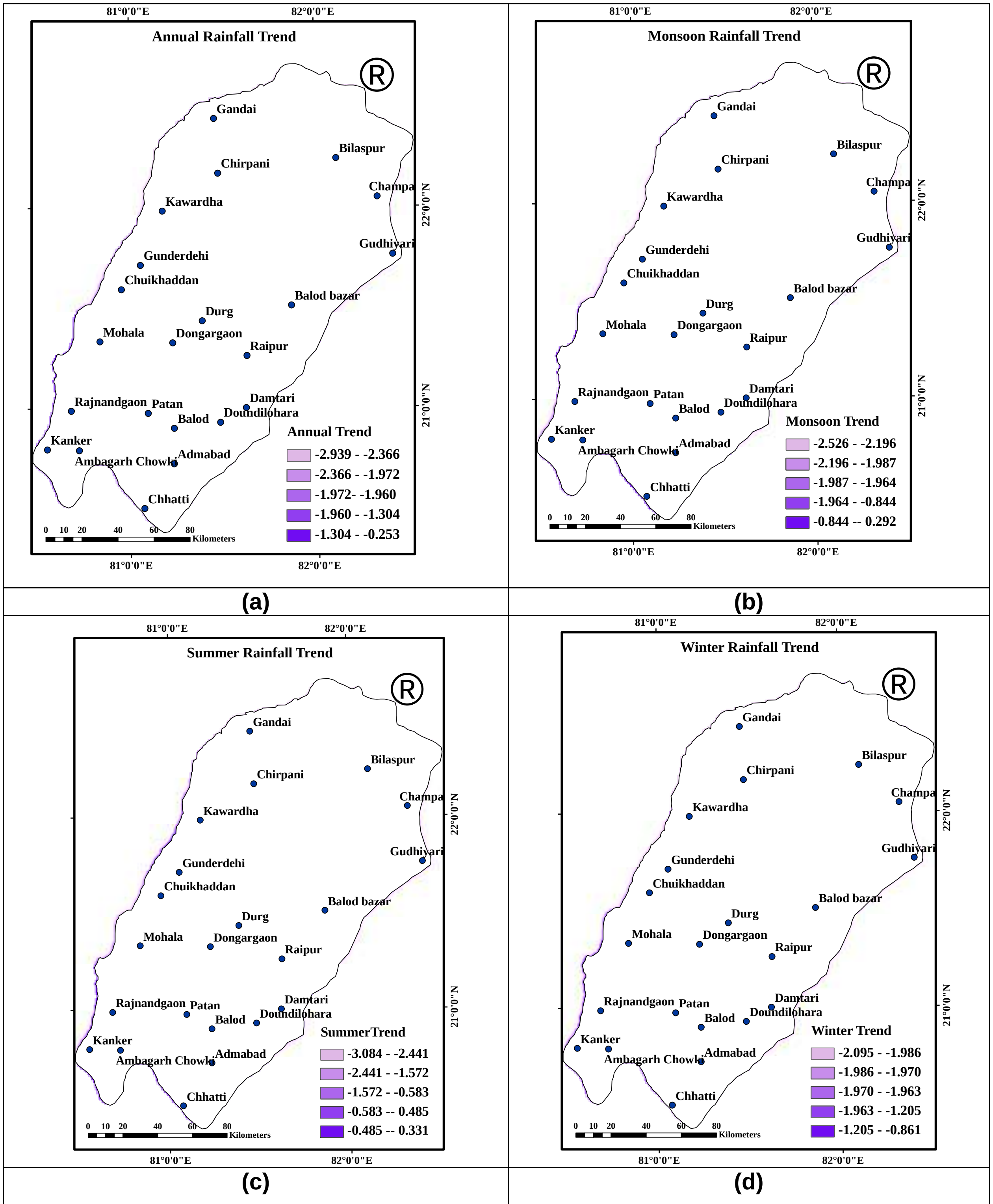


Figure 4c: Trend in annual and seasonal rainfall in Seonath river basin over the period of 1960-2010 (a) Annual (b) Monsoon (c) Summer (d) Winter

Table 1: Results of regional average annual and seasonal rainfall for entire Seonath River Basin.

Entire Seonath River Basin	Rainfall			
	Z-values MK	Sen's Slope (β)	% Change over 51 year	% Variability over 51 year
	(Col.1)	(Col.2)	(Col.3)	(Col.4)
Annual	-0.529	-2.4	-12.33	30.78
Summer	-0.472	-0.5	-9.0	6.95
Winter	-0.444	0.0	-1.7	17.19
Monsoon	-0.994	-2.79	-21.64	43.95

Other works are in progress

15. NIH/SWHD/NIH/15-18

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: Responsibility of the completion of the project successfully (Literature Survey, Data collection and processing, Analysis, Preparation of report, Publications etc.)

Type of Study: Sponsored Research

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

Budget sanctioned: 12.6 lakhs

Date of Commencement: 17 October 2014

Scheduled date of completion: 31 March 2017

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

Statement of the problem:

Asia-Pacific monsoon (APM) is the most energetic and largest monsoon system of the globe, covering Indian Subcontinent, Indo-china peninsula, China, South China Sea, Korea, Japan and Northwest Pacific Ocean. It is the thermally driven circulation. Heterogeneous changes in global tropospheric temperatures from last few decades are observed to make spatiotemporal changes in global rainfall distribution. In the era of global warming, despite rising global surface temperature, most part of the Indian subcontinent (Indo-Gangetic plains and central India) is experiencing weaker monsoon and an increase in occurrences of extreme rain events (EREs). An index will be developed to delineate the global monsoonal regime and commencement and cessation of monsoon circulation and start and end of the monsoonal rains across Asia-pacific region. Influence of global temperature changes on the characteristics monsoon circulation as well of rainfall occurrences (start and end of monsoon, intensity, frequency, location and duration of rain spells and extreme rain events) will be studied thoroughly.

Objectives:

1. To investigate the underlying mechanism of intensification and weakening of Asia-Pacific monsoon circulation intensity in the backdrop of heterogeneous global temperature change.
2. Determination of commencement and cessation dates of monsoon circulation and start and finish of monsoonal rains.
3. To understand the structure of the monsoon circulation associated with large-scale extreme rain events over and across India.

Objectives vis a vis Achievements:

Objectives	Achievements
To investigate the underlying mechanism of intensification and weakening of Asia-Pacific monsoon circulation intensity in the backdrop of heterogeneous global temperature change.	• Asymmetry in the global tropospheric temperature change has been documented quantitatively in details. • The annual cycle of Global tropospheric parameters (Temperature, MSLP, PPW, GPH, U&V wind etc.) during six selected times of the year are studied in details in order to understand the genesis of Asia-pacific monsoon as well as other sub-regional monsoons.
Determination of commencement and cessation dates of monsoon circulation and start and finish of monsoonal rains.	• The area under monsoonal rains across the globe at any time of the year has been delineated objectively. • A uniform criterion is developed to determine commencement and cessation of Asia-pacific monsoon circulation and start and end of monsoon rains for 19 sub-regions across India.
To understand the structure of the monsoon circulation associated with large-scale extreme rain events over and across India.	• Identification of different trade wind convergence systems/zones developed over Asia-Pacific, South Africa, Australia and North and South America during boreal and austral summer.

Recommendations of Working Group/TAC/GB:

The approach of the research problem is well appreciated by working group members. Committee advised making more focus on objectives of the study and also suggested to study extreme rain events over the Himalayan region.

Analysis and Results:

(1) Dataset collected/used:

1. NCEP Climate Forecast System Reanalysis (CFSR) 6 hourly products from 1979-2014 at 2.5X2.5 degree resolution (Temperature, Geopotential height, U and V wind at 12 isobaric levels, Mean sea level pressure, and Perceptible water)
2. 0.5 degree gridded rainfall data from India Meteorological department.

(2) Features of Global Atmospheric parameters during six selected times of year

The annual cycle of the global atmospheric parameters (e.g temperature, mean sea level pressure, geopotential height and thickness, the wind, Perceptible 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). On an annual basis, the Normal annual tropospheric (1000-250hpa) temperature (TT) of the globe (1979-2013) is about -11.1 ^{0}C. On an average, the northern hemisphere (NH) is slightly warmer than the southern hemisphere (SH). Normally the equator to North Pole (NP) temperature gradient is lower (28.5^{0}C) comparing to South Pole

(SP: 37.8^{0}C). The equator to pole thermal gradients results into pressure gradients and therefore in atmospheric motions.

In austral summer, during the end of January, The thermal equator passes from over South Africa, Australia and South America continents and equatorial South Pacific Ocean. Normally the tropospheric temperature anomaly over the entire southern hemisphere is positive (2.8 ^{0}C) with the warmest area (+6^{0}C) is over the South Pole. The equator to pole temperature slope is steeper by 7.6^{0}C in NH and that is reduced by 7.9^{0}C in SH. Cooler temperatures of the NH during January reflect in the positive pressure anomaly over entire NH land area, more concentrated over Manchuria, Mongolia and adjoining Russia (10 to 12mb).

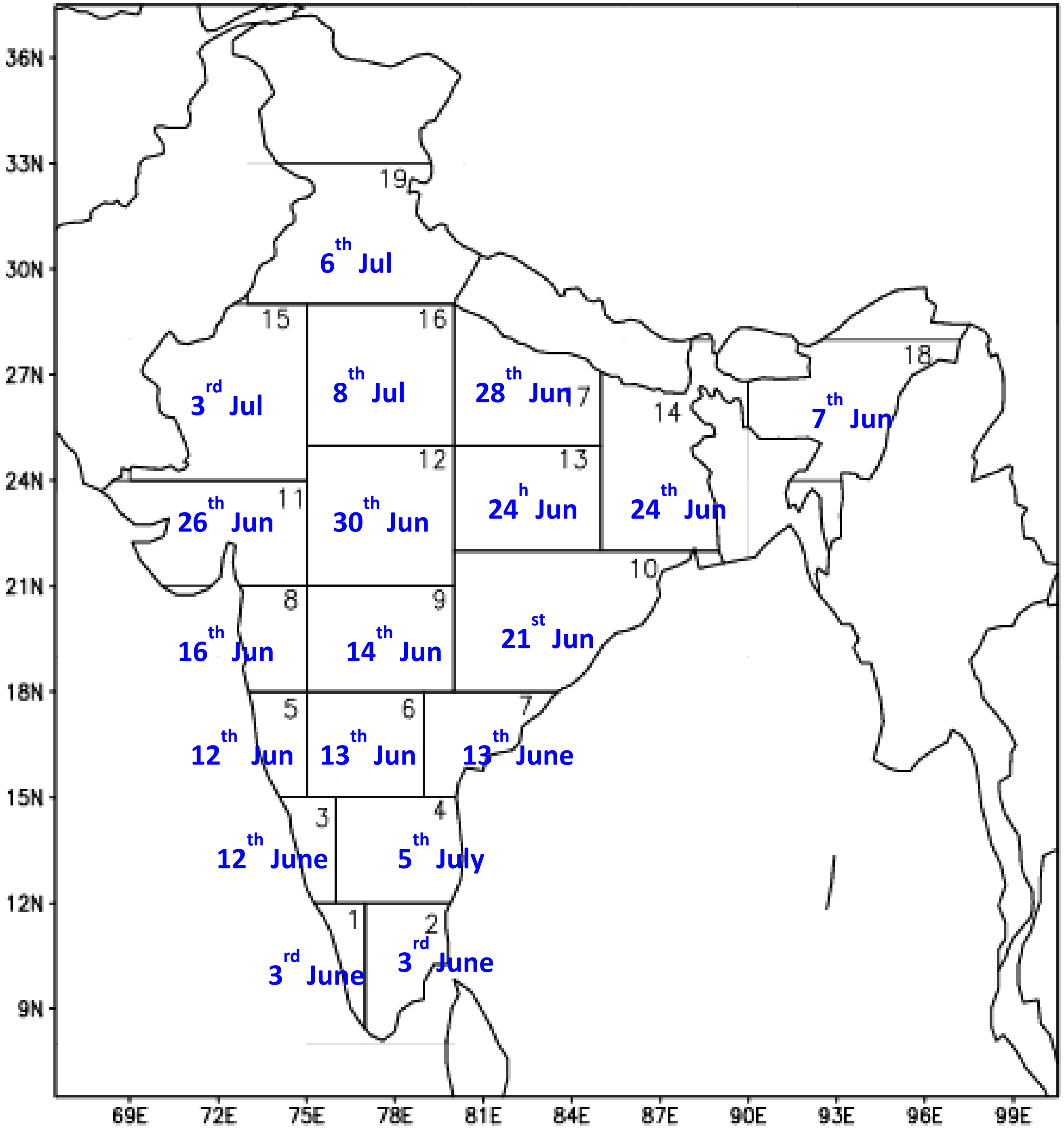
During the peak of boreal summer, at the end of July, the thermal equator lies on 30^{0}N latitude belt over Saudi Arabia, Iran, Afghanistan, Pakistan, North India, South China as well as North America. The positive anomaly over entire NH becomes most prominent (+5.3^{0}C) while negative anomaly persists over entire SH(-2.4^{0}C). The anomalous warmest tropospheric area of the globe (~+12-16^{0}C) higher than the normal annual mean value (NAMV) is seen over the Tibet, North China, Mongolia and Northeast Russia. The equator to pole TT slope reduces prominently (-11.9^{0}C) in NH and rises (+6.2^{0}C) in SH. Entire land area of NH up to its Pole shows strong negative pressure anomaly. The whole Asian continent is now covered up with the intense low-pressure area (10-12mb lower than NAMV). It is the period when Asia-Pacific monsoon circulation is in its developed stage.

(3) Development of an index to delineate the area under monsoon circulation at any time of the year

The equator is well known for hot-humid-cloudy-rainy weather. Short period spreading of equatorial weather conditions as a regular annual event (seasonal) during which a region receives a considerable portion of its annual rainfall is popularly known as a monsoon. Equatorially conditioned atmospheric parameters at different isobaric levels are used to delineate the area under normal monsoon condition. Normally, largest spreading of equatorial thermal condition occurs during the beginning of July through the middle of August. Spreading and intensification of equatorial low-pressure area follow that of the thermal spreading from April through May. Lastly, it becomes large enough to cross the boundary of thermal spreading due to its merger with subpolar low. The PW field follows the spreading of areas of low pressure and convergenceslastly (collision, horizontal shear and meander of large-scale equatorial-maritime moist airflows, orographic effect and Coriolis Effect) but within the thermal spreading.

(4) Determination of onset and withdrawal dates of monsoon over 19 sub regions of the country.

Based on physiographical, geographical characteristics and rainfall occurrences, a country has been divided into 19 subregions. A uniform objective criterion has been developed in order to determine normal start and finish of monsoon rains over 19 subregions of the country (figure below). The criterion has been further modified to separate pre-monsoonal, post-monsoonal and equatorial rains. The application of the criteria on a yearly basis is in progress.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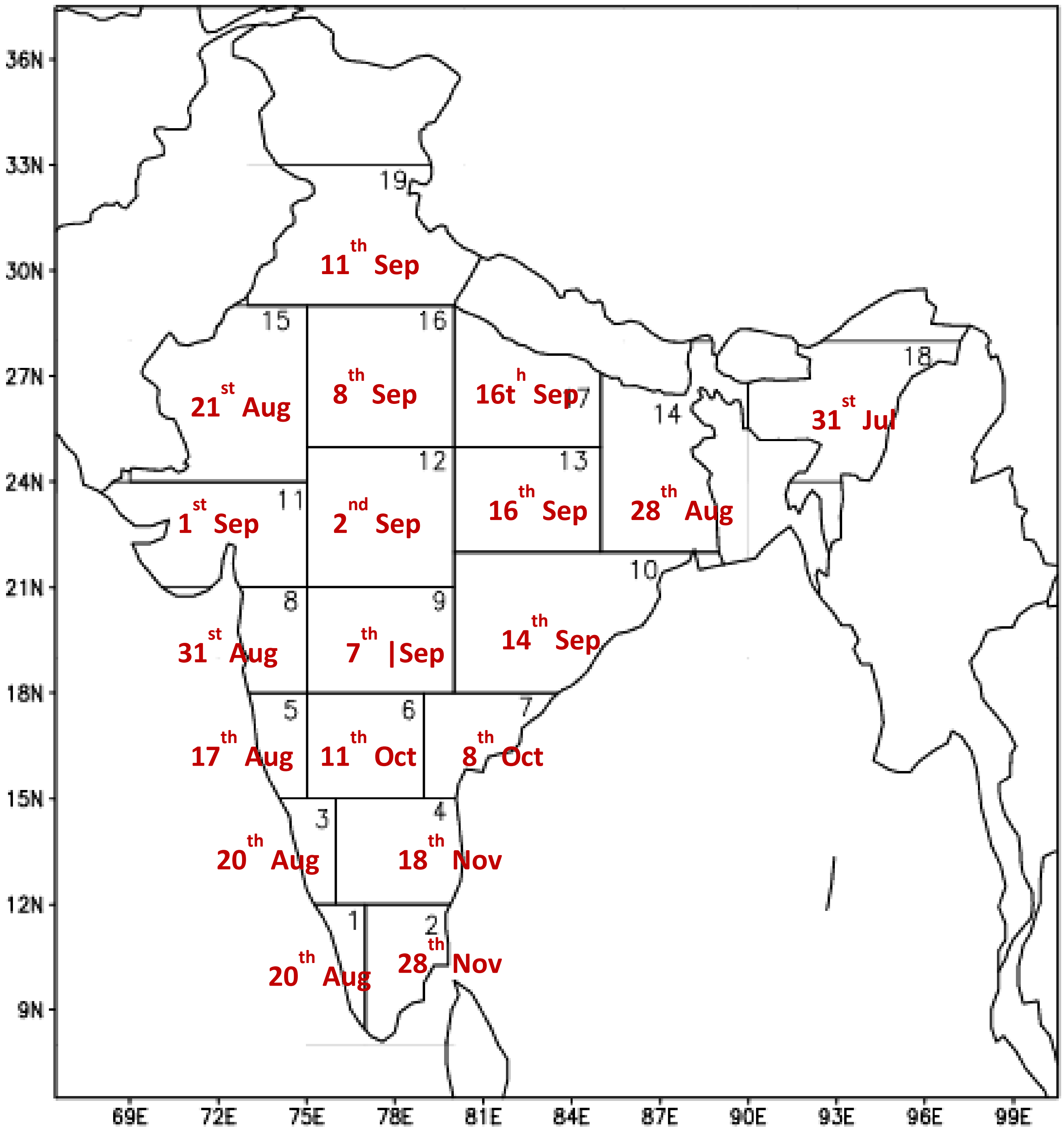


(5) Identification of global trade wind convergence systems producing significant rainfall

Depending upon the global thermal field and pressure field, global wind field also changes accordingly, reflecting into the formation of different types of trade wind convergences across the globe. They are an integral component of the same large-scale atmospheric circulation system. These are the areas of formation of the different rain-producing weather systems and occurrence of intense rain events. Formation of different trade wind convergence zones during six selected times of the year across the globe are documented. Intensity, shape, size, location of these systems are the major determinant factors of the performance of the monsoon will be studied in details.

Adopters of the results of the study and their feedback:

- Funding Agency
- Operational Forecasters if interested

Major items of equipment procured:

1. Workstation
2. Printer
3. UPS

Lab facilities during the study:

None

Data generated in the study:

1. Rainfall of 19 subregions of the country from 1979-2013 using daily high-resolution gridded data.
2. Years onset and withdrawal dates of Pre-monsoon, monsoon and post-monsoon rains across Asia-Pacific region as well subdivisions of India

Study Benefits/Impact:

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

Specific linkages with Institutions/beneficiaries:

None

Shortcomings/Difficulties:

Shortage of high resolution observed data of meteorological parameters in order validate the results

Future Plan:

Near real-time global monitoring system for the area under monsoonal condition and time evolution of rain-producing weather systems

16. NIH/SWHD/NIH/15-18

Title of The Project	**Snow cover variability in the Upper Yamnotri Basin**
Thrust Area under XII five year Plan:	Integrated water resources management/ Watershed hydrology

Project Team:

a. **Project Investigator:** Mr. Naresh Kumar, Scientist B

b. **Project Co-Investigators**: Dr. Manohar Arora, Scientist D
Dr. Rakesh Kumar, Scientist G & Head SWHD

Date of Starting: April 2016

Scheduled date of completion: June 2018

Objectives

1. Study of snow cover variability in the Upper Yamnotri Basin
2. Development of snow depletion curves for Upper Yamnotri Basin

Present State of Art

The extent of snow cover is considered as an important parameter for various hydrological applications. In terms of spatial extent, snow cover is second largest component of the cryosphere and covers approximately 40 – 50 % of the Earth's land surface during Northern Hemisphere winters. Annual precipitation of snow feeds the accumulation zone of the glaciers. Himalayas being the loftiest mountain of the world are abode of the snow and glaciers. The three major river systems of India i.e the Indus, the Ganga and the Brahmaputra have their origin in the snow and glacier fed areas of the Himalayas. Snow melt is also the source of fresh water required for drinking, domestic use, agriculture and industrial sectors for the low lying areas of these river systems. Estimation of snow cover is one of the important parameters for the runoff estimation and forecasting for the snow and glacier fed rivers. However the mapping and monitoring of seasonal snow cover is a challenging task especially in the harsh climatic conditions and rugged terrain of the high mountainous areas.

Remote sensing has emerged as a useful technique for snow monitoring. Snow cover monitoring using satellite images started in 1960 and since then potential for satellite – based mapping has been enhanced by the development of sensors with higher temporal frequency and higher spatial resolution. Sensors with better radiometric resolutions, such as MODIS and AWiFS have been used for generating the snow products. MOD10A2, a product of MODIS is used for mapping of maximum snow cover extent over eight days. The algorithm used to generate maximum snow cover over eight days uses MOD10A1 data as input. The multiple days of observations for a cell are examined. If snow cover is found for any day in the period then the cell in the "Maximum_Snow_Extent" SDS is labeled as snow. The logic minimizes cloud cover extent in that a cell would need to be cloud obscured for all days observations to labeled as cloud. If all the observations for a cell are analyzed but a result is not reached then that cell is labeled as no decision. Snow cover extracted from earlier data and snow products prepared using satellite images have been analyzed to know the trends in the snow cover variability in many studies. Singh et.al., have shown through the analysis of MODIS data that there is an increasing trend of snow covers in Indus Basin, where as Ganga and Brahmaputra basins have shown decreasing trends during the same period. A decrease in snow areas has been observed globally since the 1960s.

Methodology

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

- Data base preparation in ArcGIS (Basin map and drainage network)
- Down loading of MODIS Mod 10 A2 data from National Snow and Ice Data Center (NSIDC)
- Snow cover analysis of the study area
- Preparation of snow depletion curves for the study area for different years

Research Outcome from the Project

- Snow depletion curves for Upper Yamnotri Basin.

Cost Estimate:

a. Total cost of the Project Rs. 30.00 Lacs
b. Sources of Funding Internal Funding from NIH
c. Sub head wise Abstract of Cost

Sr. No.	Sub Head	Amount (in Rupees)
1	Salary	Rs. 27,00,000.00
2	Travelling Expenditure	Rs. 1,00,000.00
3	Infrastructure/Equipment/Data	Rs. 1,00,000.00
4.	Experimental Charges	-
5.	Misc. Expenditure	Rs. 1,00,000.00
	Total	**Rs. 30,00,000.00**

d. Justification for sub-head-wise abstract of cost:
Salary may be taken for 27 man months @ 1.00 lacs/man month average
Travelling expenditure for Field visit and collection of data as per requirement
Infrastructure/Equipment/Data charges are required for collection of data/satellite data
Misc. Expenditure: Miscellaneous expenditures like stationary, printing, etc.

Work Schedule

a. Probable date of commencement of work April 2016
b. Duration of Work 2 years 3 months
c. Stage of work and Milestone

S.N	Work Element	**First Year (2016-17)**				**Second Year (2017-18)**				**Third Year (2018)**
		April-June	Jul-Sep	Oct-Dec	Jan-Mar	Apr-June	Jul-Sep	Oct-Dec	Jan-Mar	April-June
1	Literature Review & Data Downloading									
2	Preparation of basin maps etc.									
3	Data analysis									
4	Preparation of report									

17. NIH/SWHD/NIH/16-17

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

Study group	Sushil K. Singh, Scientist F
Date of start of study	01 April 2016
Duration and scheduled date of completion of study	01 Year (with 06 month intended extension) 31 March 2017
Type of study	Internal

Objectives of study

To illustrate and demonstrate the practical application of the generalized GEV on the available Indian data including those collected at NIH.

Statement of problem and brief methodology

In an earlier report, the practical unification of both type 2 and type 3 GEV distributions in a single GEV was taken up and a simple and an optimization methods for estimation of its parameters were considered with limited testing/application. In this report, it is intended to take up the methodology as above for application and illustration on measured/published data on Indian rivers' GD sites.

Achievement/progress:

It is an application study in which the developed methodology and analysis by the author is intended to be applied on the published Indian data at various GD sites including those available/collected at NIH. The report is at the initial stage.

Adopters of the results of study and their feedback

Practitioners, field engineers, and academic personals.

Deliverables

Research report detailing the developed equation and research papers in International Journals with illustrative application on the published international data and the Indian data available/collected at NIH.

18. NIH/SWHD/NIH/16-17

Title of the study: **Application and development of analytical models on data collected at NIH under Saph-Pani Project**

Study group Sushil K. Singh**,** Scientist F
(with possible inclusion of young scientist across the divisions' line)

Date of start of study 01 April 2016

Duration and scheduled date of completion of study 03 Year; 31 March 2019

Type of study Internal; Funding (Tentative) **–** INR 45.00 Lakh

Objectives of study

1. To apply and illustrate on the above surface-water groundwater interaction data, the developed and published analytical models by the author, a complied detail of which has earlier been submitted to our Ministry and Institute both directly and indirectly.
2. To possibly develop new analytical models if application on the data as at item 1 suggests so.
3. The items 1 and 2 are also with the aim to suggest general application of these and other methodology concerning the area of surface-water groundwater interaction in general with respective merits/demerits.

Statement of problem and brief methodology

It is an application study in which the developed methodologies and analyses by the author are intended to be applied on the concerning data collected at NIH as stated above.

The intended development of new analytical model and methodology would be along those adopted in the development of earlier such models by the author.

Achievement/progress:

The report is at the initial stage.

Adopters of the results of study and their feedback

Practitioners, field engineers, and academic personals.

Deliverables

Research report detailing the developed equation and research papers in International Journals with illustrative of ease in application in comparison to existing methods.

WATER RESOURCES SYSTEM DIVISION

Scientific Manpower

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

NATIONAL INSTITUTE OF HYDROLOGY

राष्ट्रीय जल विज्ञान संस्थान

आपो हिष्ठा मयोभुवः

WORK PROGRAMME FOR THE YEAR 2016-2017

SN	Title11	Study Team	Duration	Funding (Rs. in Lakhs)
Completed Sponsored/ Internal Studies				
1.	Assessing climate change impact across KBK region of Odisha	P. K. Mishra Sharad K. Jain Sanjay K. Jain	3 Years (04/13-03/16)	NIH (28)
Ongoing Internal Studies				
1.	NIH_Basin – A WINDOWS based model for water resources assessment in a river basin	M. K. Goel Sharad K. Jain Deepa Chalisgaonkar Prabhash K. Mishra	3 Years (04/13-03/16)	NIH (16)
2.	Glacier change and glacier runoff variation in the upper Satluj river basin	Sanjay K. Jain Sharad K. Jain Renoj J. Thayyen	2.5 Years (10/13-03/16)	NIH (12)
3.	Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh	Renoj J. Thayyen S. P. Rai Sanjay K Jain Sudhir Kumar	3 years (04/14-03/17)	NIH (48)
4.	Hydrologic Modelling of a part of Satluj Basin using SWAT Model	P. K. Agarwal Sharad K. Jain Tanvear Ahmad M. K. Goel Sanjay K. Jain M. K. Nema	2 -3/4 Years (06/14-03/17)	NIH (23)
5.	Decision Support System for Water Resources Planning in Upper Bhima basin, Maharashtra	D. S. Rathore M. K. Goel, R.P. Pandey Sanjay Kumar Surjeet Singh	2 years (07/14-06/16)	NIH (34)
6.	Modeling of Narmada basin by using the GWAVA model	Sanjay K. Jain Sharad K. Jain T. Thomas (RC-Bhopal) P. K. Mishra P. K. Agarwal M. K. Nema	2.25 years Dec. 2014 – Mar 2017	NIH
7.	Runoff modeling of Shyok River, Karakorum Range	Renoj J.Thayyen Sanjay K.Jain	3 years Dec-2014 to Nov.2017	NIH (38)
8.	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	NIH+
9.	Development of Ganga Information Portal	Deepa Chalisgaonkar Sharad K. Jain D. S. Rathore Sanjay K. Jain Sudhir Kumar P. K. Mishra P. K. Agarwal M. K. Nema	3 years (04/15-03/18)	MoWR (65.55)
10.	Study of hydrological changes in selected watersheds in view of	L. N. Thakural D. S. Rathore	3 years (04/15-03/18)	MoWR (44.30)

	climate change in India.	Surjeet Singh Tanvear Ahmad Sanjay K. Jain Sharad K. Jain		
11.	Studies on Temporal Variation of Sediment Yield in Hilly Watershed of Upper Ganga Basin, Uttarakhand	P.K. Singh Sharad K. Jain Sanjay K. Jain M. K. Nema	2 Years 01/16-12/17	NIH (8.20)
New Sponsored Study for the year 2016-2017				
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.	NMSHE SUB-PROJECTS	-	-	-

COMPLETED STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2016/01

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

2. Project team:

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

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

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

4. Objectives:

1. To analyze long-term historical climatic data to determine trend
2. To analyze the future climate in the region based on downscaled GCM data
3. To assess the current potential and utilization gap of water resources in the region to develop management plan

5. Methodology

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

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

The downloaded large-scale daily predictors of Hadley Center's GCM (HadCM3) for HadCM3 A2 and B2 future scenarios for 139 years (1961–2099) on 3.750 latitude x 3.750 longitude grid-scale (http://www.cics.uvic.ca/scenarios/sdsm/select.cgi) is downscaled using Statistical Downscaling Model (SDSM). The Statistical Downscaling Model (SDSM) is a multiple regression-based tool, introduced by Wilby et al. (2002), for generating future scenarios to assess the impact of climate change. HadCM3 is a coupled atmosphere-ocean GCM developed at the Hadley Centre of the United Kingdom's National Meteorological Service. HadCM3 has been chosen because of its' wider acceptance in many climate change impact studies. Further, it provides daily predictor variables, which can be exclusively used for the SDSM model. Water resources availability and utilization will be made using primary and secondary data collected through field visit and from different multiple sources. It is planned to utilize SWAT model to assess the water resources particularly the recharge component in the basin.

6. Analysis and Result: Summary

The KBK (Kalahandi-Koraput-Bolangir) region situated in the Southern-Western part of Odisha is prone to drought and poverty in spite of good rainfall with lot of agriculture activities. This can be attributed to several reasons including physiography, climate, soil, landuse-landcover, human interventions, etc. To investigate the effect of climate change in the region, the study was conceptualized with three major objectives: (i) To analyze long-term historical climatic data to determine trend; (ii) To analyze the future climate in the region based on downscaled GCM data; and (iii) To assess the current potential and utilization gap of water resources in the region to develop management plan. In this study, Mann-Kendall test and Sen's slope estimator test are utilized to investigate the trend for rainfall (110 years), temperature (102 years), and potential evapotranspiration (102 years). The year having considerable shift in rainfall and temperature pattern in the region has also been detected using Pettitt's test and Standard Normal Homogeneity Test (SNHT). The results indicate significant decreasing annual rainfall trend at 5% significant level in the district of Nuapada and increasing trend in Malkangiri district. The southern districts with dominant forest coverage viz. Koraput and Rayagada are showing increasing rainfall trend though non-significant, whereas Bolangir, Kalahandi, Nabarangpur and Sonepur districts are showing decreasing trend. Monsoon rainfall shows decreasing trend in the districts of Nuapada, Kalahandi, Sonepur, Bolangir and Rayagada. The entire region is witnessing decrease in winter rainfall which plays a significant role for the rabi crops.

The future rainfall and temperature is also downscaled for the region using HadCM3 Global Climate Model (GCM) for A2 and B2 scenarios. The KBK region is falling mainly in two sub-basins viz. Tel and Sabari sub-basins. The catchment area of the Tel basin is Indravati project, Patora dam are few projects meeting the irrigation and drinking water demand in the region. Apart from this, few multipurpose projects (major and minor) are in pipe-line such as Ong irrigation project, Lower Suktel project, Tel project, etc. under AIBP and RIDF programmes in the KBK region. The water availability and utilization for Tel basin (sub-basin to Mahanadi basin) has been investigated. Daily discharge data for the Tel river for the duration 1972-2012 has been analyzed to compute annual dependable flow. The average annual yield for the basin is found to be about 9934 Mm^3 at 75% dependability. SWAT model has been applied to validate the results for the Kantamal and Kesinga G&D sites. There are no major irrigation projects in the Tel basin. However, the combined annual utilization for drinking water, irrigation, and industry is about 4210 Mm^3. SWAT model.

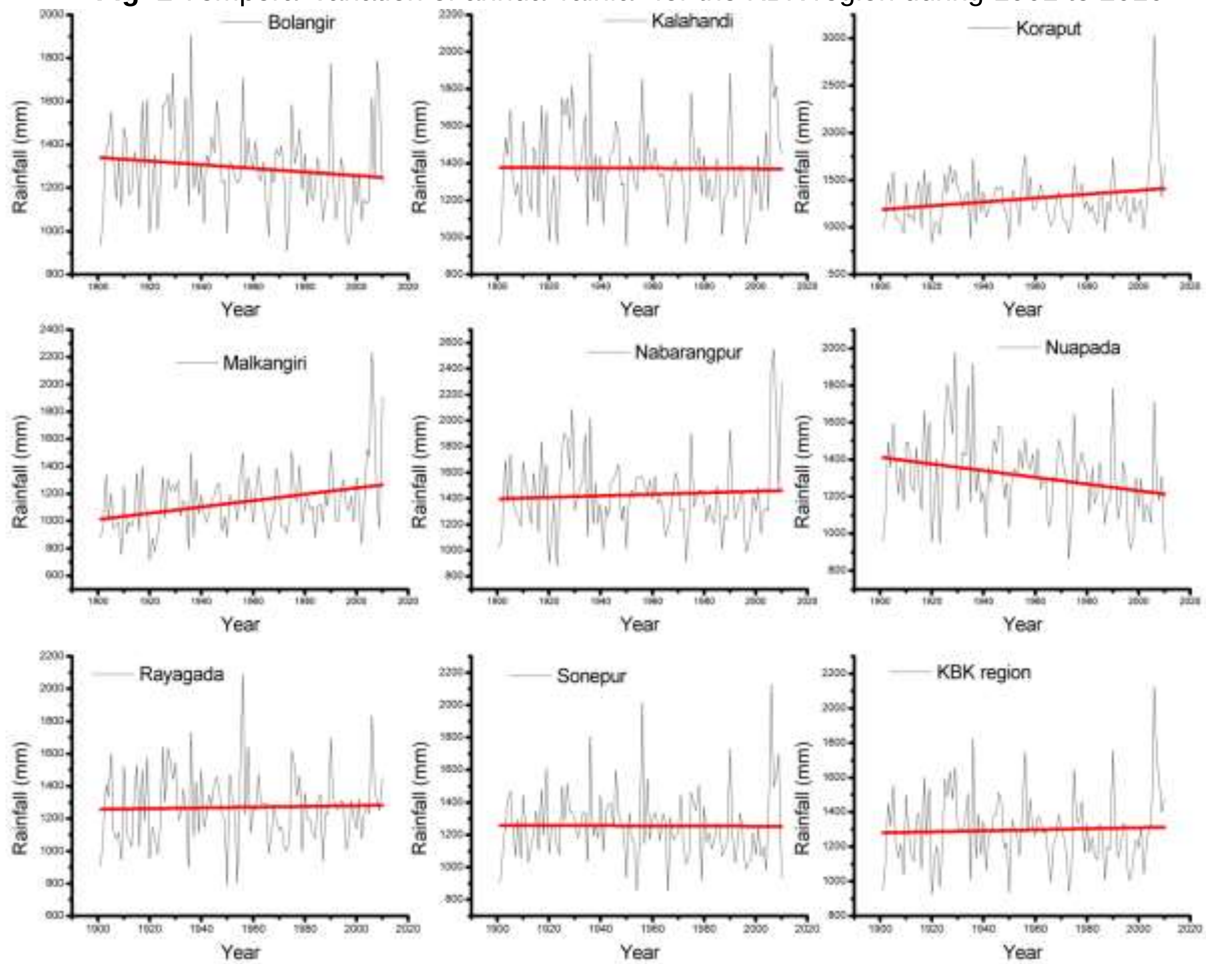
The important findings from the study are:

i. Northern KBK region getting drier (decreasing rainfall trend) whereas Southern KBK region is getting wetter.
ii. Entire KBK region is 'warming', Northern part is showing increasing rate of trend in last one decade, whereas Southern KBK region is showing a more or less constant rate of change in the temperature.
iii. An increasing trend in the potential ET in the entire KBK region.
iv. Precipitation and temperature (max) will likely to increase in future in the region as per HadCM3 A2 and B2 scenarios.
v. The average annual water availability at 75% dependability in the Tel basin is about 10,000 Mm^3 sufficient to meet the water demand in the region with proper storage and water management practices

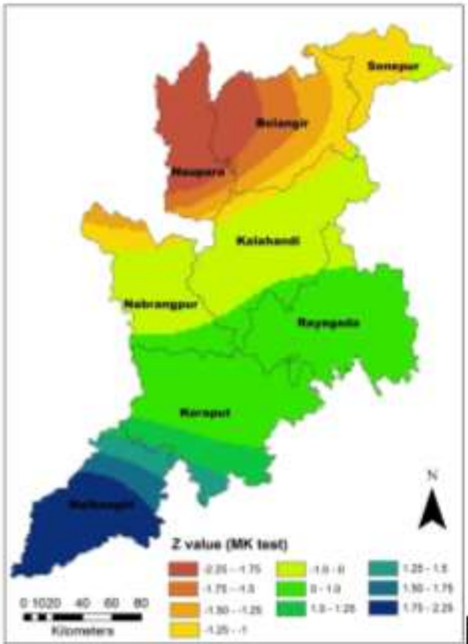
The distinct climate variability of the Northern-Southern parts can be attributed to the distinct physiography of the region with a clear ridge line dividing the Northern and Southern districts. Northern districts are 'land-locked' with less coastal influence (about 300-350 km away) in comparison to South parts (100-150 km). Also the northern region is exposed to intense irrigated agriculture due to Hirakud reservoir and presence of lot of industries since 2003-04, whereas the southern districts viz. Malkangiri and Koraput have dense forest coverage influencing the climate in the region. Soils in the district of

Nuapada and Kalahandi are mostly ‘Black Cotton’ with high clay content resulting in poor retention of rainfall.

Fig. 1 Temporal variation of annual rainfall for the KBK region during 1901 to 2010



(Thick red lines represent linear trend lines)



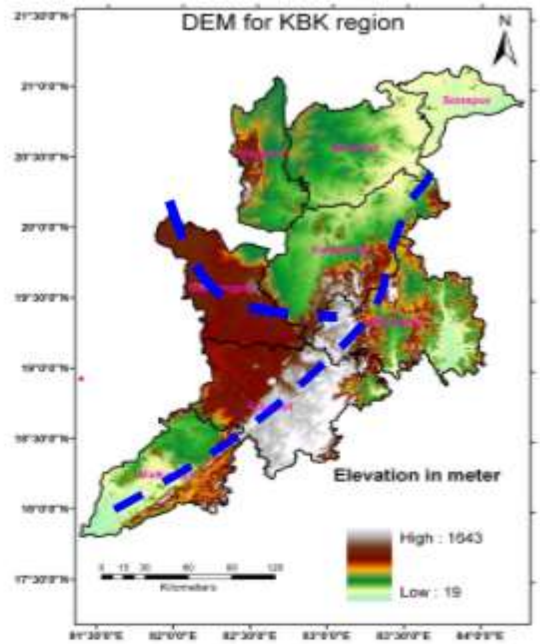


Fig. 2.1: Z value (MK test) for the annual rainfall (110 years) of the KBK districts; **Fig. 2.2** DEM for the KBK region indicating a distinct clear ridge.

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2016/01

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

2. **Project team:**

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

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

4. **Objectives**

Envisaged objective of the study is to develop a WINDOWS interface (named as NIH_Basin – NIH_Basin-Simulation) of a model developed for assessment of water resources in a river basin for easy application by the user groups. It is also proposed to carry out a number of modifications in the model (developed in earlier study) for comprehensive analysis of water resources at basin scale.

5. **Methodology**

Model is planned to work in two modes: a) monthly mode (in which the simulation is carried out at daily time step for a month and then the spatial recharge and discharge pattern are externally used to find the revised water table in the basin with some groundwater simulation model, say Visual MODFLOW, and the revised groundwater table is used for the subsequent month), and b) continuous mode (in which the simulation is carried out at daily time step for the complete period for which hydro-meteorological data are available). In the second mode, grid-wise pumping and recharge estimations are accumulated over each sub-basin and then divided by the S_y of sub-basin to convert water withdrawal/ recharge to corresponding change in groundwater level which can be applied to initial groundwater surface to find the revised surface in the sub-basin, thus avoiding the necessity of detailed groundwater simulation.

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

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

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

6. **Present Progress:**

The concerned PI is on a visit to the Netherlands.
The progress will be placed on table at the time of meeting.

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2016/02

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

2. Project team:

a. Project Investigator: Dr. Sanjay K. Jain, Sc "G"

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

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

4. Objectives:

The objectives of the proposed study are as follows:

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

5. Methodology

- Creation of database of the study area(s)
- Glacier inventory and glacier change occurring in the study area.
- Trend analysis of past and future meteorological data
- Glacier mass balance study and modeling of glacier melt runoff
- Projection of temperature change
- Assessment of changes in glacier melt runoff vis-à-vis glacier change/change in meteorological inputs

6. Research outcome from the project

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

7. Cost estimate

a. Total cost of the project: Rs. 12.00 lakhs

b. Source of funding: NIH

c. Sub Headwise abstract of the cost

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

8. Work Schedule

a. Date of commencement of the project: October 2013

b. Duration of the project: 3 years

c. Stages of work and milestone:

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

9. Progress:

Three sub basins of Satluj basin have been taken and they are Baspa, Tirunglhad and Spiti (shown in Figures 1 & 2). In these three basins glacier change have been computed using glacier map obtained from Topographical maps (1966) and satellite data (2000, 2006 and 2011). It was observed that the glacier areas in these basins have been receding. Trend analysis of discharge data of three sites (Sangla, Thangi and Khab), temperature data (Raksham, Kaza, Kalpa) as well as snow water equivalent (SWE) have been carried out. The changes in glacier have been correlated with temperature and aspects have been obtained.

The data base for modeling of snow/glacier melt runoff is under preparation. The model will be simulated for assessment of runoff under present and future scenarios. For future scenarios, already correspondence with Dr. Dimri from JNU, Delhi has been made. The setup of simulation of the model will take another 3-4 months; therefore an extension of 6 months is required for completion of the report. The progress of the study will be presented in the meeting.

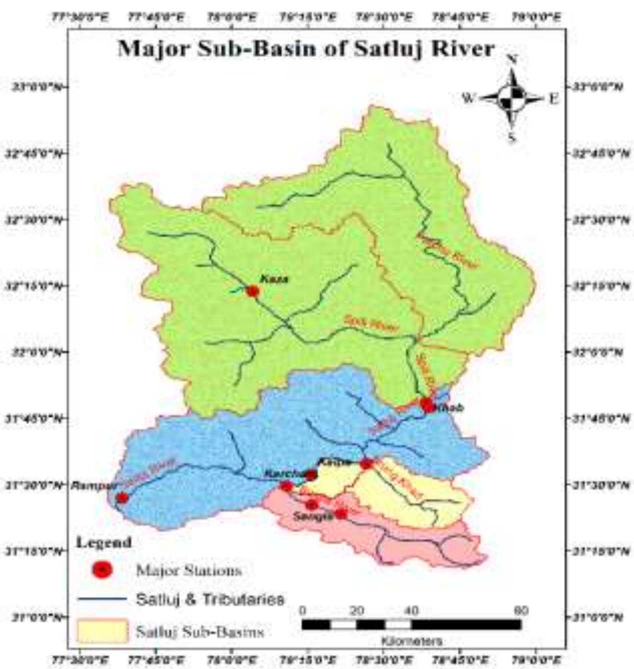


Fig. 1 Study area

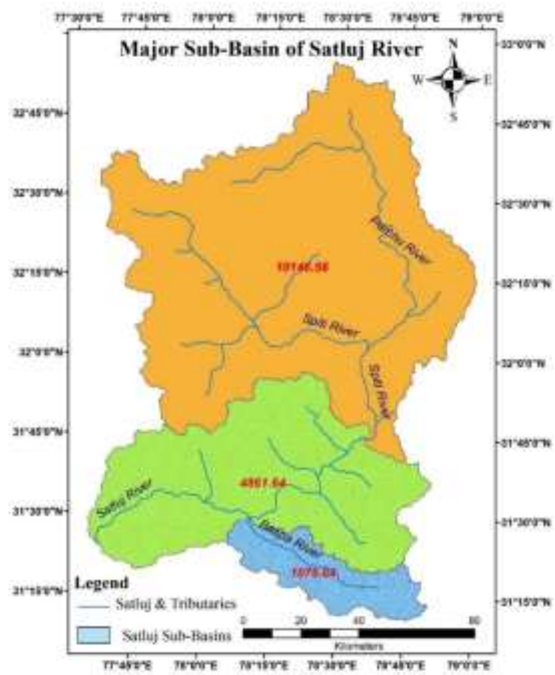


Fig. 2 Major sub-basins of Satluj River

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2016/03

1. **Thrust Area** **:** Himalayan Cryosphere and Climate Change

2. **Project team** **:** Dr. R.J. Thayyen, Dr.S.P. Rai, Dr. Sanjay Jain, Dr. Sudhir Kumar

3. **Title of the project** **:** Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh.

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

5. **Methodology**
    a) Monitoring of weather parameters by AWS at 3500 m a.s.l., 4700 m a.s.l. and 5600 m a.s.l. for studying the orographic forcing
    b) Monitoring discharge and Electrical conductivity at 4700 m a.s.l & 3500 m a.s.l.
    c) Measuring ground temperature for permafrost studies
    d) Geophysical investigation of potential permafrost zones
    e) Isotope studies of stream discharge at 4700 m a.s.l. and 3500 m a.s.l.
    f) Runoff modeling by SNOWMOD by incorporating the new SELR concept

6. **Research Outcome from the Project:** The project is aimed at quantifying various hydrological components in the catchment and its seasonal responses. Better understanding of the lean season winter outflow from the groundwater system is intended to bridge the critical knowledge gap of the mountain groundwater resources and its linkages with the surface water. Understanding of the orographic processes and mountain climate at the nival/ glacier systems to decipher the climate change impact on the cold-arid cryospheric system better.

7. **Cost estimate:**
    a. Total cost of the project: 48 lakhs
    b. Source of funding: NIH
    c. Sub Head-wise abstract of the cost

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

8. Work Schedule

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

9. Analysis and results

This study was initiated in July 2014 in continuation of the studies of past 05 years in the Ladakh region (Fig.1). In view of the expanded research preview, a new discharge and meteorological station are established at 3700 m a.s.l. at Gonpa area. During the reporting period mass balance of data generated from Phuche glacier is processed. It is seen that Phuche glacier recorded positive mass balance of 0.15 m w.e during 2014-15 mass balance year. Winter mass balance of 2014-15 was 0.67 m w.e as on 25-05-15. Post winter accumulation continued till 23-6-16 and a further accumulation 90 mm w.e. recorded during this period. This has delayed the glacier exposure to August 22 and resulted into positive mass balance response of the glacier in the study year. Meteorological data is generated from 3700, 4700 and 5600 m a..s.l. and discharge data from 4700 m a.s.l. were also analysed during the reporting period.

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

<u>**ONGOING STUDIES**</u>

<u>**INTERNAL RESEARCH PROJECT: NIH/WRS/2016/04**</u>

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

2. Project team:

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

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

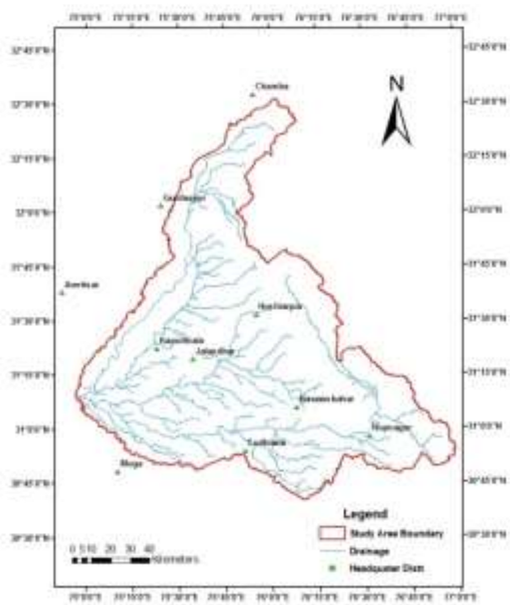
3. Title of the Project: Hydrological modeling of a part of Satluj basin using SWAT Model

4. Objectives:

i. To develop the data base of a part of Satluj river basin (between Ropar D/s of Bhakra dam to Harike) and
ii. To carry out hydrological modeling of the basin using ArcSWAT model to find out water balance components, e.g. actual evapo-transpiration etc.

5. Methodology

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



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

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

6. Research Outcome from the Project

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

7. Cost Estimate:

e. Total cost of the Project: Rs. 23.00 lakhs
f. Sources of Funding: NIH
g. Sub head wise Abstract of Cost

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

8. Quarterly Break up of cost estimate for each year
Year: 2015-16

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

9. Work Schedule

d. Date of commencement of work June 2014
e. Duration of Work 2-3/4 Years
f. Stage of work and Milestone

SN	Work Element	**First Year (2014-15)**			**Second Year (2015-16)**				**Third Year (2016-17)**			
		Jun-Sep	Oct-Dec	Jan-mar	April-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jen	Jul-Sep	Oct-Dec	Jan-Mar
1	Literature Review & Data Collection											
2	Development of data base for a river basin for SWAT model											
3	Application of SWAT model											
4	Analysis of Results											
5	Preparation of Report											

10. Progress made between December 2015 onwards

- From the meteorological data downloaded earlier, input weather data for the model has been prepared.

- The outflow at Bhakra and Pong dam is available. For simulation of the model, discharge data at Harike barrage is required. For discharge data at Harike, Chief Engineer, Irrigation Department, Punjab was contacted and discharge data for 2011-15 have been obtained. However, for the simulation of the model, data for the period of 1995-2010 is required, which is not available in digital form. Therefore, hard copies of the data will be collected in the month of April 2016. After that calibration & validation of the model will be carried out.

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2016/05

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

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

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

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

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

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

6. **Methodology**

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

7. **Research outcome from the project**
   a. Water availability in various sub-basins in present and changed future climate.
   b. Reservoir operation rules for existing and future climatic scenarios: Model was set up for reservoir operation and optimization in Khadakwasla complex.
   c. Meteorological and hydrological drought indices: Data preparation was done for computing meteorological drought indices.

d. Conjunctive use in canal command areas.
e. River water quality modeling in river reaches and impact of climate change: Water quality model was set up.
f. Interfaces for decision support.

8. Location map/ study area

Upper Bhima basin up to Ujjani in Maharashtra state

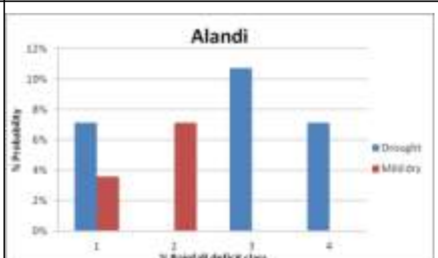
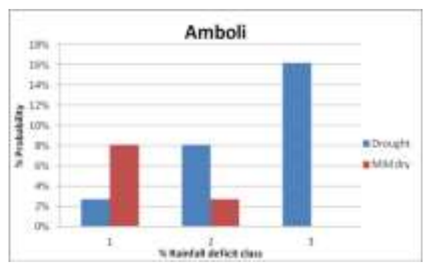
9. Approved action plan and time line

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

10. Recommendations / suggestions in previous WG

None

11. Achievements

Year	Objectives	Achievements
2015	Drought prediction	  *Meteorological drought*: Probability of drought of four month scale for mild dry and drought cases were estimated using SPI values. Figure shows plot for two stations between drought probability (in %) and the percent deficit rainfall (June-September) classes <20, 20-40, 40-60 and >60. Overall drought and mild dry probabilities were 25 and 11%, 27 and 11% for Alandi and Amboli respectively.
2015-16	Water quality modeling	*Load calculation method (MS Excel)*: Taluka level source data (population, livestock and fertilizer) were distributed (uniformly) to catchments and summed to find values for the catchments. Catchment wise effluent load was also obtained. Unit loads for sources and concentrations for effluents were used to obtain total loads. Catchment wise runoff factors and load apportioning (except for effluents) in to time varying and constant flux, NO_3-N and NH4-N fractions (for fertilizers) were specified. Total time varying load and constant flux were computed. Time varying load was distributed using discharge data and constant flux (assumed to be diffuse flux) was added to determine total pollutant flux.

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2016/06

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

2. Project team:

a. Project Investigator: Dr. Sanjay K. Jain, Sc G

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

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

4. Objectives:

A major goal of the proposed study is to do hydrologic modeling of the basin. The objectives of the proposed study are as follows:

- Collection and processing of historical data
- Future climate projections will be applied to see the changes in meteorological variables.
- Modelling of rainfall runoff.
- Impact of changes on stream flow in the basin.

5. Methodology

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

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

6. Research Outcome from the Project

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

7. Work Schedule

a. Date of commencement of work November 2014

b. Duration of Work 2-3/4 Years

c. Stage of work and Milestone

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

8. Progress

The hydro-meteorological data for the study area have been procured from India Meteorological Department, Pune, and the hydrological data have been obtained from Central Water Commission, Bhopal. Efforts have been initiated to setup the model for the study area. The data layers pertaining to the land use/land cover have been completed. Similarly, the data layer of soil classification and Digital Elevation Model (DEM) has also been completed in GIS format. The data required by the model in the gridded format have been extracted from these GIS layers. Presently the season-wise cropped area data is being prepared in GIS and the necessary data for the model run shall be extracted thereafter.

The default (normal) run of the model has been completed successfully after correction of the initial problems in the source code. However, still some issues persist pertaining to the computation of total flows/local flows in the grid cells and the use of various options available in the post-processor. The matter is being looked into by CEH at present. The model has been setup for the entire Narmada basin and initially an attempt was made for single site calibration of the model using the observed flows at Hoshangabad. Some issues pertaining to model calibration are being sorted out with CEH. Thereafter the multi-site calibration will be carried out considering all the inputs including cropped area and reservoirs for the Narmada basin up to Hoshangabad.

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2016/07

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

2. **Project Team:**
   Project Investigator: Dr. R.J Thayyen, Sci-D
   Project Co-Investigators: Dr. Sanjay Jain, Sci-G

3. **Title of the Project:** Runoff modelling of Shyok River, Karakorum Range

4. **Objectives:**
   1. To generate runoff data at Km 150 for BRO-HIMANK
   2. To develop a baseline runoff and meteorological data of Shyok basin
   3. Runoff modelling of Shyok River at KM 150 & Shyok village

5. **Methodology**
   1. Monitoring of weather parameters and discharge by AWS at Km 150 (5600 m a.s.l.) for generating climate data for runoff modeling.
   2. Generation of snow cover depletion curves through melt season
   3. Runoff modeling by SNOWMOD and Win SRM at this two stations

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

7. **Cost Estimate**

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

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

8. **Work Schedule**

S. No.	**Work Element**	**First Year**				**Second Year**				**Third Year**			
		Q1	**Q2**	**Q3**	Q4	**Q1**	**Q2**						
1.	Monitoring weather												

2.	Monitoring Q												
4.	Runoff modeling												

9. Analysis and result

Runoff of Shyok River is observed at discharge station set up at km 150 at Durbuk-DBO road. Water level monitoring is carried out at 5 minutes interval. The data has been downloaded in the month of September 2015 from the remote site and analysis of the data has been carrying out. Intermittent flow velocity measurement is carried out at the discharge section. Rating curve is generated by this data and cross section measurement of the discharge site and discharges for 2015 summer months is calculated. Snow cover depletion curves of the basin for the past three years including 2015 were generated and trend in the snow cover depletion is studied during the reporting period. Temperature data from BRO is awaited for undertaking the snowmelt runoff modeling.

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH/WRS/2016/08

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

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

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

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

5. **Methodology**

(A) Study Area:

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

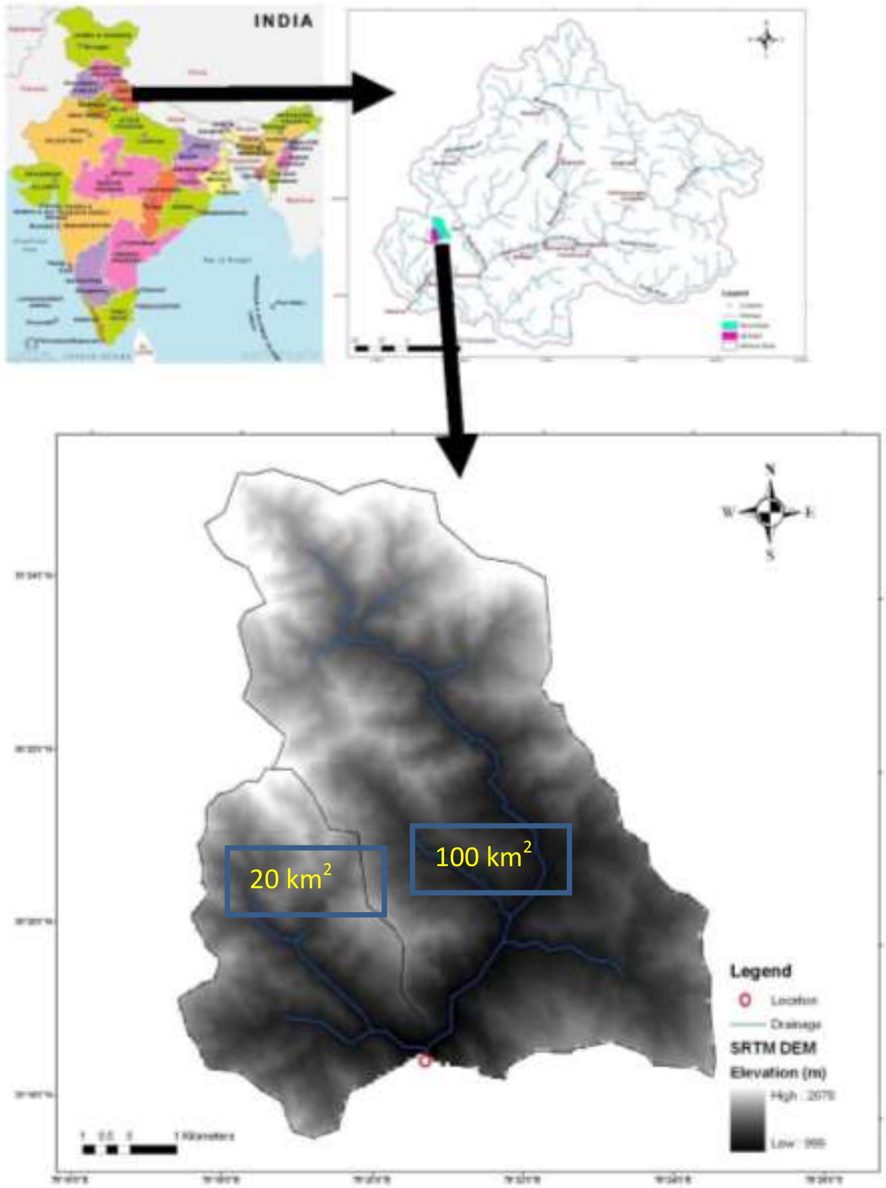


Fig. 1.0 Location of the Hinval watershed up to Jijli within India

(B) Experimental setup

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

(C) Soil Heat Flux

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

(D) Evapotranspiration (ET)

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

(E) Soil Moisture

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

(F) Hydrologic Modelling

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

6. 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.

7. 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.

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

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

9. Work Schedule:

a. Date of commencement of the project: 01.01.2015

b. Duration of the project: 5 years

c. Stages of work and milestones:

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

10. Progress till date:

The construction and establishment of the gauging structures (rectangular weir) in the agricultural as well as forested catchment has been completed and manual water level monitoring (via Staff gauge) has started from Feb-2016. The installation of one automatic weather station (AWS) with soil parameters monitoring station has also been done in the agricultural catchment and all the data at an interval of 30min is being received at NIH servers through FTP from 23rd of March on near real time basis. Meanwhile, the recruitment of one RA and one filed staff has also been done from another sponsored project . For installation of automatic water level recorder,work order has been issued and the instrument setup and installation process may take another 30-35 days. Efforts are underway to fence the installed AWS and other instruments for ensuring their secure and safe long term operation. Since the project is about experimental hydrology, so only once we have some 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.

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH-E/WRS/2016/09

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

2. **Project team:**

   a. Project Investigator: Deepa Chalisgaonkar, Sc F

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

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

4. **Objectives**

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

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

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

The Government of India has recently launched the ambitious ‘Namami Gange’ an Integrated Ganga Conservation Mission with activities related with conservation and rejuvenation of the Ganga. Recognizing the multi-sectoral, multi-dimensional and multi-stakeholder nature of information in the Ganga basin, it is need of the hour to develop a web-based platform where different types of data/ information (facts; publications; data; maps; photographs; etc.) related to Ganga basin is available at one place. ‘Ganga Information Portal’ (GIP) is a step in this direction to develop a web-based information portal where variety of information on Ganga basin will be uploaded and maintained at National Institute of Hydrology, Roorkee.

6. **Methodology**

The GIP is being developed by using the World Wide Web (WWW) technology which is based on an open unstructured distributed hypermedia information system. It consists of non-linear, flexibly linked HTML (Hyper Text Media Language) documents, in which different types of WWW objects are being embedded.

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

7. **Research outcome from the project**

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

8. Cost estimate:

a. Total cost of the project : Rs.65.55 lakhs

b. Source of funding : NIH

c. Sub Headwise abstract of the cost

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

9. Quarterly Break up of cost estimate for each year

2015-2016

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

10. Work Schedule:

a. Date of commencement of the project : April 1, 2015

b. Duration of the project: 3 years, however, GIP is an integrated information portal which requires continuous efforts in up-gradation and maintenance.

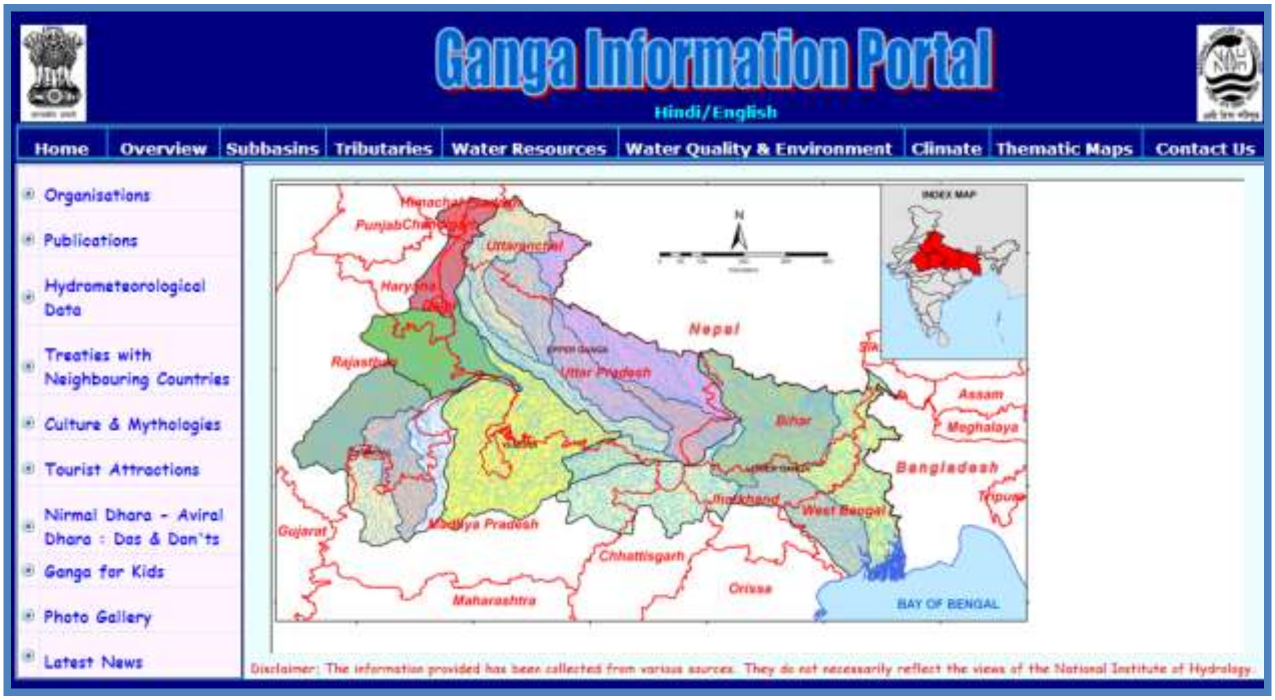
c. Stages of work and milestone:

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

11. Progress:

The portal is being developed as per the sitemap shown in Fig.1. The information is being categories as Overview, Sub Basins, Watersheds and Tributaries, Water Resources, Climate, Thematic Maps, Photo Gallery, Organisations, River Development & Rejuvenation, Publications, Treaties, Mythologies, Nirmal Dhara - Aviral Dhara: Dos & Don'ts, Cultural, Ganga for Kids, Latest News etc.

Presently the work is being done on compilation of technical reports, technical notes, project reports, case studies, research papers, M.Tech and Ph.D thesis etc. Various organizations are being contacted for this purpose. The collected publications are being computerized and will be will be made available through this portal



ONGOING STUDIES
EXTERNAL RESEARCH PROJECT: NIH-E/WRS/2016/10

1. Thrust Area under XII five year Plan

2. Project team:

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

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

4. Objectives-

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

5. 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. Cost estimate:

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

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

8. Quarterly Break up of cost estimate for each year

Year: 2015-16

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

Year: 2016-17

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

9. Work Schedule:

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

S. No.	Work Element	First Year	Second Year	Third Year
1.	Literature survey and Data collection, selection of watersheds	*		
2.	Processing and analysis of hydrometereological data, GIS database development,	*	*	
3.	Assessment of variation in surface water		*	

S. No.	Work Element	First Year	Second Year	Third Year
4.	Ground water variation, Drought characterization		*	
6.	Climate change, Inter-comparison of water resources variability in selected basins and suggestions for IWRM.		*	*
7.	Preparation of Final report			*

10. Progress of Work

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

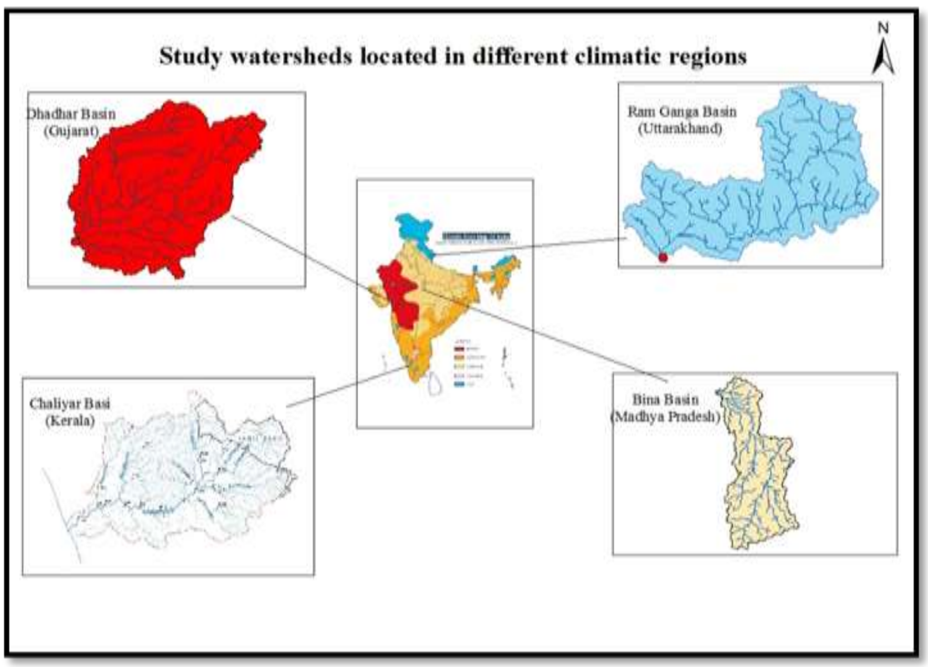


Figure 1: Study watersheds located in different climate regions of India

11. Progress since last working group

- Hydro-meteorological data for Ramganga, Bina and Chaliyar have been processed and preliminary analysis has been carried out.
- GIS data base development: Landuse/Land and soil maps prepared for Ramganga and Bina basins.
- Ground water data has been processed for Bina basin.
- Drought characterization also in process for Bina and Ramganga basin.

ONGOING STUDIES
INTERNAL RESEARCH PROJECT: NIH-E/WRS/2016/11

1. Thrust Area under XII five year Plan

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

2. Project team:

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

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

4. Objectives-

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

5. Methodology

Model Development:

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

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

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

Study Area:

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

In this study, instrumentation setups is being established for measuring suspended sediment concentration (SSC) on storm and daily basis during monsoon season. Depth Integrating Sediment Sampler (US DH 59) will be used to measure SSC. Digital hand held water velocity meters will be used to measure the stream velocity and discharge.

Probes will be used to measure temperature, dissolved oxygen (DO), biological oxygen demand (BOD), pH, conductivity, total dissolved solids (TDS), etc.

6. Research outcome from the project

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

7. Cost estimate

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

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

a. Justification for Sub-head-wise abstract of the cost
Salary head accounts for involvement of minimum 1 semi-skilled labour @Rs. 15000/-month. Travelling expenditure include visit to Hinvel watershed.
Misc. expenditure for an amount of Rs.10000.00 per quarter has been considered.

8. Quarterly Break up of cost estimate for each year

Year: 2015-16

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

9. Work schedule

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

Project Year	Jan 2016-Dec 2017				Jan 2017-Dec 2018			
Project Quarter	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**
A. Concept Building and understanding of study basin	■	■						
B. Procurement of Instruments	■	■						
C. Establishment of Instruments		■	■					
D. Data gathering, Preparation & Synthesis		■	■	■	■	■	■	■
E. Modelling Time distributed sediment yield:			■	■	■	■		

	Model Development								
F.	Model Application and Testing								
G.	Incorporation of Geo-morphological parameters in sediment yield model								
H.	Model Application and Testing								
I.	Incorporation of soil moisture accounting (SMA) procedure in sediment yield model								
J.	Model Application and Testing								
K.	Sensitivity Analysis of the models								
L.	Final Report Preparation								

10. Progress till date:

1. Keeping in view of the objectives of the proposal, the conceptualization and development of sediment graph model for estimation of temporal distribution of sediment yield is in progress.
2. The procurement process of depth-integrating sediment sampler (US DH 59) to measure the suspended sediment concentration is in progress. The weir structure and gauging staff has already been established by the division.
3. The storm event data (rainfall, runoff and sediment) of the monsoon season (June to October) will be used for analysis.

ONGOING STUDIES
INTERNAL RESEARCH PROJECT

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

PI: Dr. M. K. Goel

Envisaged objective of the study is to develop a WINDOWS interface (named as NIH_Basin – NIH_Basin-Simulation) of a model developed for assessment of water resources in a river basin for easy application by the user groups. It is also proposed to carry out a number of modifications in the model (developed in earlier study) for comprehensive analysis of water resources at basin scale. For approximating the EAC relationships for a reservoir, the approach developed by J. Mohammadzadeh-Habili et al. (2009) has been adopted, avoiding the necessity of specifying EAC tables for various reservoirs in the river basin. Rule-curve based approach has been added in the FORTRAN code for simulating the reservoir operation as per specified operation policy. The option of hydropower simulation of a reservoir has also been added. Model is planned to work in two modes: a) monthly mode (in which the simulation is carried out at daily time step for a month and then the spatial recharge and discharge pattern are externally used to find the revised water table in the basin with some groundwater simulation model, say Visual MODFLOW, and the revised groundwater table is used for the subsequent month), and b) continuous mode (in which the simulation is carried out at daily time step for the complete period for which hydro-meteorological data are available). In the second mode, grid-wise pumping and recharge estimations are accumulated over each sub-basin and then divided by the specific yield of sub-basin to convert water withdrawal/ recharge to corresponding change in groundwater level which can be applied to initial groundwater surface to find the revised surface in the sub-basin, thus avoiding the necessity of detailed groundwater simulation. During the year, a number of modifications have been made in methodology and the source code for making it more practicable and realistic. Some of these modifications include:

a. GW potential factors specified for two conditions – Temporal (based on increase in GW development) and Position (based on current average GW table in sub-basin.
b. Modification made in the input for specifying outlet from hydropower to join a downstream stream segment or to go outside of the basin.
c. For conditions when there is no crop on a grid and next season crop is yet to be planted, consideration of an intermediate land use (with specified properties) is included.

For WINDOWS interface of the model, various data input forms are being developed. During the year, efforts have been made in developing an excel-based procedure for preparing interactive data forms, to run an executable program with the data forms, and evaluate the results in Excel. The procedure helps in avoiding the development of a separate code in Visual Basic for the linkage of various data files and programs. Research outcome from the project is a spatially distributed river basin planning and management model for integrated water resources assessment and management at basin scale. The study can help water resources departments and river basin authorities in the analysis at river basin scale. It can also help in assessing the impact of various natural and anthropogenic activities on various components of the hydrological cycle at basin scale.

NEW STUDIES (SPONSORED): NIH-E/WRS/2016/01

SERB Project (New Project)

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

2. **Project Team:**
   Project Investigator **:** Dr. R.J. Thayyen, Sci-D
   Project Co-Investigators **:** Dr. Farooq Azam, Inspire Faculty
   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 & 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. Energy balance studies

The surface Energy balance (SEB) studies will be carried out on the ablation zone of both the glaciers near ELA region. Assuming a lack of horizontal energy flux transfers, for a unit of volume of a glacier (a depth from the surface where no significant heat fluxes are found) and for a unit of time, the surface energy balance can be expressed by Eq. 1 (Oke, 1987)

$$\mathrm{SWI} - \mathrm{SWO} + \mathrm{LWI} - \mathrm{LWO} + H + \mathrm{LE} + G = F_{\mathrm{surface}} \qquad (1)$$

Where SWI, SWO, LWI and LWO are the short-wave incoming, short-wave outgoing, long-wave incoming and long-wave outgoing radiation fluxes, respectively. H and LE are the sensible and latent turbulent heat fluxes, respectively. G is the conductive heat flux in the snow/ice and P is the heat supplied by precipitation. F_{surface} is the net heat flux available at glacier surface. For the data collection a portable AWS will be installed in the middle of ablation zones of both the glaciers. Measurement of energy fluxes at glacier surface will be carried out during the summer season in order to understand the melting processes on the glacier surface Roughness length of momentum, temperature and humidity will be established for both the glaciers with two layers of wind speed and temperature measurements. Sensible and latent heat fluxes will be carried out by the bulk method. The SEB studies will be complimented by the Degree Day method as well.

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 :

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

RESEARCH MANAGEMENT AND OUTREACH DIVISION

Scientific Manpower

S N	Name	Designation
1	Dr. V C Goyal	Scientist G & Head
2	Sri Omkar Singh	Scientist F
3	Dr Jyoti P. Patil (LCU-Delhi)	Scientist C
4	Sri Subhash Kichlu	PRA
5	Sri Rajesh Agrawal	SRA

WORK PROGRAMME FOR YEAR 2015-2016

SN	Title of Project/Study, Study Team	Duration
1.	**Study- 1 (RMOD/2015-16/TS-1)** Water Conservation and Management in Ibrahimpur Masahi Village of Hardwar District (Uttarakhand) **Team:** Omkar Singh, V.C. Goyal, C.K. Jain, J.V. Tyagi and Rajesh Singh	DOS: Apr 2013 DOC: March 2016 (Ongoing study)
2.	**Study- 2 (RMOD/2015-16/TS-2**) Customization of WEAP model for application in Ur river watershed in Tikamgarh district of Bundelkhand region. **(Under TIFAC Project)** **Team:** R V Kale (PI), T Thomas- RC Bhopal, Jyoti Patil, Rajesh Agarwal	DOS: Apr 2014 DOC: Mar 2016 (completed)
3.	**Study-3 (RMOD/2015-16/TS-3)** WEAP Model set up for four sub-basins under Pilot Basin Studies (PBS) Programme, jointly with the RCs/CFMSs **NIH HQs:** V C Goyal (PBS Leader), Jyoti Patil and R V Kale **Co-investigators from NIH RCs/CFMSs:** Chandramohan T (RC-Belgaum), Y R S Rao (RC-Kakinada), T R Nayak (RC-Bhopal), B Chakravorty (CFMS-Patna)	DOS: Apr 2015 DOC: Mar 2017 (Ongoing study)

Study-1

1. **Title of the Study:** Water Conservation and Management in Ibrahimpur Masahi Village of Haridwar District (Uttarakhand)

2. **Study Group:**

Investigators: Omkar Singh and V.C. Goyal
Scientific/Technical Staff Subhash Kichlu, Rajesh Agarwal **Resource Person (Senior):** Dr. Dinesh Kumar (w.e.f. 1.4.2016)

3. **Type of Study**: Internal
4. **Date of Start:** April, 2013
5. **Scheduled Date of Completion** March, 2016 (requires 6 month extension)
6. **Duration of the Study:** 3 years
7. **Study Objectives:**
   - Assessment of water demand in the study area
   - Assessment of water availability in the study area
   - Assessment of water quality in the study area & eutrophication status of ponds
   - Preparation of water conservation plan for the study area

8. **Statement of the Problem:**

In our country, most of the traditional sources of water (i.e. ponds) in villages are on the verge of disappearing/shrinking due to encroachment, siltation and water quality deterioration and face severe eutrophication. The ponds located in the Haridwar District are also suffering from various hydrological problems and are at the verge of extinction, which require immediate intervention to restore for various uses. Rain water harvesting is a popular technique of developing surface water resources that can be used to provide water for livestock, domestic use and irrigation purposes. The purpose of rain water harvesting is to either augment existing water supplies or to provide water where other sources are not available. It also aims to provide water in sufficient quantity and of suitable quality for the intended use. Therefore, water conservation and its management of village ponds is essential for proper utilizing the water for beneficial use in the society. The water conservation and rain harvesting may be helpful for improving the livelihood of the peoples. The present study has been taken for Ibrahimpur Masahi revenue village, lying under Shipla Nadi-Halzora Nadi watershed (a tributary of Solani River), District Haridwar (Uttarakhand). The area of Ibrahimpur Masahi revenue village is 14.26 km^2. The Ibrahimpur Masahi revenue village consists of 5 five sub-villages under its jurisdiction, namely- Ibrahimpur, Masahi, Belki, Inayatpur and Halzora.

9. Methodology:

In this study, the necessary data from different sources was obtained for human population, cattle and crop acreage and types in the area. The village level data on demography, dwelling amenities, public buildings, etc. was also collected door to door during surveys. Field investigations were carried out to study soil characteristics (infiltration, soil texture and soil moisture, etc.) under different land uses. The surface and ground water quality monitoring and analysis was carried out as per standard procedures (APHA 1989; Jain and Bhatia, 1987). The water quality was evaluated for drinking (BIS-2012) and agriculture purposes (BIS-1987/2001; USDA 1954). Eutrophication of ponds was assessed using Carlson's Trophic State Index (Carlson, 1977) and to suggest rejuvenation of the ponds. Rainfall data for 27 years (1987 to 2013) was used to decipher dependable rainfall at 50% and 75% frequency levels based on data of nearest hydro-meteorological observatory at Roorkee. The rainwater harvesting potential of the sub-villages covering roof top water structures (school & Govt. building) would assessed using Ghisi et. al. (2006). The planning of wastewater management vis-vis rejuvenation of existing ponds is also proposed in the study. The brief methodology is given below:

Estimation of Domestic Water Requirement (Human Needs): In this study, the quantity of domestic water (m^3) per capita per day (DWR_d), per month (DWR_m), and per annum (DWR_a) was estimated as follows (based on vision of M/o DW&S, GoI):

$$DWR_d\ (m^3/day) = (P_{rural} \times 70 + P_{urban} \times 135) \times 10^{-3}$$
$$DWR_m(m^3/month) = (P_{rural} \times 70 + P_{urban} \times 135) \times 10^{-3} \times 30$$
$$DWR_a(m^3/annum) = (P_{rural} \times 70 + P_{urban} \times 135) \times 10^{-3} \times 365$$

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

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

Where, C is number of Cattles, B is number Buffaloes, B_o is number of Bovines/yalk, S is number of Sheep, G is number of Goats, S_W is number of Swines, P is no. of birds (poultry).

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

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

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

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

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

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

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

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

Eutrophication Assessment of Ponds: Eutrophication of ponds will be assessed using Carlson's Trophic State Index (Carlson, 1977) based on Sechi disk transparency, phosphate concentration and chlorophyll content. The equations are given below:

TSI (TP) = 14.42 ln (TP) + 4.15 .....(Eq. 1)
TSI (SD) = 60 - 14.41 ln (SD) …..(Eq.2)
TSI (CHL) = 9.81 ln (CHL) + 30.6 .....(Eq. 3)

Preparation of Water Conservation Plan: The water conservation plan in the sub villages consist of following steps:

Step 1: Estimation of rainwater harvesting potential in sub-Villages: The volume of rainwater that could be harvested per household per month was estimated as per Eq. given by Ghisi et al., 2006, as below (Aladenola and Adeboye, 2010; Ishaku, et al., 2013):

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

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

$$Wa = Iv + Vc - Vu$$

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

The analysis will include estimation of:
- Household monthly harvested rainwater & balance after flushing
- Household monthly harvested rainwater & balance after flushing & laundry (combined)

Apart from above, the following analysis will also be carried out:
- Rainwater harvesting potential of village ponds
- Monthly roof top water harvesting potential of schools/govt. buildings
-

Step 2: Planning for Wastewater Management: The ponds are generally used as sink for all wastewater as well as for solid waste generated in the villages. Accordingly, village ponds are going to vanish due to the entry of sewage causing eutrophication. Therefore, it is proposed to suggest overall development of pond (s) including in-situ natural wastewater treatment enabling ponds for rainwater harvesting for the benefit of local peoples.

10. Timeline:

S. N.	Major Activities	2013-14				2014-15				2015-16				2016-17	
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.
1	Review of literature														
2	Reconnaissance survey of the study area														
3	Procurement/Collection of necessary data														
4	Field investigations (WQ, survey of ponds														

	etc.)														
5	Analysis of data for assessment of water demand, availability, Water Quality, etc.														
6	Door to door survey for village level data/ bathymetric survey of pond/eutrophication assessment														
7	Preparation of water conservation plan/ Wastewater management plan of Village (natural treatment system)														
8	Report (s) preparation														

11. Objectives and achievements:

Objectives	Achievements
i) Assessment of water demand in Ibrahimpur Masahi Revenue Village of the Haridwar District.	• Estimation of water demand for domestic, livestock and agriculture has been completed based on data obtained from various sources. (June, 14).
ii) Assessment of water availability in Ibrahimpur Masahi Revenue Village of the Haridwar District.	• Frequency analysis of monthly rainfall data pertaining to Roorkee for 27 Years (1987-2013) was carried out and deciphered dependable rainfall at F=50% and F=75%, respectively. Accordingly, Rain Water Availability at village and watershed level was carried out. (June, 14).
	• Measurement of cross section, water level and velocity data (Sept., 2014) of Shipla-Halzora Nadi was monitored at Imlikhera. The data was analysed to estimate the discharge of the river for Sept., 2014(March, 2015). • The soil texture and soil moisture data was analysed for the study area (March, 2015). • Drainage pattern was prepared using DEM (March, 2015). • Landuse/Landcover map of Ibrahimpur Masahi village was prepared using google earth images. • Groundwater utilization data pertaining to Hand pumps and Tub wells used for drinking and irrigation purposes was collected in the study area.
iii) Assessment of Water Quality Status & Eutrophication of Ponds in Ibrahimpur Masahi Revenue Village of the Haridwar District.	• Water quality sampling from River, Ponds, Hand Pumps/Tubewells, etc. was carried out in the study area and data was analyzed (March, 2015). • Water quality parameters necessary for Eutrophication analysis (Secchi depth, phosphate, Blue Green Algae, Chlorophyll, etc.) of ponds was monitored (Dec. 2015).
iv) Preparation of water conservation plan for the identified village (s)	• Bathymetric survey of village pond at Masahi was completed (Dec. 2015). • A door to door survey was conducted in the sub-villages to collect necessary data pertaining to demography, dwelling amenities, public buildings, etc. for preparation of water

	conservation plan in the study. • Capacity estimation of village ponds was completed for RWH potential of ponds using depth data of bathymetric survey. • Estimated monthly rainwater harvesting potential of 5 sub villages based on door to door survey. • Wastewater management plan of Village (natural treatment system) is being carried out.

12. Recommendation / Suggestion:

Recommendation / Suggestion/Queries	**Action Taken**
Dr N. B. Narasimha Prasad (CWRDM) inquired about water demand estimation for different uses.	Replied

- **13. Analysis & Results:** The water demand for domestic, livestock and agricultural uses has already been estimated for the Ibrahimpur Masahi Revenue Village. Water quality monitoring & analysis of different sources, delineation of drainage pattern, soil moisture and textural analysis and measurement of discharge of Shipla-Haljora nadi was also completed. The bathymetric survey of village pond at Masahi was completed. The works carried out during reporting period include: (i) Capacity estimation of village ponds for RWH potential of ponds (ii) Estimation of monthly rainwater harvesting potential of 5 sub villages based on door to door survey.

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

15. Deliverables: Technical report and papers

16. Major items of equipment procured: -

17. Lab facilities used during the study: Soil & GW Lab, WQ Lab

18. Data procured or generated during the study: Soil Characteristics, Water Quality, Discharge

19. Study Benefits / Impacts: Helpful for improving the livelihood of the local people

20. Involvement of end users/beneficiaries: Local people

21. Specific linkage with Institution and /or end users / beneficiaries: Village Panchayats

22. Shortcoming/Difficulties: -

23. Future Plan: The future Plan of the study is given below:

- Preparation of water conservation plan and natural treatment of wastewater in village ponds.

Study-2

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

2. **Study Group**:

Project Investigator Dr. Ravindra V. Kale, Scientist 'C' (until Feb 2016)
Project Co-investigator Er. T. Thomas, Sc. D, RC, NIH Bhopal Dr. Jyoti Patil, Sc. C, RMOD, NIH Delhi
Scientific/Technical Staff Mr. Rajesh Agarwal, SRA

3. **Type of Study**: TIFAC Sponsored study

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

5. **Date of start:** 01.04.2014

6. **Scheduled date of completion:** 30.09.2015 [Extension upto March 2016]

7. **Duration of the Study:** 18 Months

8. **Study Objectives:**
The main object of the study is the customization of **W**ater **E**valuation **A**nd **Pl**anning (WEAP) model for linking the Integrated Water Resource Management (IWRM) in Ur River catchment in Tikamgarh district of Madhya Pradesh (India). This main objective of the study can be accomplished with following sub-objectives:
    1. To prepare the input data structure for WEAP model.
    2. To test the ability of WEAP model to be used as a simulation tool to perform different types of scenario analysis studies

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

resources with livelihood issues and future climate change impacts will provide the decision makers to decide upon alternate management options under various scenarios.

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

10. **Approved Action Plan / Methodology**

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

Methodology:

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

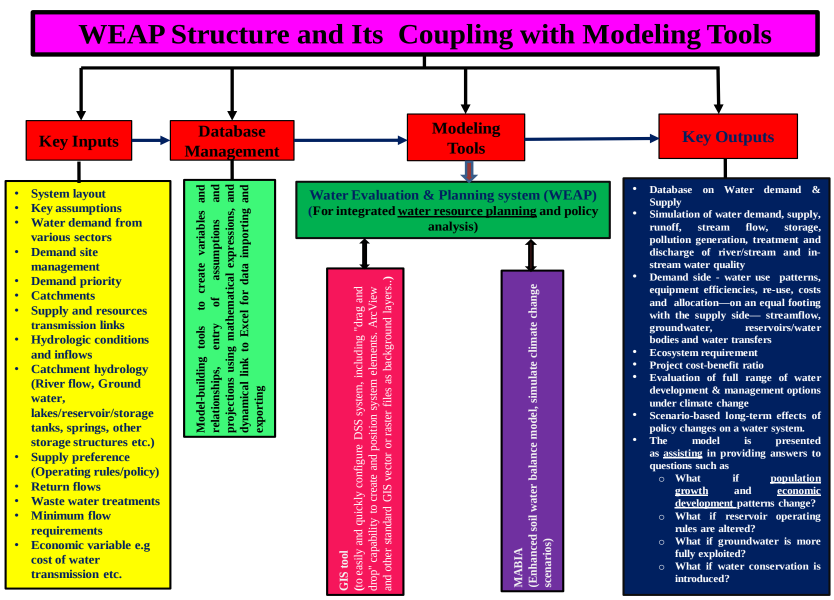


Figure 1. The WEAP model structure along with its coupling with other modeling tools to customize it for the Ur River catchment.

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

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

11. **Timeline:**

S N	**Work Element**	**First Year**				**Second Year**	
		Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**
1	Identification of site and Instrumentation at the identified site						
2	Collection of hydro meteorological data, satellite images, thematic maps etc.						
3	Compilation and verification of hydro-mertological data, baseline survey data, census data and other qualitative data						
4	Preparation of input data for WEAP model						
5	Customization of WEAP for Ur River catchment and validation of model with observed data						
6	Report writing						
	Deliverable	**1st Interim Report**				**Final Report**	

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

Objectives	**Achievements**
Preparation of input data of 8 sub-watersheds to WEAP model	• Climatic-data has been prepared. • Kharif and Rabi cropping area as well as cropping pattern data, Crop library data, soil library data, crop production and market price data has been updated. • Domestic water demand data has been prepared. • Surface runoff, reservoir storage capacity and initial storages and ground water data is prepared.
Customization of WEAP for Ur River catchment and validation of model with observed data	Task completed successfully
Deliverable	Draft report submitted

13. **Recommendation / Suggestion**

Recommendation / Suggestion	**Action Taken**
Study was extended upto March 31, 2016 for draft report submission	Draft report submitted

14. **Analysis & Results**

- In this study Ur River watershed having area of 990.37 km^2 is selected for the customization of WEAP based DSS for the IWRM. The watershed ID and watershed code of the Ur watershed is 4050104 and 2C2B4E1D, respectively as per the watershed classification system adopted by the M. P. Government. The Ur River watershed falls in the Betwa-Dhasan Lower Dhasan subcatchment. The location map of this watershed is shown in Fig. 2. Further, Figure 3 shows the details of existing streams, reservoirs/dams, micro-watersheds and tehsil areas covered by the study area.

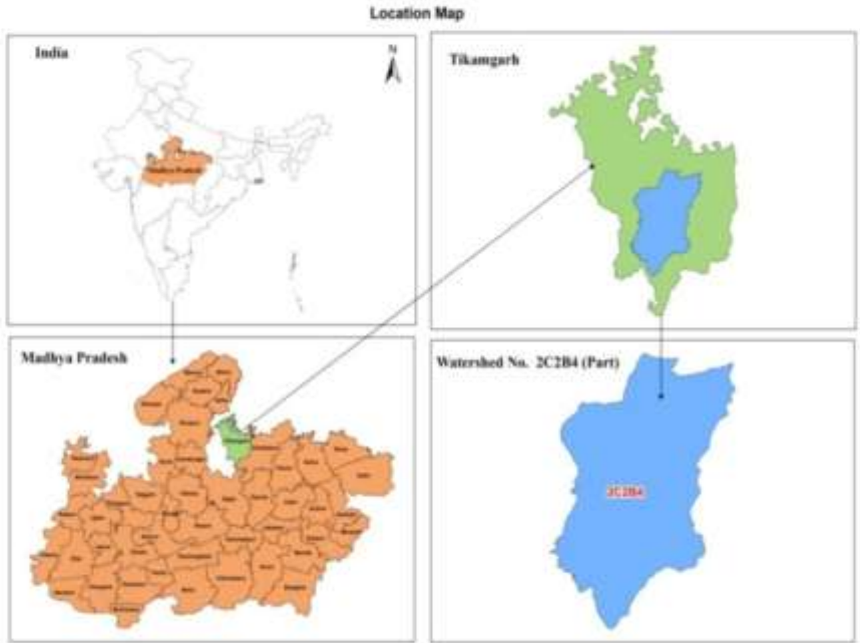


Figure 2. Location map of the Ur River catchment in Tikamgarh District (M.P.).

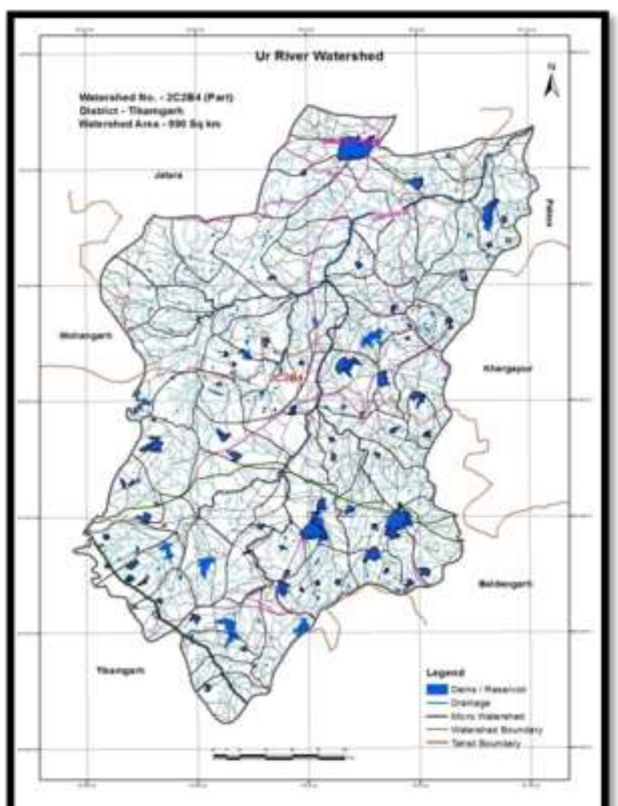


Figure 3. Map of study area showing the details of existing streams, reservoirs/dams, micro watersheds and tehsil boundaries.

- The data pertaining to climatic variables including maximum and minimum temperature, relative humidity, wind speed, etc for the last 30 years is obtained from IMD. Collection, computerization and processing of the rainfall and other statistical data from various organizations at Tikamgarh (completed). The status of data collection and processing to be used as an input for WEAP model customization is shown in following Table 1.

Table 1. Input data for WEAP model customization and its status

S.N.	Data		Frequency and source of data	Status
1.	**Groundwater Data**	• **Storage Capacity (MCM)** • Natural runoff • Maximum withdrawal • Aquifer storage capacity • **Ground water levels at various observation wells** • Lithology (rock types and thickness) • Aquifer map at possible finer grid size	State Ground Water/ Irrigation Department/ CGWB	Data shown in bold is Collected from CGWB. The available ground water level Data from state ground water Dept. is also Collected.
2.	**Reservoir storage data**	• Storage capacity (MCM) • Initial Storage (MCM) • Net Inflow	Irrigation Department/WRD	Available data collected. The lakes/tanks for which storage capacity data, initial storage and net inflow data were not available with any Government department, attempt had been made to extract the required data by using RS and GIS techniques.
3.	**Hydrological Parameters data**	• **Stream flow** • **Water level in reservoirs/tanks/ponds** • Soil moisture content in soil profile • Soil temperature in soil profile • River water temperature data for each reach • Physio-chemical data of water bodies • **Location of wells and water harvesting**	Daily Daily Daily Daily Monthly Monthly	Collection of available hydrological parameters data is completed. No stream flow records are available and hence measurement of stream discharge data is carried out with advanced

		structures		instruments. Measurement of Water level data in the selected lakes is measured during this period.
4.	**Land Use Data**	• Land use/Land cover map (.shp file) • Total Land Area (ha) • Share of Land Area for different crops • Land capability • Net Sown Area for Crops (Kharip/Rabi/Dual season crop area)	GIS/SAC Year 2010 One time Yearly season-wise data	LULC map and Land capability map prepared. Collection of crop data selected sub-watershed has been completed.
5.	**Topographic and Geomorphic Features**	• DEM/Terrain (elevation and slope) • Watershed map • Drainage density map • Canal network map	GIS/SAC [Spatial data at possible finer grid size]	DEM having resolution 2.5 m × 2.5 m has been prepared by MPCST. All other maps and .shp files are prepared using high resolution DEM.
6.	**Crop data**	• Crop name • Category of crop (*i.e.* cereal, legumes, oilseed, vegetable, root and tuber etc.) • Stage length i. Initial stage ii. Development stage ii. Mid season Stage v. Late season stage • Kcb (Basal crop coefficient) • Ky (Yield Response factor) • Ky (overall) • Height of crop (m) • Depletion factor • Rooting Depth(m) - 1.Minimum 2.Maximum • Planting Date of crop	1. State Agri. Univ 2. Krishi Vighyan Kendra (KVK) 3. FAO56 Irrigation and Drainage – Page No.56 Crop evapo-transpiration 4. Literature [Crop specific information, Season wise]	Data collected

7.	**Soil properties**	• Soil type and its properties i. Saturation ii. Field capacity ii. Coarse fragment v. Wilting point • Surface Layer Thickness (m) • Initial Moisture Depletion • Maximum Infiltration Rate (mm/day) • Soil depth • Soil texture	State Agri. Univ/Krishi Vighyan Kendra/ [One time information]	Data collected
8.	**Metrological/ Climatic Data**	• Precipitation (mm) • ETref (mm/day) • Min. Humidity and Maximum Humidity • Wind speed (m/s) • Minimum and Maximum temperature • Sunshine Duration • Solar radiation • Pan evaporation rate	-Daily time series data is required from base year to ending year. Source:- Indian Meteorological Department / KVK	Data collection completed.
9.	**Irrigation Data**	• Reservoir operation data • Irrigation Schedule • Fraction Wetted • Irrigation Efficiency • Loss to Groundwater • Loss to runoff	Irrigation Department/WRD [Daily/monthly data]	Available data is collected.
10.	**Yield data of each crop**	• Potential yield (kg/hectare) • Market price(Rs/Kg)	Krishi Vighyan Kendra/ Krishi Utapadan Samiti/centre [Cropwise yield for each growing season; Daily time series of market price]	Data collection completed.
11.	**Water Demand Data**	• Domestic water demand • Livestock water demand • Industrial water demand	Monthly Monthly monthly	Domestic water demand estimated.
12.	**Demographic and Other Parameters**	• Population density • Population growth rate • Urbanisation rate		Data collection completed.

- Field investigations for infiltration and hydraulic conductivity tests completed at 10 identified test sites and analysis is also completed.

- Following consent with district collector, Tikamgarh, various instruments and equipment were installed to collect following hydrological and climatic parameters on hourly and/or daily basis and continuous monitoring:

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

• A field visit has been carried out by the Project Staff for collection of soil samples and conducting field experiments on soil-water properties including infiltration and saturated hydraulic conductivity at ten locations as shown in Fig. 4 in the study area based on the various crop-soil combinations.

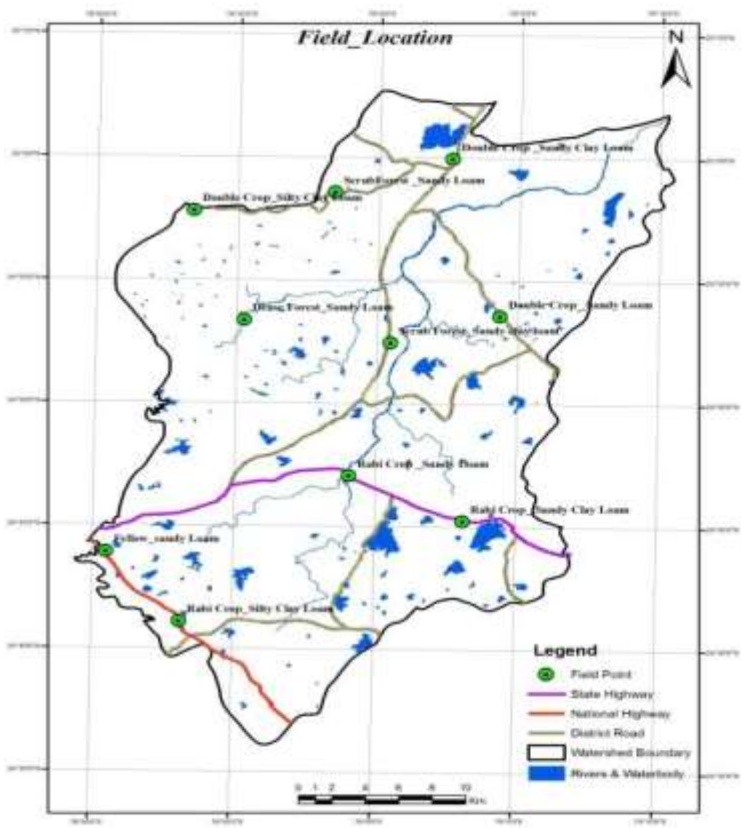


Figure 4 : Location of sites for infiltration and hydraulic conductivity tests.

- Before 42th working meeting, a schematic view required in the WEAP model customization was prepared by dividing the whole watershed into 18 sub-watersheds. Subsequently, the required input data using GIS has been extracted as per model requirement. However, due to limitation of input data requirement and in order to reduce the uncertainty in model prediction, it decided to divide the whole watershed into 8 sub-watershed based on topographic, morphologic, socio-economic and LULC conditions. Subsequently, the required input data using GIS has been extracted as per modified model requirement. The prepared schematic is shown in the following Fig. 5

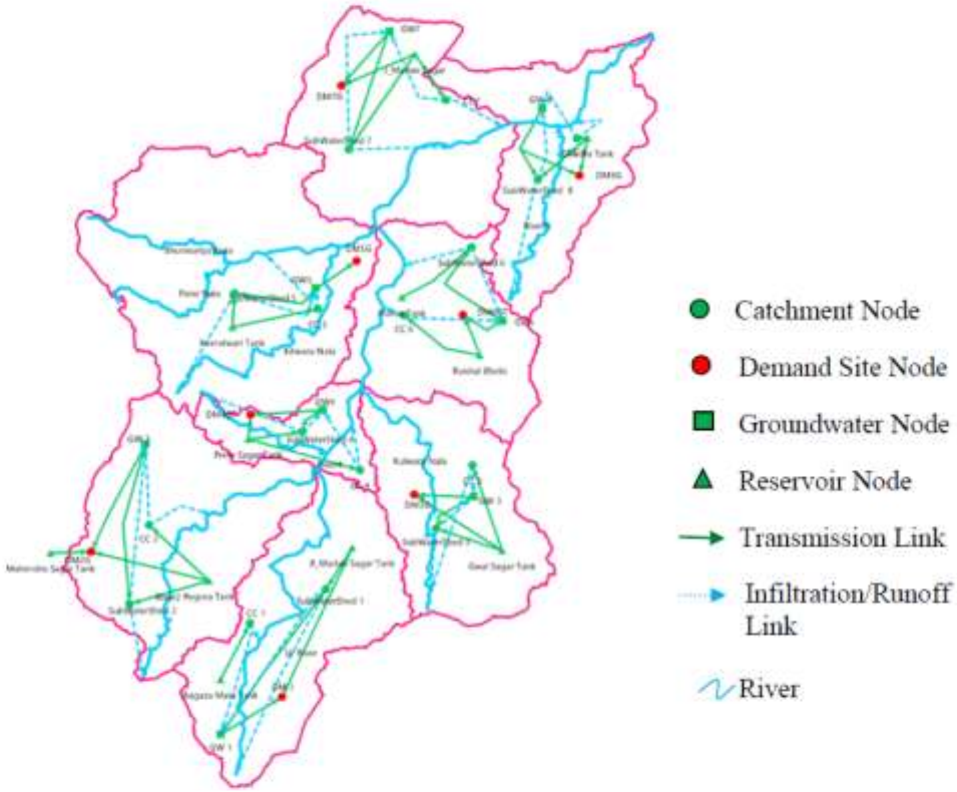
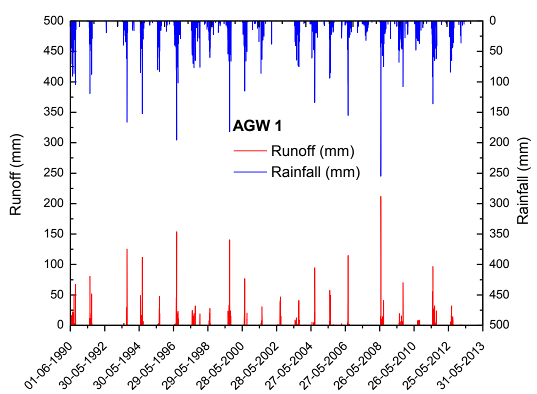
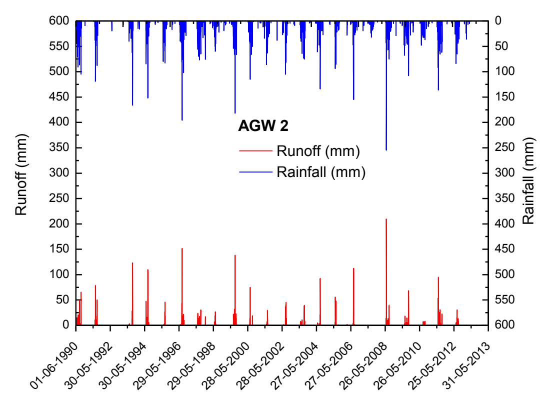


Figure 5: WEAP schematic of Ur river watershed

- Based on this schematic view, the required input data has been prepared for various demand nodes, agriculture catchments, and transmission links and entered into the Data framework. Due to lack of observed discharge data for Ur River, the runoff from each sub-watershed has been computed using standard SCS-CN method and the obtained results are shown in Fig. 6.
- The model was calibrated using observed discharge data and estimated discharge data by WEAP. Further, various irrigation management scenarios were incorporated in WEAP model to see the effects of water stress in different growth stages on crop yield. The results have been achieved which will be discussed in details during WGM.





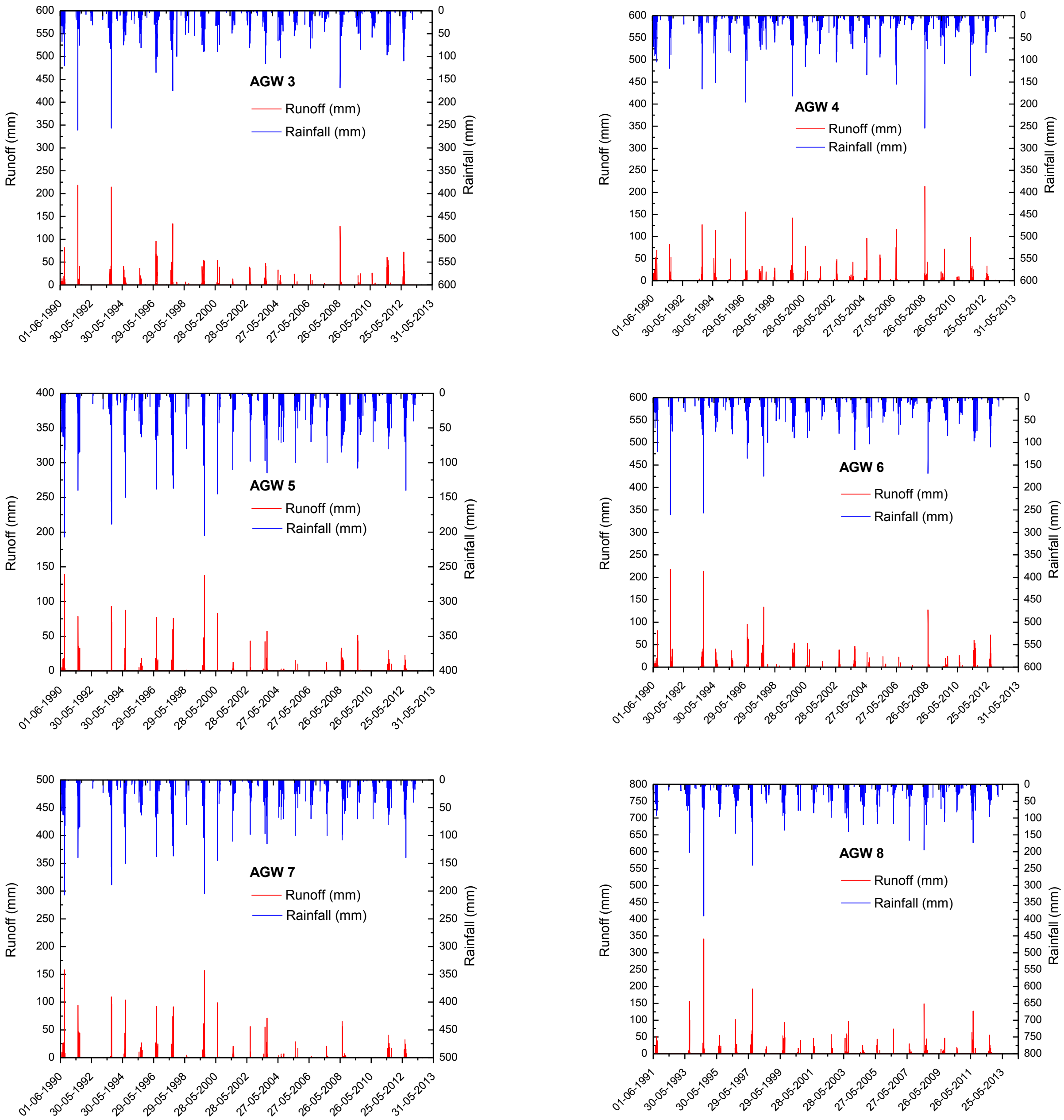


Figure 6. Rainfall-runoff hydrographs for each sub-watershed.

15. **End Users / Beneficiaries of the study:** State Govt. policy Planners/stake holders

16. **Deliverables** : Technical report& research papers

17. **Major items of equipment procured** : **High Resolution spatial data/software**

18. **Lab facilities used during the study** : **MPCST Bhopal and RC, NIH Bhopal**

19. **Data procured or generated during the study** : Metrological data from IMD, Ur River discharge data, lakes water level data, AWS data, infiltration data

20. **Study Benefits / Impacts**

Measurable indicators	Achievements
Customization of WEAP based DSS	Completed

21. **Involvement of end users/beneficiaries: State government/local stakeholders**

22. **Specific linkage with Institution and /or end users/beneficiaries** : MPCST/state Govt. Departments

23. **Shortcoming/Difficulties :** Non-availability of continuous stream flow discharge data and water tanks storage information

24. **Future Plan:** The results from WEAP model will be used in development of Decision Support System (DSS) for linking water resources with livelihood issues and future climate change impacts to assist the decision makers to decide upon alternate management options under various scenarios.

Study-3 (RMOD/2015-16/TS-4)

1. **Title of the Study:** WEAP Model set up for four sub-basins under Pilot Basin Studies (PBS) Programme

2. **Project team:**

Jyoti Patil (PI); V C Goyal (Co-PI); Chandramohan T (RC-Belgaum), Y R S Rao (RC-Kakinada), T R Nayak (RC-Bhopal), B Chakravorty (CFMS-Patna), and R V Kale (RC-Jammu)

3. **Type of Study:** Internal

4. **Date of start:** 01.04.2015

5. **Scheduled date of completion:** 31.03.2017

6. **Duration of the Study:** 2 Years

7. **Study Objectives:**

The main objective of the study is to set up the WEAP model for 5 sub-basins under the PBS Programme (Bina in MP; Zuari in Goa; Yerakalva in AP, Tawi in Jammu and Mahi in Bihar).

8. **Statement of the Problem:**

The Water Evaluation and Planning System (WEAP) contain components that allow the appraisal of water management strategies at basin level with economic values. It has been developed by the Stockholm Environmental Institute (SEI) as a decision support tool for water resources management (www.weap21.org). It is being applied particularly in regions, which are characterized by water scarcity and increasing demands. In many basins, the groundwater extractions exceed the natural recharge resulting in a deterioration of the water qualities and worsening the water shortage. The application of integrated water management strategies (IWRM), including water reuse, artificial ground water recharge, use of brackish water, storage of natural and reclaimed water, demand measures and improved water allocation among competing water uses, becomes increasingly necessary.

The economic components of WEAP allow the calculation of costs for demand notes, transmission links, treatment plants and reservoirs. Moreover, the beneficial impacts of increase in water availability for different demand sites can be evaluated in economic terms. By creating suitable indicators the economic losses of unmet demands and the environmental costs of low river flows can be evaluated as well. WEAP offers the possibility to perform cost-benefit analyses of alternative measures to tackle water problems. For instance, the construction of a reservoir or of a new treatment technology at a demand node to mitigate water shortage can be compared in terms of net present values. The economic net benefits of investments on annual basis can be calculated for different demand nodes. These calculations methods serve to find out the most appropriate IWRM strategy at basin level. Furthermore, various financing options under different loan conditions and pricing policies can be considered.

WEAP was applied successfully to model the hydrological features and water management strategies at many basins and it is being developed further. An example is the co-operation between the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) and the German Federal Institute for Geosciences and Natural Resources (BGR) (www.acsad-bgr.org). A further example is the research project 'Integrated Water Resource Management in the Lower Jordan Rift Valley (SMART)', funded by the German Ministry of Education and Research (BMBF) (www.iwrm-smart.org).

9. **Methodology**

Customization of the WEAP model will be carried out for the respective sub-basins on a daily/monthly time step. First, a database will be prepared covering the required hydrologic, demographic and socio-cultural data, to be used with the model. Then, a draft schematic of the WEAP model will be prepared defining the demand and supply nodes, etc. The draft WEAP schematic will be discussed with the local stakeholders, and their views will be incorporated in the final model set up. Results from the WEAP model analysis will be used to prepare an integrated water management plan for the 4 sub-basins. Next, the integrated water management plan will be shared with the local stakeholders in the form of a training workshop.

10. **Timeline**:

SN	Work Element/ Milestone	2015-16				2016-2017			
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
1	Creation of database	√	√						
2	Draft WEAP model set up			√	√				
3	Stakeholders' meeting				√	√			
4	Finalization of WEAP model set up						√	√	
5	Training workshop								√

11. **Objective and achievement during last six months:**

Objective	Achievement
Draft WEAP model set up	Under progress with available data

12. **Recommendation / Suggestion:** No Specific comments

13. **Analysis & Results:**

14. **End Users / Beneficiaries of the study:** Water Resources Planners of the respective sub-basins

15. **Deliverables:** Training workshop for the stakeholders

16. **Major items of equipment procured:** Nil

17. **Lab facilities used during the study:** Nil

18. **Data procured or generated during the study:** None

19. **Study Benefits / Impacts:** Outputs of the study will be used in preparation of integrated water management plans for each sub-basin

20. **Involvement of end users/beneficiaries:** Local stakeholders

21. **Specific linkage with Institution and /or end users/beneficiaries:** Various line departments (KVKs, Irrigation, WRD, Agriculture, Industry)

22. **Shortcoming/Difficulties:** Classified data of Mahi basin is difficult to access. Belgaum centre needs training to set up the model.

23. **Future Plan:**

WEAP model will start to set up in the basins having required data. Stakeholders meeting will be arranged in the PBS area.

WORK PROGRAMME FOR YEAR 2016-2017

SN	Title of Project/Study	Study Team	Duration	Funding
	Internal Studies			
1.	**Study- 1 (RMOD/2015-16/TS-1)** Water Conservation and Management in Ibrahimpur Masahi Village of Hardwar District (Uttarakhand)	Omkar Singh (PI), V C Goyal, Dinesh Kumar	DOS: Apr 2013 DOC: March 2016 (requires 6 month extenstion)	NIH
2.	**Study-2 (RMOD/2015-16/TS-3)** WEAP Model set up for four sub-basins under Pilot Basin Studies (PBS) Programme, jointly with the RCs/CFMSs	**NIH HQs:** Jyoti Patil (PI), V C Goyal **NIH RCs/CFMSs:** Chandramohan T (Belgaum), Y R S Rao (Kakinada), T R Nayak (Bhopal), B Chakravorty (Patna), R V Kale (Jammu)	DOS: Apr 2015 DOC: Mar 2017 (Ongoing study)	NIH
	Sponsored Projects			
3.	Integrating hydrology, climate change and IWRM with livelihood issues: Development of methodology and a DSS for water-scarce Bundelkhand region in India- preparation of final report	V C Goyal (PI), T Thomas, Jyoti Patil, Rajesh Agrawal	DOS: Aug 2013 DOC: Jul 2016	TIFAC (Rs 56.64 lakh)
4.	IWRM Based Development Plan for Water Security in Four Districts of Bundelkhand Region in India	V C Goyal (PI), Omkar Singh, Jyoti Patil, T R Nayak, Ravi Galkate, T Thomas, R K Jaiswal, Shashi P Indwar, Subhash Kichlu, Rajesh Agrawal, Dinesh Kumar	DOS: Apr 2016 DOC: Dec 2016	MoWR, RD & GR (Rs 299.4 lakh)
5.	Development of a DSS for Hydrology and Watershed Management in Neeranchal Project	V C Goyal (PI)	DOS: May 2016 DOC: Mar 2021	DoLR (GoI)

Study 4

IWRM Based Development Plan for Water Security in Four Districts of Bundelkhand Region in India (Sponsored by MoWR, RD & GR)

Rationale for taking up the project

The Ministry of WR, RD & GR, has desired to extend the work being carried out by NIH, Roorkee, in Ur river watershed in Tikamgarh district of MP in other districts of Bundelkhand region. The Secretary (WR,RD&GR) desired that the Ministry wants NIH to take a lead in carrying out an integrated action research study addressing water stress situation on watershed basis. The study will deliver vulnerability maps and action plan for interventions leading to livelihood improvements in the project area. He emphasized on designing the project in a participatory mode so that involvement of various local stakeholders is ensured while implementing the suggested interventions through mobilization of financial resources from different govt. schemes. The Secretary directed NIH to take up the study on priority basis, initially in 2 districts each of UP (Lalitpur and Jhansi) and MP (Chhattarpur and Tikamgarh), and prepare interventions report within 8 months, which will then be discussed with the respective DCs for mobilization of funds and with local implementation agency (including NGOs) for interventions.

Statement of the Problem

Water scarcity is a major problem in the Bundelkhand region of central India due to recurring drought conditions, deforestation, stone mining activities, inefficient land and water management, and unpredictable and extreme weather patterns due to climate change impacts. In such a water-scarce area, the allocation and efficient as well as equitable use of a limited but essential resource (i.e. water) is critical in both individual and collective development pathways and livelihood security. To improve the water situation in the region, it is felt that an integrated water management approach (e.g. IWRM) has to be undertaken. The IWRM approach has to be built around the concept of efficient management (both supply and demand side) and sustainability (quality and quantity), and building of institutional systems at various levels (village, block, district levels) for community based management of water challenges.

An integrated action research project is required to address the water stress situation on watershed basis. The study will deliver vulnerability maps and IWRM Plan for interventions leading to livelihood improvements in the project area, initially in 2 districts each of UP (Lalitpur and Jhansi) and MP (Chhattarpur and Tikamgarh). The IWRM Plan will be prepared within 8 months, which will then be discussed with the respective DCs for mobilization of funds and with local implementation agency (including NGOs) for interventions.

Objectives

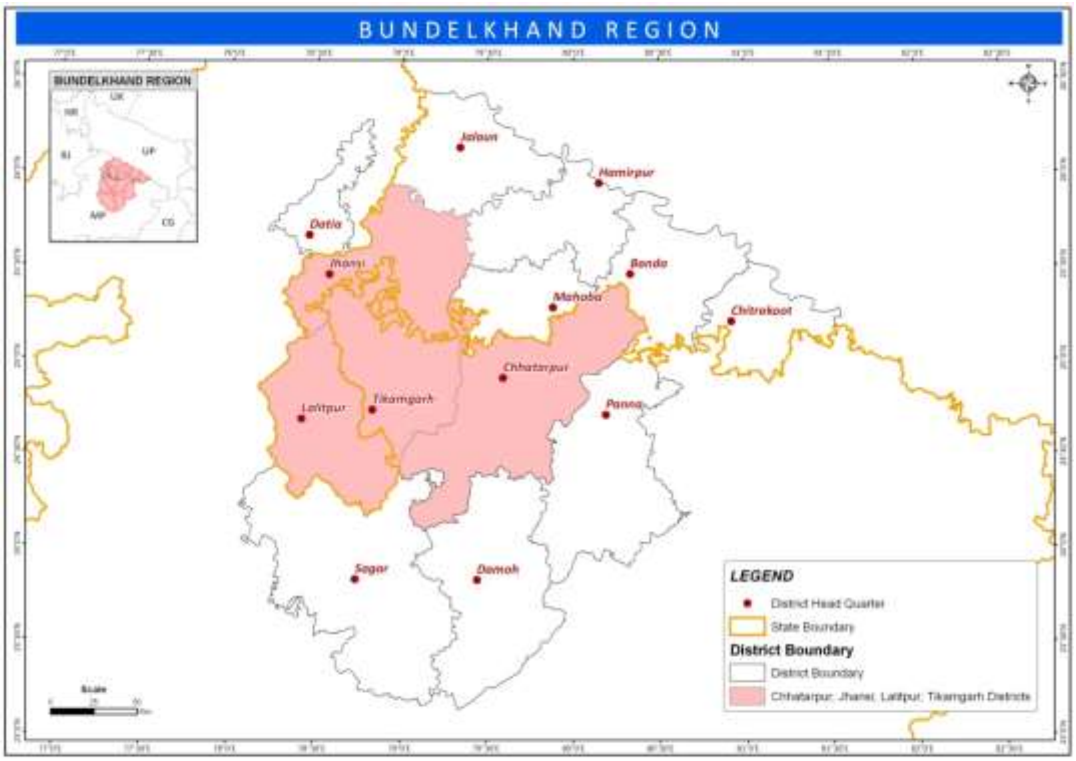
The project essentially aims to evolve a methodology for effective water management by linking with the concept of livelihood. The methodology would be developed for a selected water-scarce area (on watershed basis), which could later be tested at other sites under similar (or different) agro-ecological conditions. The research shall lead to a water management tool (i.e. IWRM Plan) to assist the local stakeholders in selecting and adopting appropriate water management practices on a sustainable basis.

The objectives of the project, therefore, are:

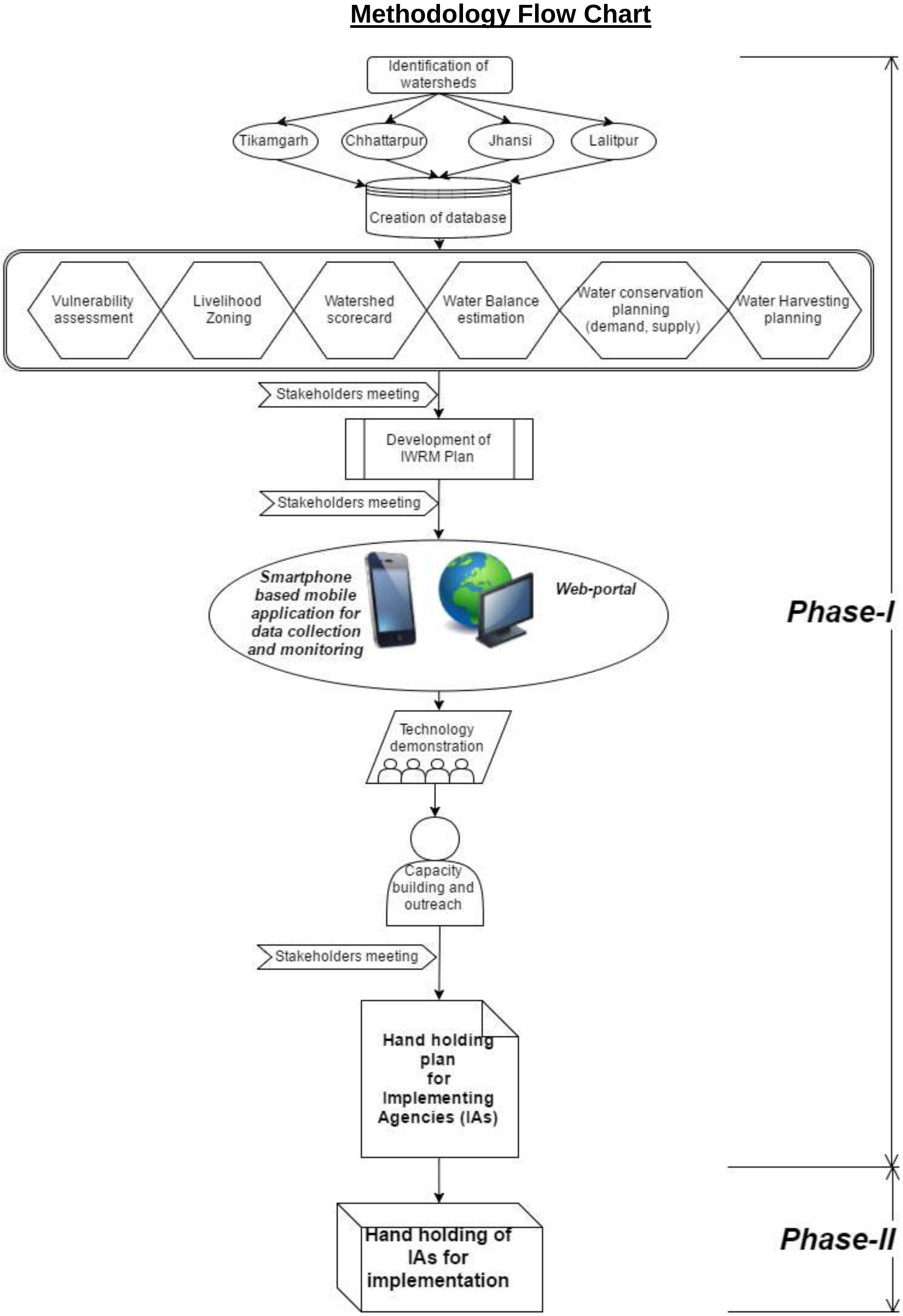
1. Assessment of water stress situation in identified watersheds of four districts (Jhansi and Lalitpur in UP; Chhatarpur and Tikamgarh in MP) in the Bundelkhand region,

2. Vulnerability and Livelihood Assessment and development of IWRM plan for the project area, and

3. Guidance and hand holding of Implementing Agencies (including district line departments and WUAs) for implementation of the IWRM plan.



Methodology



Timeline

Time (in months)> Activity	1	2	3	4	5	6	7	8	8+
Phase-I (Development of IWRM Intervention Plan)									
Consultation with project partners & finalization of action plan									
Recruitment of project personnel									
Collection of data from secondary sources in UP & MP									
Estimation of water availability from different sources									
Assessment of water demand & estimation of gap in water demand									
Water balance estimation									
Vulnerability and livelihood assessment									
1st stakeholders' meeting									
Identification of appropriate technology interventions									
Preparation of IWRM plan									
2nd stakeholders' meeting (finalization of IWRM plan)									
Training of users on IWRM plan									
Technology demonstrations									
3rd stakeholders' meeting (discussion of results & feedback)									
Documentation+ Development of Web portal (Bundelkhand Water resource Management System) and Mobile Application									
Phase-II (Implementation)									
Mobilization of Panchayats/WUAs for pilot scale testing									
Discussion with DCs & IAs for implementation									
Hand holding of IAs for implementation									

Project deliverables

The following information and products needed in the policy framework for efficient water resources management in the project area will be delivered:

- Database covering water availability, water demand and gap in demand status for the project area
- Water Situation Analysis Report
- Integrated Water Resource Management (IWRM) Plan for development of the project area
- Capacity building programmes for stakeholders
- Hand holding plan for IAs
- Final project report + Web portal (Bundelkhand Water Resource Management System) and Mobile Application

The outcome and deliverables of the project shall be of direct use to the Governments of UP and MP in planning an effective strategy for development of the region. Also, the methodology of community-based IWRM will provide a useful concept to the local Implementing Agencies to include a component of livelihood in the water uses.

Study 5

Development of a DSS for Hydrology and Watershed Management in Neeranchal Project (Sponsored by DoLR, GoI)

Background

The Department of Land Resources (DoLR), Government of India (GOI) is implementing the Neeranchal Watershed Project funded by The World Bank. The objective of the Neeranchal Project is to improve the effectiveness of the Integrated Watershed Management Program (IWMP), already being implemented by the DoLR all over the country. The Project has the following four components:

C-1. Central Institutional and Human Capacity Building
C-2. National Innovation Support
C-3. IWMP Implementation Support in Focal States
C-4. Project Implementation Support

The Component C-2 would generate knowledge, tools, and new approaches to support improvements to IWMP, and will support piloting at field level to develop a clear body of evidence for innovations. This Component has two sub-components:

C-2.1: Research Coordination, Innovation Fund and Knowledge Sharing
C-2.2: Institutional Applied Research and Development

The sub-component C-2.2 has two consolidated areas of focus:

1. Agricultural performance, rural livelihoods, and climate change, and
2. Decision support systems and data bases for hydrology and watershed management.

Objective*(s)*

The specific objective of the current assignment to NIH is to:

- Develop and pilot new Decision Support Systems (DSS) to support DoLR and States to implement IWMP at landscape, expanded sub-watershed and micro-watershed levels,
- Tools to support DoLR and States to assess investment requirements, select sites, set priorities,
- Systems to provide improved hydrological information to support landscape level assessment and more integrated watershed planning,
- Systems to help farmers and local authorities make better water management decisions as part of watershed planning,
- Technical backstopping to States for urban watershed management.

Methodology

3.1 For development of a DSS, which will incorporate the concepts of Integrated Water Resources Management (IWRM) and hydrologic inputs to link with the livelihood opportunities in the project areas, the following study components are planned by the National Institute of Hydrology, Roorkee:

- Assessment of water demand for different uses (including livelihood)
- Estimation of water availability from different sources
- Estimation of gap in water demand (at both spatial and temporal scales)
- Planning for addressing the gap through (1) reduction in demand, (2) augmentation of supply using appropriate technology-based solutions, and (3) optimization of water management interventions keeping in view the gap in demand, water availability, livelihood opportunities and associated economics, and socio-cultural acceptance

- Generating scenarios of future water availability (with suggested interventions) and demand, and estimation of potential gap in water demand (including possible livelihood opportunities)
- Planning for addressing this potential gap in water demand for each developed scenario
- Hydrological evaluation of existing water conservation/harvesting structures
- Handholding support for hydrological inputs to DPR
- Capacity building of the local stakeholders and institutions

A DSS on hydrology inputs for watershed management (DSS-H) shall be developed, and the models and knowledge developed will be presented to the DoLR/State authorities for integration into the IWMP. The broad scope of activities of the DSS is shown in the box below.

DSS-H: scope of activities

I. Hydrological Assessment

- Water demand management
  - Spatial & temporal water availability from different sources
  - Water balance
  - Water demand gap for different uses
  - Water management plan (covering hard and soft options)
- Scenario development
- Hydrological monitoring in pilot micro-watersheds

II. Socio-Economic Evaluation

- Appropriate interventions & prioritization based on site conditions and economic returns
- Market and non-market benefits from interventions

III. Watershed Management

- Institutional networking and capacity building
- Suitable sites & designs for water harvesting and conservation structures
- Impact assessment (environmental, social and economic)
- Preparation of ‘watershed scorecard’ (based on biophysical and socio-economic indicators)
- Convergence with other operational schemes

IV. Capacity Building and Outreach

- Training of stakeholders
- Interaction workshops
- Documentation and dissemination activities

Outreach & Dissemination

Training will be a key element of dissemination and it should be seen as a tool that can maximize the impact of DSS-H dissemination efforts. The trainings planned under the project focus on the physical processes involved in the DSS-H development together with application-specific case studies. These trainings are also considered to be important vehicles of creating awareness among researchers and students, who would take the knowledge forward both in terms of value addition through research inputs and later adoption in real practice when they enter into professional life. Organization of these training courses is expected to provide the expected impact among the user communities and stakeholders through dissemination and exploitation of project results.

Regular interaction workshops and awareness activities will also be conducted and documentation prepared to ensure that the stakeholders' views are adequately addressed and the developed concepts and technologies are adopted by the target group and thus the DSS-H software can be put into practice.

Timelines

S N	Activity	Timing (from start of project)	Deliverables
1	Inception Report, Annual Action Plan	01 month	Inception report
2	DSS needs assessment	06 months	Needs assessment report
3	DSS model conceptualization	06 months	DSS model conceptualization report
4	Database development	12 months	Database development report
5	Generic DSS development	14 months	Report on Generic DSS development status
6	DSS customization	18 months	Report on State wise DSS-H customization for each pilot watershed
7	DSS testing & refinement	20 months	1. Report on outcomes of Consultation workshops 2. Test report of refined DSS-H model
8	DSS application and demonstration	24 months	Report on State wise case study on application of developed DSS-H outcomes of Consultation workshops
9	DSS pilot runs, evaluation & fine tuning	24-36 months	Pilot run report & Operation manual
10	Hydrological evaluation of water conservation/ harvesting structures	24-36 months	Report on hydrological evaluation of selected structures containing observations and improvement
11	Handholding support for hydrological inputs to DPR	36-60 months	1. Interaction workshops 2. Report on hydrological inputs to selected DPRs
12	Capacity building, dissemination and outreach plan	Intermittent during project	1. Reports on Stakeholders' consultation workshops 2. Report on Training of SLNAs
13	Draft final report	60 months	Draft final report and handing over the final version of DSS-H to SLNAs

HARD ROCK REGIONAL CENTRE BELGAUM

Scientific Manpower

S N	Name	Designation
1	Dr.B.Venkatesh	Scientist F & Head
2	Dr.B.K.Purandara	Scientist E
3	Dr.Chandra Mohan T.	Scientist D
4	Dr.M K Jose	Scientist D
5	Dr.N. Varadarajan	SRA
6	Mr.Chandrakumar S	SRA

REGIONAL CENTRE, BELGAUM
WORK PROGRAMME FOR THE YEAR 2015-2016

SlNo.	Title of the Study	Study Group	Duration	Funding
1	Integrated Water Resources Management (IWRM) on a Pilot Basin – Zuari River Basin, Goa	Chandramhoan T, Purandara, B.K and V.C. Goyal	3 years (Apr 2013 - Mar2016)	Internal (PBS)
2	Comparative Analysis of Various Rainfall-Runoff Models for Rivers of Western Ghats	B. Venkatesh, M.K. Jose, and Chandrakumar	3 years (Apr2013 - Mar2016)	Internal (*Completed)*
3	Studies on Spring flows and estimation of Groundwater Recharge in Ghataprabha Sub-basin	B.K. Purandara, N. Varadarajan, Sudhir kumar and Rajan Vatsa	2 years (Apr2013 - Mar2015)	Internal *(Completed)*
4	Application of Geostatistical methods for analyzing sedimentation pattern in river basins of Kerala State	M.K. Jose and Chandramohan T	2 years (Oct2014 – Sep2016)	Internal *(Completed)*
5	Modeling of Sediment Yield From River Basins of Kerala & Goa, Using SWAT Model	Chandramona T and B Venkatesh	2 years (Oct2014-Sep2016)	Internal
6	Runoff estimation in a catchment using GIS and WEB based tools: A case study	M.K. Jose and B.Venkatesh	1 year (Sept 2014- August 2015)	Internal *(Completed)*
7	*Impact of Land use/Land cover Changes on Ground water – A Case Study*	*B.K. Purandara, B.Venkatesh and N.Varadarajan*	*2 years (Oct2014-Sep2016)*	*Internal*
8	Impact of Urbanization on Surface and Ground water Quality and Quantity – A Case Study	B.K.Purandara, Sudhir Kumar and N. Varadarajan	2 years (Oct2014-Sep2016)	Internal *(Completed)*

SKJ : Sharad K. Jain
VCG : V. C. Goyal, Scientist F
BKP : Purandara, Scientist E
MKJ : Mathew K. Jose, Scientist D
NV : N. Varadarajan, SRA
SK : Sudhir Kumar, Scientist G
BV : B. Venkatesh, Scientist F
CMT : Chandramohan T., Scientist D
RV : Rajan Vats Scientist B
CK : ChandraKumar S., SRA

PROGRESS OF STUDIES UNDER WORK PROGRAM FOR THE YEAR 2015- 2016

1.0 Integrated Water Resources Management (IWRM) on a Pilot Basin – Zuari River Basin, Goa

Study Group	: Chandramohan T., B. K. Purandara, V. C. Goyal
Date of start	: April 2013
Duration	: 3 years
Funding	: Internal

Statement of the Problem:
IWRM provides the means of balancing and meeting the needs for use of water resources in such a way as to ensure the equitable and sustainable use of the water resource. It is based on the principle that, in order to maximise the benefits of the water resource and to ensure equitable use of water, needs of all the water users in the catchment must be balanced. The basis of IWRM is that different uses of water are interdependent. Additional benefits can be derived when different user groups are consulted in the planning and management of water management programs.

During the 12th 5-year plan period, National Institute of Hydrology (NIH) has proposed a project on Integrated Water Resources Management (IWRM) under Pilot Basin Study (PBS) at each of its Regional Centres. As per the discussions and deliberations held at various levels, NIH Regional Centre, Belgaum is collaborating with the Water Resources Department (WRD), Goa for carrying out the IWRM project in the Zuari River Basin. The need for the IWRM study for the Zuari Basin is important as;

- Data network is inadequate to represent the hydrology
- Lack of ET measurements within the forest areas affects the accuracy of water availability estimates
- Mining is a great threat to the general health of river and EIA studies are not carried out in a detailed manner
- Solutions have to formulated for the increased extent of salt water ingression into the upstream river reaches
- Limited coordination between agencies dealing with Water

Objectives:

- ➢ Assessment of basin characteristics and its hydrology
- ➢ Working out an IWRM frame work for Zuari basin in consultation with WRD, Goa
- ➢ Instrumentation of the basin with the latest hydro-meteorological gauges
- ➢ Quantifying the soil hydraulic properties
- ➢ Water availability studies
- ➢ Hydrological studies such as flood frequency analyses, erosion and sediment transport studies, water quality assessment, etc.
- ➢ IWRM plan for equitable distribution of available water resources for different users in the catchment

Methodology:
Zuari River is the second largest river in the State of Goa and having many environmental and water resources related issues. There is a need for comprehensive analysis of these hydrological issues leading to evaluate quality & quantity of water, water-human relationship, socio-economics and institutional setup for managing water resources in the basin. Also, the Western Ghats mountain ranges located in the south-western part of India is undergoing substantial changes due to man's activities, which hugely impacts the hydrological regime of this fragile ecosystem. Hence, it is important to conduct detailed hydrological analyses within a typical pilot basin which represents all types of hydrological complexities to provide a model for the hydrology of the region as well as representing the sensitive Western Ghat region. The various steps involved in the study:

- ➢ Identification of water related issues pertaining to Zuari basin by interaction with the people
- ➢ Identification of working partners who can be a part of the IWRM framework
- ➢ Preparation of an IWRM framework
- ➢ Design of an instrumentation strategy
- ➢ Field experiments for the evaluation of soil hydraulic properties
- ➢ Water availability studies – Surface Water & Groundwater

- ➢ Formulation of equitable water use strategy

Expected Research outcome from the project:
The expected deliverables from this project are:

- A greater understanding of human-water relationships and to derive ‘best practice” norms for better utilisation of the water resources in the region.
- Act as a model basin for detailed studies of hydrological processes in the Western Ghat region.
- Formulation of a set of recommendations regarding implementation and management policies of the water resources projects to the related departments.
- A greater understanding of human interference and water linkages in the catchment.
- Preparation of short briefing in non-technical language to spread the awareness about the best management practices of water and environment in the catchment.

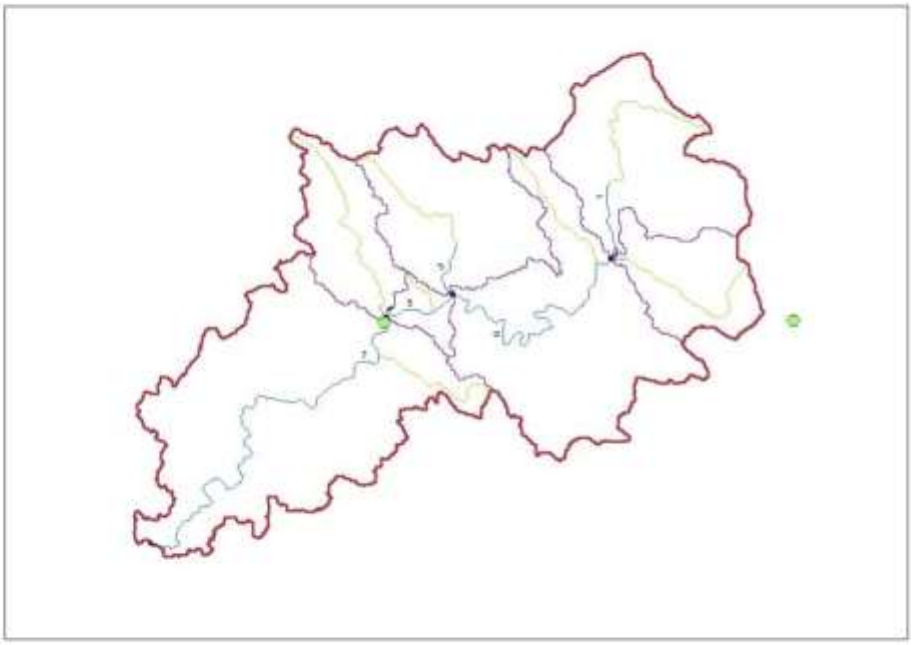
Progress

- Water related issues for the basin were identified
- An instrumentation strategy was formulated
- Status Report was prepared
- Discharge and meteorological data pertaining to the basin were collected from WRD
- A training workshop on Project Hydrology with an introduction to IWRM-Pilot Basin concepts was organized at WRD, Goa, during 20th to 22nd November 2013.
- Master plan documents prepared by WRD for Zuari basin were collected
- Estimation of evapo-transpiration for the basin using various methods
- Collection of groundwater data completed
- Estimation of ground water balance
- Preparation of interim report
- Setting up of SWAT model for the basin
- Estimation of surface water balance
- Estimation/collection of data regarding various water uses and future demands
- Collection of reservoir data for WEAP model application
- Field/Laboratory studies for estimation of soil hydraulic properties

2.0 Comparative Analysis of Various Rainfall-Runoff Models for Rivers of Western Ghats

Study Group	: B. Venkatesh , S. Chandrakumar and M K Jose
Date of start	: April 2013
Duration	: 3 years
Funding	: Internal

The SWAT model has been set-up for 20 basins (18 in Karnataka and 2 in Kerala). The calibration and validation of the SWAT model has been completed for all these basins. A sensitivity analysis is being carried out for selected basin. The results obtained for one basin are presented as below



Demarcation of sub-basins in Maninala for SWAT analysis

The SWAT model was calibrated using the data for 2000 to 2005 and validated for a 2 year period (2006-2007). Calibration of the model was done by adopting the manual calibration procedure. The sensitivity analysis was carried out using the option provided within the model to identify the most sensitive input parameters, acceptable model evaluation results and sensible ranges of parameters uncertainty. As few of the model parameters are not possible to measure in the field and are need to be calibrated against the observed discharge. Therefore, during the calibration period, the model parameters were varied within the physically allowed range and more realistic to the natural condition of the basin. The root mean square error (RMSE) and the normalized objective function (NOF) were used to assess the model efficiency.

Parameter ranges and values used in the Sensitivity analysis

Model Parameters	Variable Name	Range	Model Value
Curve Number	CN	69-85	78
Soil Evaporation Compensation Factor	ESCO	0.75-0.95	0.85
Plant uptake compensation factor	EPSO	0.01-1.0	0.55
Soil available water capacity (mm)	SOL_AWC	0- 50	22

Baseflow alpha factor	ALPHA-BF	0.05-0.8	0.48
Groundwater revap Coefficient	GW_REVAP	0.02-0.2	0.02
Groundwater delay time (days)	GW DELAY	0-100	31
Deep aquifer Percolation fraction	RECHARGE_DP	0-1	0.05

Table : Performance Indicator

Performance Indicator	Calibration	Validation
Root Mean Square Error (RMSE)	86.29	85.35
Normalised Objective Function (NOF)	01.98	01.68

The model evaluation statistics obtained for both calibration and validation period are tabulated in Table. The Table revealed that, the RMSE values for calibration and validation are lower and are indicative of the higher efficiency of the model in simulating the flow. Similarly the lower values were obtained for other evaluating parameter NOF.

The calibrated and Validated SWAT model was used to simulate the water balance component of the basin using 0.25 degree IMD data and CCCMA data for the period 1961-2000. The third generation Couple Global Climate Model (CGMA3) projected data were used in this study. The simulated average monthly water balance component for entire basin and at sub-basin level are tabulated in following Tables

Table : Monthly values of annual average water balance component for Manimala basin

Month	0.25 degree IMD data					CGMA3 data				
	Rainfall (mm)	Surface runoff (mm)	Later flow (mm)	Water Yield (mm)	ET (mm)	Rainfall (mm)	Surface runoff (mm)	Later flow (mm)	Water Yield (mm)	ET (mm)
January	14.69	1.43	1.39	57.23	71.08	34.84	8.19	1.2	23.38	47.24
February	26.61	0.78	0.85	19.43	46.03	51.69	6.62	1.37	14.32	48.83
March	39.32	0.62	1.09	6.71	33.69	142.69	48.17	3.28	56.21	53.55
April	123.32	9.03	2.21	14.25	48.44	157.66	77.52	3.88	92.95	45.06
May	200.13	52.84	4.11	67.22	62.99	516.51	332.36	8.24	362.11	58.1
June	594.08	282.9	9.27	334.66	44.91	379.98	217.43	9.56	267.92	60.13
July	674.19	359.64	14.59	500.34	44	373.89	219.64	9.18	290.1	68.56
August	452.93	210.17	12.15	406.92	53.74	261.34	117.74	7.92	194.02	70.67
September	313.61	118.24	7.9	302.5	58.36	282.15	141.17	8.25	216.34	59.51
October	365.04	139.96	9.73	308.33	63.34	211.8	96.85	6.61	174.8	68.81
November	197.23	71.46	8.09	220.82	54.24	56.27	15.21	3.09	73.9	39.52
December	50.59	9.14	3.52	118.29	39.53	24.14	4.69	1.45	38.56	21.2

From the table above, it is observed that, the majority of the runoff occurs during the south-west and north-east monsoon during the year amounting to 45% with the IMD data, whereas, the simulation using the CGMA data show that 51%. However, the ET estimates show a very low amount using the IMD temperature data and almost double the amount with CGMA data. This could be due to the fact that, the IMD data is grid averaged data and CGMA is obtained through simulations.

The analysis has been completed and the report writing is in progress and will be submitted within 2-3 months.

3.0 Studies on Spring flows and estimation of Groundwater Recharge in Ghataprabha Sub-basin

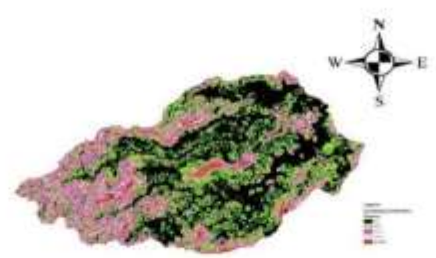
Study Group : B. K. Purandara, N. Varadarajan, Sudhir Kumar, C. P. Kumar, Rajan Vats
Date of start : April 2013
Duration : 2 years
Funding : Internal

Springs are classified according to the conditions under which water flows to them. Some surface under pressure, while others do so as a result of discontinuities in the strata that held the water underground. For instance, in a seepage or filtration spring the water percolates from many small openings in porous ground, while in fracture springs the water comes from joints or fractures in otherwise solid rock, and for tubular springs the outflow opening is more or less round. To understand the possibilities of water tapping from springs, the distinction between gravity springs and artesian springs is most important. A further sub-division can be made into depression springs and overflow springs.

Objectives:

(i) Identification of Springs in parts of Ghataprabha and parts of Sindhudrug district.
(ii) Estimation of runoff and groundwater using conventional and SWAT model Identifying the source of spring using Isotopic techniques
(iii) A rapid assessment of potential environmental consequences of developing a spring (this includes landslide study, erosion and water quality)
(iv) The environmental assessment of the study area which includes investigating the flow direction of surface run-off above the spring; human activities and water uses in the catchment area, i.e. habitation, farming, grazing, etc.; and the type of plants growing in the catchment or recharge area

Study Area : Ghataprabha sub-basin including parts of Sindhudrug district



Application of SWAT Model

The SWAT model was set up for the Ghataprabha sub basin, following the step by step procedure outlined in the SWAT user guide. The basin was divided into 3 major sub-basins and each sub-basin sub divided into smaller sub-basin based on the DEM and stream network of the study area. The minimum and maximum sizes of the sub-basins were 13.09km^2 and 1229.28km^2, respectively. The sub-basin delineation was followed by automatic parameterization of streams and subdivision of the sub-basins into Hydrologic Response Units (HRUs) based on soil and landuse data and a predefined threshold of 05% soil and 05 % landuse. The maximum HRU size was 446.27 km^2 and the minimum was 0.17 km^2. The model was simulated for the period: 1990-2005.

Groundwater Recharge Estimation using ArcSWAT and Conventional methods

Table below illustrates the mean of annual rainfall, runoff, evapotranspiration and recharge during 1990 to 2005. Groundwater recharge and surface runoff increases and decreases with precipitation and they show the same trends throughout the years. However, evapotranspiration shows a constant trend throughout the years. This is not unexpected since ET is a function of solar radiation, wind speed and daily dew point.

Table: Estimated Ground water recharge using SWAT model and Conventional methods

Year	Rainfall in mm	GW R in mm	% Recharge	Chaturvedi (mm)	% Recharge	Krishna Rao (mm)	% Recharge
1990	1129.1	218.7	19.37	205.2	18.17	204.14	18.07
1991	1499.1	274.1	18.28	236.4	15.76	292.92	19.53
1992	1303.5	227.9	17.48	224.7	17.24	257.42	19.74
1993	1174.7	217.9	18.55	225.8	19.22	258.57	22.01
1994	1585.4	305.7	19.28	252.7	15.94	346.71	21.86
1995	697.4	94.6	13.55	162.0	23.22	110.92	15.90
1996	1123.7	225.0	20.02	223.2	19.86	252.46	22.46
1997	1725.8	283.7	16.43	256.0	14.83	358.15	20.75
1998	1007.1	195.3	19.39	197.1	19.57	184.13	18.28
1999	1381.4	271.5	19.65	242.8	17.57	312.94	22.65
2000	1327.2	230.1	17.34	224.4	16.90	255.79	19.27
2001	937.8	178.9	19.07	182.8	19.50	151.66	16.17
2002	729.0	130.2	17.86	162.0	22.22	110.83	15.20
2003	628.4	84.8	13.49	143.0	22.75	79.87	12.71
2004	1331.3	289.5	21.75	221.4	16.63	247.56	18.59
2005	2347.9	451.5	19.23	299.2	12.74	672.45	28.64
Avg	1245.6	230	18.17	216.2	18.26	256.03	19.49

From the analysis, it is observed that the groundwater recharge varies from 13% to 22% with an average of 18%. Interestingly, both Chathurvedi formula and Krishna Rao methods also shows similar recharge values. This clearly demonstrates the applicability of ArcSWAT model in predicting groundwater recharge.

Runoff Estimation using SWAT Model and Conventional Methods

Figures below shows the runoff estimated by empirical methods such as Inglis, Lacey and Khosla methods for the Ghataprabha sub-basin up to Daddi (small basin). The results obtained by these methods are compared with the SWAT output. The runoff value estimated by SWAT model varies between 31% and 62% with an average of 45.91%. According to Inglis formula, the surface runoff vary from 36% to 67% with an average runoff of 57.57% . Lacey's methods showed variation between 26% and 57% and average is 39.92%. However, the runoff estimated by Khosla's method deviated far off from the predicted runoff using SWAT. Both Inglis and Lacey's method predicted relatively closer values as compared to Khosla's method.

Isotopic studies have been carried out in NIH, Nuclear laboratory. The results, shows that most of the streams in both Chandgad taluk and Western Ghat region of Sindhudrug are fed by rainfall recharge.

As there is a decline in the yield of the spring water various measures to protect the streams should be taken up immediately. The scope exists for construction of suitable artificial recharge structures in the district in limited areas. The structures recommended for the hilly areas are: contour bunds, gully plugs, nala bunds and check dams. For other hard rock areas, the Nala bunds, check dams and KT weirs are suggested. The existing dug wells may also be used for artificial recharge of ground water provided source water is free of silt and dissolved impurities.

Table 5.4 Estimated Runoff by SWAT model and Conventional methods

year	Rainfall in mm	% Runoff obtained by SWAT model	Inglis Runoff in mm	% Runoff	Lacey's Runoff in mm	% Runoff	Khosla's Runoff in mm	% Runoff

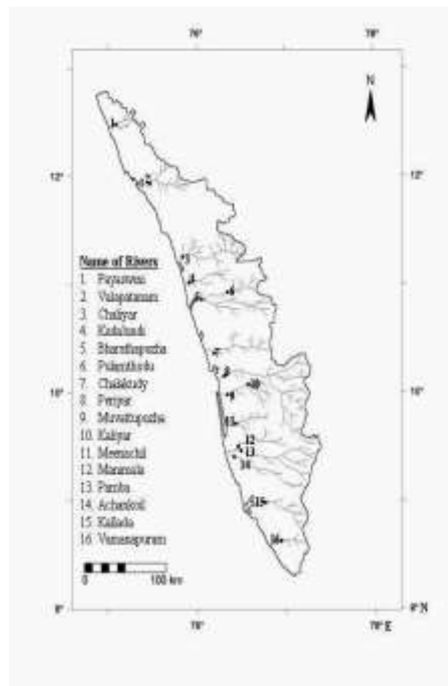
1990	1129.15	41.92	654.77	57.98	436.32	38.64	1013.90	89.79
1991	1499.19	50.66	969.31	64.65	682.70	45.53	1383.94	92.31
1992	1303.54	51.47	803.00	61.60	548.75	42.09	1188.29	91.15
1993	1174.73	46.32	693.52	59.03	465.00	39.58	1059.48	90.19
1994	1585.45	54.01	1042.63	65.76	744.03	46.92	1470.20	92.73
1995	697.38	39.13	287.77	41.26	195.29	28.00	582.13	83.47
1996	1123.74	45.35	650.17	57.85	432.95	38.52	1008.49	89.74
1997	1725.81	56.57	1161.93	67.32	846.44	49.04	1610.56	93.32
1998	1007.12	37.50	551.05	54.71	362.23	35.96	891.87	88.55
1999	1381.47	54.34	869.24	62.92	601.20	43.51	1266.22	91.65
2000	1327.22	49.12	823.13	62.01	564.55	42.53	1211.97	91.31
2001	937.76	36.90	492.09	52.47	322.03	34.34	822.51	87.71
2002	729	34.00	314.65	43.16	210.72	28.90	613.75	84.19
2003	628.37	31.17	229.11	36.46	163.07	25.95	513.12	81.66
2004	1331.3	44.26	826.60	62.09	567.29	42.61	1216.05	91.34
2005	2347.91	61.99	1690.72	72.00	1331.29	56.70	2232.66	95.09
Avg	1245.57	45.91	753.73	57.57	529.61	39.92	1130.32	89.63

4.0 Application of Geostatistical methods for analyzing sedimentation pattern in river basins of Kerala State

Study Group	**:** Mathew K. Jose and Chandramohan T
Date of start	: October 2014
Duration	: 2 years
Funding	: Internal
Status	: Completed

Sediment transport is an inseparable part of fluvial systems like river flows. Sizes of sediment particles vary from pebbles and gravel to silt and clay. Transportation of sediment starts when the shear stress acting on the bed exceeds the critical shear stress of the bed material. The sediment moves in the direction of flow from high region to low region. The modes of transport can be classified into different categories like *Contact load* (sediment particles that roll or slide along the bed), *Saltation load* (sediment particles hopping or bouncing along the bed), *Bed-load* (sediment moved on or near the bed), *Suspended load* (sediment moving in suspension).

Sediment transport is a variable because as it is constantly subject to changes. Sediment load varies due to geological and geomorphological characteristics. The alteration to sediment transport can come from changes in water flow, water level, weather events and human influence. The rainfall/ precipitation characteristics, flow conditions in the river, ratio of densities of sediment and fluid, size distribution of sediment particles etc. affect the sediment transportation process in river systems. The observation and measurement of sediment yield from various rivers are being carried out in the country by various State agencies as well as Central agencies.



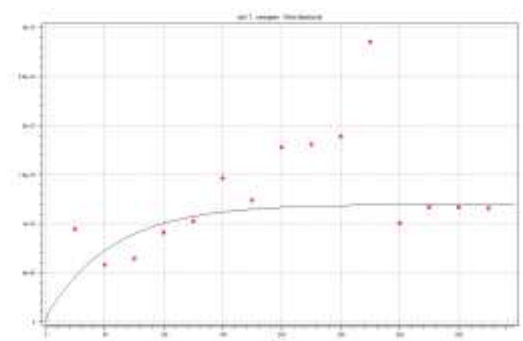
Analysis of sediment yield data facilitates to understand the distributional characteristics of sedimentation in river basins. Evolving a sediment distribution relationship over the region, consisting of different catchments, may be helpful in estimating sedimentation rates at non-sampling locations. Such estimates are being carried out using different statistical techniques. However, geostatistical analyses (*Cressie, 1991; French, 1995; Goovaerts, 1997*) would be better estimates of mass fluxes compared to those obtained through conventional methods. This kind of analysis is possible, as processes like river sedimentation with time-space variation may be considered as regionalized variables (*Deutsch and Journel, 1998*) and estimation of two dimensional semivariograms allows the spatial scale of variability to be incorporated into interpolated sedimentation surfaces (*French et al, 1995*). Therefore, geostatistical techniques can be effectively utilised in analysing such variables to bring out their spatial structure.

The analysis of sediment yield data of long periods over a large area is helpful in investigating and understanding the distributional characteristics and behavioural pattern of sedimentation in river basins in a region. In the presented study, geostatistical analysis of sediment yield data from sixteen river basins of the State of Kerala has been undertaken with a view to reveal the spatial and temporal distribution pattern of sedimentation in the region.

The study area consists of various river basins of Kerala state situated in the humid tropics and bound by $8^0$18´ N & $12^0$48´ N and $74^0$52´ & $77^0$22´E. In the study area there are 41 rivers flowing westward and 3 rivers flowing eastward originating in the Western Ghats. The study area under consideration has highly undulating features with altitudes varying from sea level to thousands of meters. Based on topography, the area may be categorized into low land area, mid land area and high ranges. Since the region is characterized by steep slopes consisting of mountains and valleys, generation and transport of sediment is an integral aspect of river flows. The state is characterized by distinct rainfall patterns consisting of SW monsoon during June to September and NE monsoon during October to December. The nature of rainfall, their intensities and spatial distribution vary between these two seasons.

The mean annual rainfall in the study area (Kerala State) is more than 3000mm.There is considerable variability of rainfall between South to North of the state in the range of 900mm to 3500mm. In addition to this variability in the south-north direction, there is a steep variation of rainfall in the west-east direction (that is, from coastal area to the hilly region) due to orographic influences. This orographic variability ranges between 1400mm (along the coast line) to 6000mm (in the high ranges. The overall rainfall contribution during SW monsoon is about 70% and NE monsoon is 25%. The contribution of NE monsoon in the southern parts of the state is much higher than that of north Kerala. Therefore, the sedimentation behavior also is expected to vary in time and space. Geological formations in the study area are crystalline rocks, sedimentary rocks and laterite. In the low lying areas and river valleys recent and sub-recent sediment formations also exist. The land use patterns observed in the state can be classified into arable land, forest land, agricultural plantation, grass land and waste land. The present study utilizes sediment and flow data of 16 rivers from the state. The data was recorded over a period during 1989-2007 by the Central Water Commission (CWC) using sampling method at the discharge measurement locations.

Spatial analysis of sediment yield data of the study area has been carried out using geostatistical tools. The software SGeMS has been utilsed for the purpose. Various cases have been considered for the analysis giving due consideration to the regional variations, seasonal variations as well as monsoonal behavior in the northern and southern parts of the study area. The long term average of the sediment data has been computed using long records of sediment data, and the long term mean value of each data sampling location has been used for the spatial analyses. For preprocessing the data, various graphical techniques like scatter plots, QQ-plots and PP-plots have been employed.



In the first case data of the whole region is taken together and did the analysis. In the second and third cases, the study is divided into two zones of North and South regions separately to investigate any regional disparity. In the other cases seasonal variations of the monsoonal rainfall characterized by the southwest and northeast monsoon have been analysed separately for the whole area as well as for the designated zones also.

Using the corresponding data, empirical variograms were calculated with appropriate parameters. Using the calculated parameters variogram models were fitted. In general, variogram models of the exponential type were found to be fitting for the various cases. The evolved variogram models were used to simulate the spatial sediment distribution using simple Kriging method. The mean and variance values for different cases are given in Table.

Table: Mean and variance values of sediment distribution for various cases

Region	*Mean*		*Variance*	
	SW monsoon	NE monsoon	SW monsoon	NE monsoon
Whole study area	112178	26309.4	1.01e10	2.5e8
North region	160998	23537.8	1.21e10	2.83e8
South region	49408.4	29873.5	9.03e8	2.28e8

It may be seen that the mean value of North region is higher than that of the south region. Analysis of seasonal variation due to SW monsoon and NE monsoon (post monsoon) showed differences in sedimentation pattern during the two rainy seasons, and also regional disparities existed. The correlation structure of the whole area revealed that the sedimentation pattern is much more consistent in the northern parts of the study area compared to the south region. North region has about 70%, South region has 45% and whole region has 37% of spatial correlation. However, during NE monsoon north region indicated less spatial correlation while southern region showed higher spatial correlation.

Analysis of sediment distribution pattern of west-flowing rivers of Kerala has been carried out by giving due consideration to regional as well as seasonal aspects. The sediment data has been partitioned into regional zones as well as seasonal (SW & NE monsoonal) basis to investigate variabilities. North region has yielded comparatively good spatial correlation structure in both the monsoon seasons. During NE monsoon, Southern region yielded more sediment compared to northern region, possibly due to intense rainfall in the south during NE monsoon. However, sediment contribution from the northern region during SW monsoon is much higher compared to the southern region. This may be attributed to the heavy orographic rainfall spells in the Western Ghats of the northern region during SW monsoon. For the south region, during SW monsoon, sediment yield has a variance just half of that of NE monsoon. Therefore, the sediment yield in the southern parts are highly variant during the NE monsoon period. The geostatistical analyses revealed that the sedimentation characteristics in Kerala river catchments tend to increase from north to south during NE monsoon. During SW monsoon season northern region yielding more sediment compared to southern region. The quantitative increment in sediment yield towards the southern parts of the state during NE monsoon may be due to the high intensity of the storms during that period. The study revealed that maximum spatial correlation in north region compared to south region. Also, seasonal variation is observed between SW monsoon and Post monsoon periods.

5.0 Modeling of Sediment Yield from River Basins of Kerala & Goa, Using SWAT Model

Study Group	: Chandramohan T and Venkatesh B
Date of start	: October 2014
Duration	: 2 years
Funding	: Internal

Objectives:

- to test the performance of SWAT model in predicting sediment yield by acquiring the most sensitive sediment parameters in the river basins
- to develop calibrated sediment parameters so that the model can be used in ungauged watersheds for prediction of sediment yield.

Present state-of-art:
Soil erosion and related degradation of land resources are highly significant spatio-temporal phenomena in many countries. Soil erosion, generally associated with agricultural practices, leads to decline in soil fertility, brings on a series of negative impacts of environmental problems, and has become a threat to sustainable agricultural production and water quality in the region. It has been estimated that in India about 5334 m-tons of soil are being removed annually due to various reasons. Often, a quantitative assessment is needed to infer the extent and magnitude of soil erosion problems so that effective management strategies can be resorted to. But, the complexity of the variables makes precise estimation or prediction of erosion difficult. Many empirical and conceptual methodologies have been formulated for the prediction of erosion and sediment yield. However, majority of them are site specific and cannot be used for other regions.

The emergence of soil erosion models have enabled the study of soil erosion, especially for conservation purposes, in an effective and acceptable level of accuracy. For this purpose, several available empirical, physically based, or conceptual models could be used. The latest advances in spatial information technology such as GIS, have augmented the existing methods and have provided efficient methods of monitoring, analysis and management of earth resources.

M**ethodology:**
In this study, the physically based SWAT model will be applied to undisturbed river basins of Kerala and Goa State for the prediction of soil erosion and sediment yield. SWAT model is a watershed scale, continuous, long-term, distributed model designed to predict the impact of land management practices on the hydrology, sediment, and contaminant transport in agricultural watersheds. SWAT subdivides a watershed into different subbasins connected by a stream network, and further into hydrological response units (HRUs). The SWAT system is embedded within geographic information system (GIS) and can integrate various spatial environmental data including soil, land cover, climate and topographic features.

Expected Research outcome from the project:
Reliable predictions of the quantity and rate of runoff and sediment transport from land surface into streams, rivers, and water bodies are needed. Predictions of runoff and sediment yield, support decision makers in developing watershed management plans for better soil and water conservation measures.

This study is aimed at calibrating the SWAT model by identifying major sediment related parameters pertaining to west flowing rivers originating from Western Ghat Region. This calibrated model can be used to predict sediment yield from ungauged river basins of the region.

Progress
The River basins such as Manimala, Vamanapuram and Valaparanam in Kerala and Zuari river basin in Goa have been selected. The required catchment area maps, soil and land use data have been collected. The flow data for few basin in Kerala have been collected and for other basin it is in progress.

- Daily discharge and sediment data for the three basins are collected from CWC
- SWAT model and its applicability to sediment yield simulations were studied from the latest literature available. Model was installed and its various modules, data requirements and model parameters were explored.

- The SWAT model for Manimala basin has been set-up and a calibration run has been completed. Similarly, for other basins also will be completed.
- Preparation of interim report, enumerating the broad objectives of the study, model characteristics, sediment modeling and the characteristics of the selected river basins.
- Calibration of SWAT model was done for the three Kerala rivers; Vamanapuram, Manimala and Valapatanam.
- Model parameters for Valapatanam river basin was selected for the application of model for Zuari basin.
- SWAT model is being applied to Zuari basin.

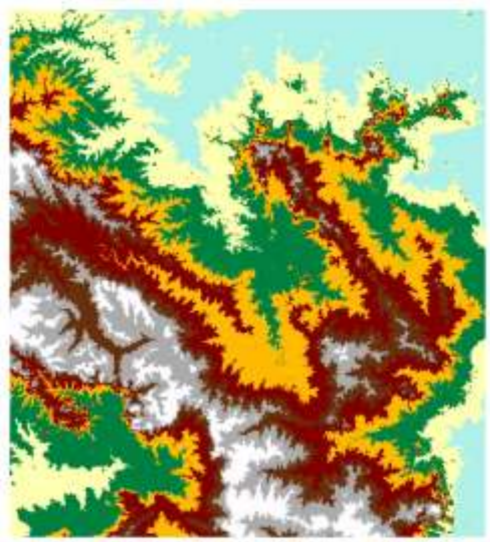
The project may be extended till December 2016 to complete the remaining work.

6.0 Runoff estimation in a catchment using GIS and WEB based tools: A case study

Study Group : Mathew K. Jose and B. Venkatesh
Date of Start : October 2014
Duration : 1 Year
Funding : Internal
Status : Completed

Runoff estimation by preparation of digital elevation model and land use classification from the R Manjirasub basin, a tributary of R Godavari using application of GIS techniques. Geographic information systems (GIS) have been used for various analyses of spatially distributed data. The power of a GIS lies in its ability to reference features to a geographic location just as a conventional map does. The ArcGIS program is used for the study along with web applications like Google Earth and other web resources in public domains where data is shared freely. Hydrologic analysis performed using the above tools to estimate the runoff from the R Manjira sub basin, a major tributary of R Godavari.

The Soil Conservation Service (SCS) curve number method is used for estimating runoff volume from the watersheds of the study area. The method accounts for most of the runoff producing watershed characteristics, such as soil type, land use, hydrologic condition, and antecedent moisture condition. To describe these curves mathematically, SCS assumed that the ratio of actual retention to potential maximum retention was equal to the ratio of actual runoff to potential maximum runoff, the latter being rainfall minus initial abstraction. Mathematically,



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

$Q = 0$ for $P < 0.2S$

where

S = potential maximum retention (mm)
Q = accumulated runoff depth (mm)
P = accumulated rainfall depth (mm)

The potential maximum retention S has been converted to the Curve Number CN in order to make the operations of interpolating, averaging, and weighting more nearly linear. This relationship is given by:

$$CN = \frac{25400}{254 + S}$$

The above equation shows that the Curve Number CN can range from one hundred to zero. For example, for impervious areas, S will be zero and CN will be 100; all rainfall will become runoff. For highly permeable, flat-lying soils S will go to infinity and CN will be zero; all rainfall will infiltrate and there will be no runoff. In drainage basins, the reality will be in between.

The Curve Number is a dimensionless parameter indicating the runoff response characteristic of a drainage basin. In the Curve Number Method, this parameter is related to land use, land treatment, hydrological condition, hydrological soil group, and antecedent soil moisture condition in the drainage basin and these could be derived using ArcGIs.

The study area of the river basin Manjira has been demarcated. Web applications Google Earth, googleMap, Landsat images etc. have been utilized. The runoff estimation procedure follows the flowchart of: DEM preparation in Arc GIS, Flow Direction maps, Flow accumulation, stream definition, catchment grid delineation, watershed delineation, flow length calculation, land cover/ land use map preparation, Curve number computation, and finally runoff depth calculation.

7.0 Impact of Land use/Land cover Changes on Ground water – A Case Study

Study Group	**:** B. K. Purandara , B. Venkatesh and N Varadarajan
Date of Start	: October 2014
Duration	**:** 2 Years
Funding	: Internal

State of Art

In many developing countries, extensive areas are undergoing land use change. The largest changes in terms of land area, and arguably also in terms of hydrological impacts, often arise from afforestation and deforestation activities. There is now increasing recognition of the potential for land use and particularly land use change to impact on parts of the water cycle other than just rivers and lakes. The potential impacts on recharge characteristics are of particular concern as the water allocation process assumes a certain level of recharge of suitable quality (on average) each year – if this level of recharge is not achieved this will cause on going aquifer depletion in many parts of the country and cause adverse social and economic consequences. Generally groundwater recharge can be defined as the downward flow of water, originating from precipitation, rivers, canals or lakes, reaching the water table and thereby elevating the water levels. "*Groundwater recharge is the major limiting factor for the sustainable use of groundwater because the maximum amount of groundwater that may be withdrawn from an aquifer without irreversibly depleting it, under current climatic conditions, is approximately equal to long-term (e.g. 30 years) average groundwater recharge. Therefore, long-term average groundwater recharge is equivalent to renewable groundwater resources*" (Döll & Fiedler 2007).

Study area

The watersheds selected for the study are situated on the leeward side of the Sahayadri Mountains (Malnad area of Karnataka) in Siddapur taluk of Uttarakannada district. The present study considers three watersheds, one each under acacia plantation, degraded forest and natural forest. The areas of these selected watersheds are 7 ha, 9 ha and 6 ha respectively. These watersheds fall between 74^{o} 47' 20" to 74^{o} 52' 30" E Longitude and 14^{o} 22' 20" to 14^{o} 22' 30" N Latitude.

The region has a tropical climate with mean monthly temperatures ranging from 20 ^{o} - 27^{o} C. The average annual rainfall is 2800 mm with significant intra-annual variability. About 70-80% of the rainfall falls between June to Sept (south-west monsoon), while another 20% is spread over remaining 8 months. The geology of the area consists of "Dharwar (Chlorite-) schists, granitic gneisses and charnockites from the Archanea complex. Broadly, the soils of this region have been categorized as red sandy or sandy-clay loams, or more specifically as mainly Ferrallitics (French soil taxonomy) or Alfisols and Inceptisols.

A meteorological observatory was established in the vicinity of these selected watersheds (this observatory is used as representative for all selected watersheds). An autographic and non-autographic raingague was used to measure the rainfall. Along side of this, air temperature (maximum and minimum) and wet and dry bulb temperature were also measured.

Objectives

- To understand the relationship between rainfall-runoff and groundwater recharge under different forest types
- To estimate evapo-transpiration under different forest covers/land covers
- To determine the in-situ soil hydraulic properties (such as infiltration, saturated and unsaturated hydraulic conductivity, soil moisture retention characteristics
- To estimate the groundwater recharge under different land use/land covers as well as based on field and laboratory methods, numerical solutions and also using tracer techniques

- To develop a conceptual ground water model based on detailed hydrogeology, soil and land use pattern

Methodology

- Groundwater level monitoring in selected watersheds in parts of North Kanara district
- Soil moisture monitoring using moisture probes and estimation of ET using the soil moisture data
- In-situ determination of soil hydraulic properties and determination of aquifer parameters across an array of land use/land covers
- Surface and groundwater balance estimates of selected watershed
- Numerical modeling using Visual Modflow/GWM systems

Field monitoring and experiments could not be carried out due to financial limitations. Therefore, following aspects were studied using existing data

- Rainfall-runoff analysis using available data
- Estimation of the soil hydraulic properties such as infiltration, hydraulic conductivity and soil retention characteristics and to determine the variation of parameters with reference to changes in land use/land covers.
- Modelling of soil moisture movement using Hydrus – 1D model.

Rainfall Analysis

Rainfall is the major driving force in determining the overall climatic conditions and to understand the hydrological regime of a given region. Variations of rainfall in time and space exert a significant influence on the magnitude and characteristics of various hydrological processes. In this regard, rainfall analyses of daily, monthly and annual basis has been carried out. This will help to estimate the water availability of the region.

Table: Daily rainfall Characteristics of the Study Area for Normal Rainfall

Rainfall Class by depth (mm)	No. of Rainy Days	Rainfall Amount (mm)	% of Total Rainy Days	% of Annual Rainfall	Cumulative % Annual Rainfall
>80	6	749.6	5.88	22.40	22.40
40.1 to 80	27	1531.6	26.47	45.76	68.16
20.1 to 40	26	749.0	25.49	22.37	90.53
10.1 to 20	11	168.2	10.78	5.03	95.56
5.1 to 10	11	86.0	10.78	2.57	98.13
<5	21	62.6	20.59	1.87	100
Annual Total	102	3346.8	100	100	

In conclusion, it may be said that in a tropical monsoon environment, the difference between a high rainfall year and an average year may be entirely on account of a few high magnitude rainfall events. However, the few events can have a significant impact of not only total water yield, but also on runoff generation mechanism producing flash floods and causing erosion. This analysis highlights the importance of investigating intra - annual variability of rainfall while classifying years as above or below normal rainfall.

Hourly Rainfall Intensity

The Sahayadri region is characterised by higher annual rainfalls due to long duartion low intensity rainfall. It is reported that the 15 minute intensities often exceed 40mm/hr contributing about 15 % of total annual rainfall. In the present analysis, hourly rainfall data recorded at Kodigibail using a recording type of raingauge was analysed to understand inter - annual and intra - annual variabilities. Rainfall intensities of hourly rainfall were extracted from the rain gauge charts and categorised under 6 classes depending on the magnitude of intensities.

From the analysis of the hourly rainfall intensities during below normal rainfall, normal rainfall and above normal rainfall, it was noted that the recorded maximum hourly intensity was of the order 50.5 mm/hour during above normal rainfall. The total number of rainfall hours varied from 1140 hr (47.5 equivalent days) for normal rainfall category to a minimun of 646 hr (27 equivalent days) for below normal rainfall category showing large inter annual variation. The corresponding percentage of days (in comparision to the total number of rainy days) for normal rainfall and below normal rainfall were 47 % and 30 % respectively. During above normal rainfall received higher rainfall within 682 hrs. This suggest that the intensity of rainfall was very high with an average hourly intensity of 5.88 mm/hr in comparision with other two years (2.90 mm/hr for 2011 and 4.56 mm/hr for below normal rainfall).

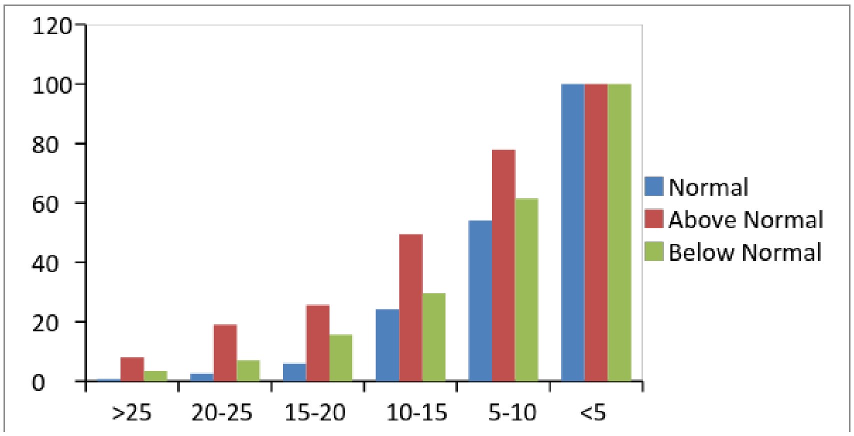


Fig : Hourly rainfall intensity for the study area

Further, the results showed that the study area received high intensity rain (>25mm/hr) only on few occasions and their contributions were also lower (1 %,8 % and 4 % respectively in all three categories of rainfall). Low intensity rainfalls contributed more than 70 % for normal rainfall category and below normal rainfall category lasting for 94 % of the time and above 50 % for above normal rainfall category lasted for 80 % duration. Contributions from rainfall of moderate intensity between 10 to 25 mm/hr were 24 %, 42 % and 26 % approximately for all the three category of rainfall which lasted for 6, 15, and 7% of the times. Results showed evidences of rainfall at Kodigibail being contributed mostly by the spells of low intensity rainfall rather than higher intensity rains though there were large year to year variations in the intensities.

Runoff Analysis

In the present analysis, an attempt is made to characterize differences in the runoff responses of the three watersheds possessing distinctly different land covers. The daily stream flows from the experimental watersheds were measured during the study period using calibrated broad crested notches. These observed mean daily discharge values were converted to equivalent runoff depth units (mm) so as to facilitate the comparison with the rainfall. Fig. 2 shows the monthly distribution of measured runoff under different land covers (under above normal rainfall condition).

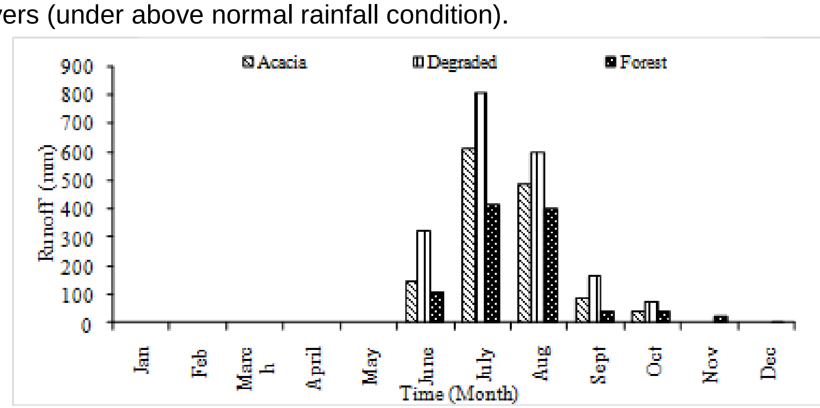


Fig : Monthly distribution of measured runoff under different land cover above Normal Rainfall

It can be noted from figure, that the degraded watershed yielded more runoff in comparison to that of the other two land covers. Runoff from the watershed covered with acacia plantation was smaller in comparison to degraded watershed. The least discharge was observed under the forested watershed.

However, the flow was reported up to November in forested watersheds which could be largely attributed to the higher moisture holding capacity of the forest soils resulting in more sustained runoff in comparison to the degraded watershed. Also the flow in acacia watershed continues till the month of October which indicated that the water holding capacity of the soil conditions similar to that of forests.

Some of the Important Observations of the study are listed below

- The specific discharge is highest in degraded watershed (24% higher than forest) and lowest in forested watershed
- The influence of land-use on the soil moisture variation and its dynamics is observed and statistical analysis indicates the root density is concentrated within 30 to 90 cm and down to 200 cm in Acacia plants and in natural forest respectively
- The soil moisture deficit index has an influence on the runoff generation in the watersheds.
- The Ksat values in Acacia are more or less comparable with that of the forest, hence the possibility of more water movement down the soil strata.
- Comparatively higher groundwater recharge is observed in the acacia plantation.
- It is observed that the hydraulic properties such as infiltration and hydraulic conductivity showed an improvement in comparison to degraded lands. In the degraded forests, Hortonian overland flow is very common phenomenon.
- The current study clearly indicated that selective reforestation and afforestation with acacia species ameliorates the surface hydraulic properties and encourages greater percolation and conversely, inhibits infiltration excess overland flow occurrence.
- It is also noticed that there is a declining trend in the field saturated hydraulic conductivity (K*) with the depth across all the land covers. It is further observed that there is an improvement of hydraulic properties below 0.5m. It is also found that subsurface flow and surface overland flow are dominating preferential flow path existing in study area.
- Spatial and temporal variation of soil moisture indicated that in the degraded forests the moisture content varies considerably in comparison to acacia and forested watershed. The temporal variation of soil moisture was influenced by influenced by rainfall and peak soil moisture was generally preceded by peak rainfall. The response of soil moisture to rainfall in the degraded forests was relatively faster compared to other two watersheds.
- Groundwater recharge estimated for different land use/land covers indicated that the maximum recharge is in the acacia plantation (19.5%) and minimum in the degraded forests (9.5%). Recharge in the forested watershed was also greater than degraded forests in-spite of higher ET (16.5%).

8.0 Impact of Urbanization on Surface and Ground water Quality and Quantity – A Case Study

Study Group : B. K. Purandara, Sudhir Kumar and N. Varadarajan
Date of Start : October 2014
Duration : 1 year
Funding : Internal

The risks of aquifer pollution are substantially affected by groundwater hydrology. Aquifers (water-bearing layers of soil) lie in the saturated zone below the water table. Soil above the water table is unsaturated with water, and is classified as part of the unsaturated zone. ***Pathogens do not travel farther or faster than the water in which they are suspended.*** Water flows very slowly in the unsaturated zone, as flow is along a thin and tortuous path along the surface of soil particles. Flow is much more rapid in the saturated zone, as water flows directly through the soil pores. Most on-site sanitation systems depend upon the capacity of the soils in the unsaturated zone to accept and purify effluent. *The key factor that affects the removal and elimination of bacteria and viruses from groundwater is thus the maximisation of the effluent residence time between the source of contamination and the point of water abstraction. Because of the very low velocities of unsaturated flow, the unsaturated zone is the most important line of defence against faecal pollution of aquifer**s.*** Commonly used guidelines in many soil conditions keep the bottom of the pit at least 2 m above the water table, and at least 15 m from any well used for drinking purposes. In some areas, however, such criteria cannot be met, or the soil conditions (such as fissured limestone) do not assure groundwater protection when such guidelines are followed. In these cases, the choice of sanitation technology depends upon a number of factors, including the relative risks of alternatives.

In order to understand the movement of contaminants and microorganisms, a detailed investigations have been carried out in parts of Belgaum city, also known as Second Capital of Karnataka. This is one of the fast developing city in Karnataka and needs infrastructure development with regard to waste disposal and water quality aspects. Population growth and urban development dramatically altered the natural watershed and ecosystem structure and functions and put stress on water resources. Anthropogenic activities are of a major force in changing the hydrological cycle as well as the climate. Therefore, in the present study an attempt was made to link the urbanization, agricultural development, and the subsequent water resources exploitation with the change of water environments in Belgaum and adjoining areas and evaluate the impacts of human activities on the regional hydrological cycle and water quality. According to the historical records, the depth of the water table was shallow. After the 1970s, the increase of groundwater pumping began to result in the fall of the groundwater level at a rate of 0.1 to 0.5 m year^{-1}. Further, there is a close relationship exists between urbanization and water pollution. Urban areas with ever growing population stress and lack of facilities to dispose the domestic and industrial wastes in proper scientific manner resulted in both surface and ground water pollution. Fortunately, in most urban area pollutants are of a point source nature and are controlled by discharge regulations.

However, in urbanized areas, the land is altered to meet the needs of the people who live there. This alteration of the land accelerates nonpoint source pollution because it changes the way water moves, increases surface runoff, and causes erosion. Moving with the water, eroded soil from agriculture areas are the other pollutants, which cause numerous water quality problems in a city and its adjoining parts.

Objectives

Considering the above issues, the district administration has raised some of the issues related to solid waste management, sanitation and water quality issues related to both surface and ground water. Therefore, the present study has been proposed for Belgaum city with the following objectives.

1. Ground water availability studies of Belgaum City and adjoining areas (proposed for the inclusion under BCC)
2. Surface and Ground water quality investigations in Belgaum city and adjoining areas
3. Issues of Solid waste management and its impact on water quality
4. Analysis of microorganisms and their decay rate estimation

Conclusions

Ground water has traditionally been considered to be the water source least susceptible to contamination by indicator bacteria or human pathogens. This is certainly true of ground water from deep, confined aquifers. However, in the present investigation, it is noticed that the microbiological quality of ground water is contaminated with microorganisms which is attributed to the dumping of solid wastes and discharge of liquid wastes in unplanned manner. The microorganisms enters the ground water system due to its connection with a contaminated surface environment, such as seepage from a waste lagoon or a contaminated surface water, or a subsurface source of contamination such as a septic tank, a broken or leaking sewer line, or an old or improperly designed land-fill.

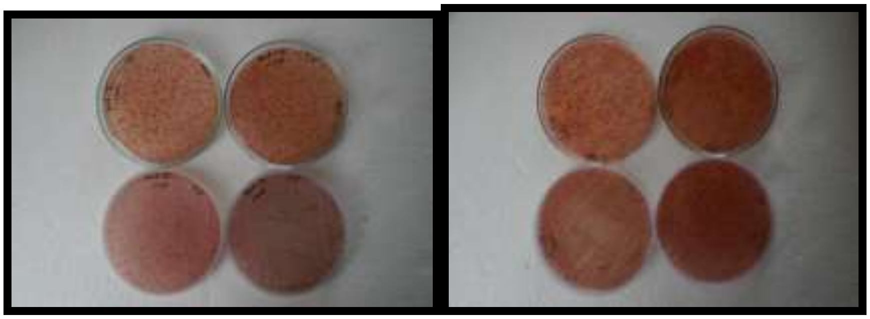
One of the major causes of ground water pollution in Belgaum city could be due to the ongoing urbanization and uncontrolled abstraction of water. The land use changes are quite marked in extension areas of the city, particularly on the western and northern zones. In these areas lots of agriculture lands have been converted to habitation lands. Further, agriculture deep ploughing, the uses of heavy machinery, application of excessive fertilizers and pesticides, drainage and irrigation have all lead to water quality problems.

Another important problem associated with ground water quality issues of Belgaum city is due to the long term usage of ground water for irrigation. The excessive irrigation in some parts of the city, results in building up of salts in the soil by capillary rise from water table. If there is not enough leaching, a process of secondary salinization and associated sodification takes place, leading to the soil and ground water salinization. As water moves beneath the root zone but above shallow permeable layers a local ground water system is formed. Salts in the soil are dissolved and salt is deposited on the surface. The primary cause appears to be farming practices in general and cropping pattern in particular. Further, due to high intensity rainfalls in the city, erosion of dumped wastes and soils takes place rate seems to be very high and these sediments acts a carrier of polluting chemicals, such as pesticides and plant nutrients. Based on the present investigations and data analysis, it is noted that the major cause of water pollution in Belgaum city is due to the manmade disturbances. Bacteriological pollution is mainly due to the mixing of sewage water with the shallow aquifers. Geomorphologic and soil characteristics play significant role in transporting solutes to ground water and surface water bodies. This is clearly demonstrated through VLEACH model application. Further, the widely distributed iron contamination is geogenic in origin which can be controlled by proper techniques. Apart from this, following activities are also contributing to water pollution.

- Contamination of groundwater supplies by unsewered sanitation.
- The bacteriological contamination of shallow wells in all types of geological formation.
- The increase of chloride in many wells is a clear indication of mixing of sewage water with groundwater
- It is observed that the inner part of the city is getting contaminated due to the thrust of population and commercial complexes.
- A temporal change in the chemical composition of the ground water is noticed at certain locations from the point of recharge to the point of discharge.

Following figures illustrates the number of microrganisms present in three different environments namely Waste water, soils and ground water. There is a sharp decline in counts of microorganisms in three different media.

Microscopic overview of E-coli at PB Road and Sulebhavi



Microscopic overview of E-coli at Kudchi and Sulebhavi (Soil)

Table 1 shows Decaying coefficients estimated from the present study.

Table 1 Observed decay coefficients for Various Microorganisms

Micro organisms	Effluent	Waste water	Clean water	Ground water
E-Coli	0.0069	0.029	0.0625	0.0078 to0.02
Klebisellia	0.01	0.111	3.33	0.0028 to 0.028
EFaecalis	NG	0.111	0.222	NG
NLF moist	0.0055	NG	NG	0.005 to 0.8
MINULf	0.013	0.104	0.104	NG
Pseudomonas	0.0041	0.0041	0.0813	0.083 to0.8

DRASTIC index developed for the study area delineated nine critical zones as pollution potential zones. These areas lie mostly in the innermost part of the city and commercial complex where population density is quite high. Further, there are no power sewer lines and dumping sites in this area. Therefore, the DRASTIC parameters show a clear indication of these points. However, it is suggested that the modification of DRASTIC parameters by incorporating other factors such as land use, land cover, chemical applications, well density, irrigation type and intensity will enhance the accuracy of the results.
At the outset, based on the analysis of the data collected, followed by field investigation and discussion held with number of scientists working in this area indicated that groundwater is getting contaminated, especially, due to waste disposals without any precautions. This observation shows that it is necessary to go for sewage treatment plans so that the pollution due to use of this water by farmers and mixing of sewage with ground water can be minimized.

Recommendations

1. Stringent action should be taken for the management of solid wastes
2. Reconstruction and lining of sewer lines may be taken up on priority basis
3. Restructuring of waste management plan with provision for organic farming by conversion of waste in to organic manures
4. Organising awareness programs in each ward and also in city outskirts to bring knowledge on waste management.
5. Scientific based management plan with technological innovations
6. Regular monitoring of groundwater and surface quality in various parts of the city to understand the impact of waste management on water quality aspects.
7. Sewage treatment plants should be installed at various parts of the city where it is discharged to the Bellary nala.

APPROVED WORK PROGRAM FOR THE YEAR 2016-2017

SNo.	Title of the Study	Study Group	Duration	Funding
1	Integrated Water Resources Management (IWRM) on a Pilot Basin – Zuari River Basin, Goa	CMT, BKP, VCG	Apr 2013 –Dec 2016	Internal
2	Modeling of Sediment Yield From River Basins of Kerala & Goa, Using SWAT Model	CMT and BV	Oct2014-Sep 2016	Internal
3	Clean and safe drinking water supply to rural community using river bank filtration techniques in hard rock regions of Krishna basin, Karnataka, India.	BKP & SK	Apr 2016 – Mar 2019	DST Sponsored
4	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
5	Dam Break Analysis of Dams in Sharavathi and Varahi River Valley	BV & All RC Staff	2 years	KPCL Consultancy
6	Hydro-geological investigation in MRPL campus	BKP & All RC Staff	1 year	MRPL Consultancy
7	Hydro-Geological study for Kudgi Super Thermal Power Project Stage-I (3x800) mw, Bijapur, Karnataka	SK & RC Staff	1 year	NTPC Consultancy

CONTINUATION OF THE ON-GOING STUDIES

1.0 Integrated Water Resources Management (IWRM) on a Pilot Basin – Zuari River Basin, Goa

Cost estimate for one year (2016-17):

a. **Total cost of the project** **:** Rs. 4,50,000
b. **Source of funding** **:** Internal
c. Sub Headwise abstract of the cost

Since this is a part of the Institutes IWRM/PBS study, WEAP model application is planned for the regional centers at NIH Roorkee. The finalization of the study and report preparation will be done thereafter.

Sl.No.	Sub-head	Amount (in Rupees)
1.	Wages	Nil
2.	Travelling expenditure	2,50,000
3.	Conducting workshop/awareness programs	1,50,000
4.	Misc. expenditure	50,000
	Grand Total:	4,50,000

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

The present project is in its second year and the works to be completed are:

1. Travel to NIH Roorkee, for the WEAP model application
2. Application of mathematical model for water resources management
3. Organizing workshop, awareness program etc.

Keeping in view of these works,

- Travel expenditure for Scientists and other staff to Goa, Delhi and Roorkee
- Organizing workshop/awareness program at Goa

Quarterly Break up of cost estimate for 2016-17:

Sl. No.	Sub-head	Amount (in Rupees)			
		1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
1.	Wages	-	-	-	-
2.	Travelling expenditure	1,00,000	1,00,000	Nil	50,000
3.	Workshop/awareness program			50,000	1,00,000
4.	Misc. expenditure	15000	15000	10000	10000
	Sub- Total:	1,15,000	1,15,000	60,000	1,60,000
	Grand Total	4,50,000			

The study will be completed by December 2016.

2.0 Modeling of Sediment Yield from River Basins of Kerala and Goa, Using SWAT Model

Cost estimate:

- **a. Total cost of the project** **:** Nil
- **b. Source of funding** **:** Internal
- **c. Sub Head wise abstract of the cost**

SWAT model is calibrated for the three rivers in Kerala; Vamanapuram, Manimala and Valapatanam. The model parameters are being regionalized to apply for the ungauged basin, Zuari.

These regionalized parameters will be used for the application of the model for the Zuari basin to simulate discharge and sediment.

The study will be completed by December 2016.

New Studies proposed for the year 2016-2017

1.0 Estimation of Water Availability for Ungauged Basins in Western Ghat Region

Project team:

a. Project Investigator	Chandramohan T
b. Project Co-investigator	Venkatesh B, Mathew K Jose, Purandara B.K. N. Varadarajan, Chandra Kumar S.
Duration of the Project	: 3 Years
Funding	: Internal/NHP

Statement of the Problem

Lack of adequate hydrological data introduces uncertainty in both the design and management of water resources systems in ungauged catchments. Consequently, there is a need to develop methods for predicting flow characteristics at ungauged sites. The International Association of Hydrological Sciences (IAHS) recognized this need in 2002, and adopted the Prediction of Ungauged Basins (PUBS) as a research agenda for the coming decade.

Estimation of flow characteristics of ungauged catchments is usually based on transferring or extrapolating information from gauged to ungauged sites, a process called regionalization. Several regionalisation approaches have been used, and the most common method involves derivation of empirical relationships between flow and catchment characteristics. These relationships are in most cases region specific. Catchment characteristics that influence flow characteristics should ideally be used for cluster analysis. This enables determination of membership of an ungauged catchment on the basis of its catchment characteristics, to a region with a known relationship between flow and catchment characteristics. Nathan and McMahon (1990a) demonstrated that a combination of multiple regression, cluster analysis and multi-dimensional plotting improved the delimitation of these hydrologically homogenous regions within which predictive equations for flow characteristics can be developed.

Another approach that has been used for estimating flow characteristics of ungauged catchments is the use of rainfall-runoff models whose parameters have been regionalised. Most of the models predict the hydrographs at a daily time step. In the case of conceptual models, the model parameters cannot usually be measured or inferred from measurements. The parameters therefore need to be transferred (regionalised) from gauged catchments in the region, termed donor catchments. There are different methods used for parameter regionalization, which can be grouped into *five* groups: spatial proximity, similarity, model averaging, parameter regression and regional calibration. While the spatial proximity, similarity and model averaging methods, assume that the *entire* parameter set of a gauged basin is also valid in the ungauged basins, parameter regression and regional calibration methods relate *individual* model parameters to catchment characteristics.

Objectives of the Project:

1. To identify catchment characteristics that can be used for predicting flow characteristics of ungauged catchments.
2. To examine the feasibility of using catchment characteristics for identifying catchments with similar hydrological responses or delimiting hydrologically homogenous regions.
3. To identify suitable flow characteristics, which can be used to develop multiple regression relationships for prediction in ungauged basins.
4. To develop appropriate relationships between the selected flow characteristics and catchment characteristics.
5. To test the possibility for regionalising parameters of selected rainfall-runoff models on the basis of catchment characteristics, and using these to estimate flow characteristics of ungauged catchments.

Methodology :

- Selection of different types of catchment and flow characteristics for developing regional equations for water availability studies and assessing the variation of these characteristics among the selected catchments.
- Estimation of catchment characteristics such as; Catchment area, Mean of monthly and annual rainfall, Average number of rainy days per year, Maximum, average, and minimum catchment elevation, Drainage density, Slope Proportions of the catchment with different lithologies, Proportions of the catchment with different land cover types, Mean of monthly and annual potential evaporation, Normalized difference vegetation index *(NDVI),* etc.
- Developing relationships between catchment and flow characteristics using multiple regression, and if possible by neural networks. These relationships will be used for estimating discharge related parameters such as; 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.
- Application of various statistical analyses method to investigate the effects of catchment characteristics on multidimensional hydrological responses. The relative importance of each of the catchment characteristics in explaining the variance of all the flow characteristics will be investigated.
- Possibility of clustering catchments using catchment characteristics into clusters with similar hydrological responses will be investigated. An assessment of whether clustering of catchments improves the prediction of flow characteristics done will be made.
- Regionalising the parameters of a hydrological model such as SWAT model. The possibility of predicting model parameters from catchment characteristics using multiple regression will be examined.

Research outcome from the project:

A methodology to estimate water availability from ungaguged catchments of Western Ghat region will be developed using reigionalisation techniques by developing multiple regression equations for flow characteristics using selected catchment characteristics.

Cost estimate:

a. Total cost of the project **:** Rs. 17,40,000/-
b. Source of funding **:** Internal

Sl. No.	Sub-head	1st year	2nd year	3rd year
1.	Wages (Rs. 15,000/month)	1,80,000	1,80,000	1,80,000
2.	Travelling expenditure	2,00,000	1,50,000	1,50,000
3.	Collection of data/satellite data	1,50,000		
4.	Arrangement of workshop/brain storming sessions/meetings	1,00,000	1,50,000	1,00,000
5.	Misc. expenditure	1,00,000	50,000	50,000
	Total	7,30,000	5,30,000	4,80,000

Quarterly Break up of cost estimate for each year: 2016-17

Sl. No.	Sub-head	Amount (in Rupees)			
		1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1.	Wages	45,000	45,000	45,000	45,000
2.	Travelling expenditure	1,00,000	25,000	25,000	50,000
3.	Collection of data		50,000	1,00,000	

4.	Arrangement of workshop/brain storming sessions/meetings		50,000		50,000
5.	Misc. expenditure	25,000	15,000	20,000	40,000
	Sub- Total:	1,70,000	1,85,000	1,90,000	1,85,000
	Grand Total	7,30,000			

Work Schedule:

a. Date of commencement of the project April 2016

b. Duration of the project **3** years

c. Stages of work and milestone: (quarterly, for 2016-17)

Sl. No.	Work Element	First	Second	Third	fourth
1	Initiation of the project Identification of gauged and ungauged catchments to be studied within the Western Ghat region				
2	Collection/preparation of catchment maps and other related maps				
3	Collection of data on rainfall, runoff, groundwater, evaporation, etc.				
4	Identification of rainfall-runoff model and its calibration for gauged catchments				

2.0 Mapping of Drought Characteristics in Drought prone districts of Southern India

Study Group	: Venkatesh.B., and Jose, M.K.
Date of start	: April 2016
Duration	: 3 years
Funding	: Internal

Drought can be generally defined as a temporary meteorological event, which stems from a deficiency of precipitation over an extended period of time compared to some long-term average conditions. Drought always starts with a shortage of precipitation (compared to normal or average amounts), but may (or may not, depending on how long and severe it is) affect streams, soil moisture, groundwater, etc. It is a recurring natural event and a normal part of the climate of the regions, regardless of how arid or humid they are. Droughts develop slowly, are difficult to detect and have many facets in any single region. It is, thus, one of the most complex natural phenomena, that is hard to quantify and manage, and has multiple and severe social and economic impacts.

Droughts continue to have significant impacts in both developed and developing countries. Ever-increasing exploitation of water resources and associated water scarcity coupled with the growing concern that future climate change will exacerbate the frequency, severity, and duration of drought events and associated impacts explains the increasing attention that individual countries are paying to drought-related issues. Since drought is a regional phenomenon, it is useful, from a regional development perspective, to understand the pattern of various drought-related characteristics and impacts at the regional scale. Such characteristics should reflect multiple aspects of drought, ranging from quantification of drought hazard and vulnerability of water resources systems - to measures of preparedness to face future droughts. Further, the characterization of the drought complicated due to the impact of climate change. One good way of presenting diverse materials related to droughts is through mapping, whereby various drought-related indicators can be plotted at a country resolution, river basin or a regular grid – depending on the type of indicator and information available.

Despite significant drought research, studies that deals with the mapping of drought patterns and identifying the spatio-temporal pattern are limited. Even fewer studies have been reported dealing with mapping of drought-related indicators in the literature. Same is the situation in India in general and Andhra Pradesh, Karnataka, Telangana and Tamilnadu in particular. In this regard, the present study aims at mapping the number of drought-related characteristics, as well as developing associated maps covering upto village level. This study is starting point for mapping drought characteristics and shall not, therefore, be seen as exhaustive study.

The objectives of the study are; (i) estimation of drought indices using the observed data; (ii) estimation of drought indices under climate change condition; (iii) mapping of drought characteristics such as intensity, severity and duration; and (iv) developing mitigation methods suited to the study region.

Methodology:
The following methods shall be used to estimate the drought indices such as : Palmer Drought Severity Index (PDSI); Standardized Precipitation Index (SPI); Effective Drought Index (EDI) and Percent normal and other Rainfall Deficiency indices. The standard GIS software will be used to map the drought characteristics.

Research Outcome: Drought indicator mapping eventually feeds into development of a scientific knowledge base for operational drought tools such as drought monitoring, drought early warning systems, which, in turn, should form part of drought preparedness plans.

Cost estimate for three year (2016-17 to 2018-2019):

a. **Total cost of the project** **:** Rs. 7,80,000
b. **Source of funding** **:** Internal
c. Sub Headwise abstract of the cost

Sl.No.	Sub-head	Amount (in Rupees)
1.	Wages	Nil
2.	Travelling expenditure	3,50,000
3.	Purchase of Meteorological data such as Rainfall, temperature for all the drought prone areas cover Andhra Pradesh, Karnataka, Telangana and Tamilnadu states.	1,50,000
4.	Purchase of AR5 data for the same region from IITM or any other source (projected data as per IPCC AR5 Report)	1,50,000
5	Purchase of village and Taluk maps of the districts which are drought prone in the states considered for study	80,000
6.	Misc. expenditure	50,000
	Grand Total:	7,80,000

2. Justification for Sub-head-wise abstract of the cost:

Travel **:**This project requires an extensive travel to collect the data from different sources such as land records, revenue department, State Irrigation and Groundwater departments

Purchase of data **:** As the study requires the meteorological data for computing the drought indices, the observed data from the state department will be collected. If there are any gaps or in case of no data is available, then such data will be purchased from IMD on daily basis

Similarly, the GCM's data projected as per the recommendations of Assessment Report-5, IPCC will be purchased from either IITM or from any other sources. This is important as to know how the drought indices will be varying both spatially and temporally in the study region.

Purchase of village and Taluk Map : As it is envisaged to map the various drought characteristics for various

Quarterly Break up of cost estimate for each year:

Sl No	Sub-head	2016-17				2017-18				2018-19			
		1st Q	2nd Q	3rd Q	4th Q	1st Q	2nd Q	3rd Q	4th Q	1st Q	2nd Q	3rd Q	4th Q
1	Wages	NIL											
2	Travelling		50,000	50,000			50,000	50,000	50,000		50,000	50,000	
3	Purchase of data from IMD		50,000	50,000		50,000							
4	Purchase of GCM's Data						50,000	50,000	50,000				
5	Purchase of village and taluk maps		20,000	30,000		30,000							
6	Miss. expenditure				15,000				15,000			20,000	
			1,20,000	1,30,000	15,000	80,000	1,00,000	1,00,000	1,15,000		50,000	70,000	
	Grand total (Rs)	7,80,000											

Work Elements of the project

Sl NO.	Work Element	2016-17				2017-18				2018-19			
		1st Q	2nd Q	3rd Q	4th Q	1st Q	2nd Q	3rd Q	4th Q	1st Q	2nd Q	3rd Q	4th Q
1	**Identification of district which are prone for Drought in AP, Kar, T'na**												

	and TN												
2	Purchase of Data & Maps												
3	Literature review on Drought												
4	Computation of Drought Characteristics using the data for a grid of 0.5^o by 0.5^o												
5	Interim Report												
6	Computation of Drought Characteristics using the GCM's data for a grid of 0.5^o by 0.5^o												
7	Mapping of drought characteristics using GIS Software												
8	2nd Interim Report												
9	Spatial analysis of the drought characteristics												
10	Submission of Final Report												

3.0 Spatial Analysis of Suspended Sediment Data of Rivers of Karnataka State

Project team:

- **a. Project Investigator:** Mathew K. Jose
- **b. Project Co-investigator:** ChandraMohan T.

Objectives

There are a number of factors like morphology, rainfall, landuse, topography etc that may influence suspended sediment yield through river flow. As Karnataka spreads across different hydrometeorological zones, variation in the sedimentation process also can be expected. There are number of sediment gauging sites operational in Karnataka for different rivers maintained either by CWC or WRDO.

By using the data from these gauging locations, it is proposed to carry out spatial and temporal analysis of discharge and suspended sediment data of various rivers of Karnataka.

Present state-of-art

Spatial correlation structure of variability of sedimentation over river basins can be studied using variogram analysis methods. Standard geostatistical tools may be used for the analysis. The proposed analysis may bring out the spatial characteristics of suspended sediment transport from various river basins of the Karnataka state.

Methodology

Using geostatistical analysis methods, parameters concerned can be analysed to reveal spatial structure and inter-relationships in the domain. Random processes like sedimentation have structural and random characteristics with variability in space and time. Thus, sedimentation being a regionalized variable in the geostatistical context, analysis of spatial correlation structure of sediment yield at various locations on different river systems may reveal the regional sedimentation characteristics. Evolving a spatial sediment distribution structure over the region, may help in predicting potential sedimentation rates at non-sampling locations.

Research outcome from the project

Spatial structure of suspended sediment yield from rivers in the region of the state of Karnataka.

Cost estimate:

- **a. Total cost of the project :** Rs.2.50 Lakhs
- **b. Source of funding:** Internal
- **c. Sub Headwise abstract of the cost**

		Man Months		
Sl No	Sub-head	PI (Sc D)	Co PI(Sc D)	Amount (in Rupees)
1	Travelling expenditure	25000/-	25000/-	50,000/-
2	Infrastructure/Equipment/ Software	-	-	150,000/-
3	Experimental charges	-	-	-
4	Misc. expenditure	-	-	50,000/-
	Grand Total			2.50 lakhs

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

The expected cost include travelling of PI/ Co-PI to the study areas / and visiting organizations concerned to gather data. Also, procurement of application software and other associated assorted activities related to the project.

Work Schedule:

a. Date of commencement ofthe project: April 2016

b. Duration of the project : one Year (March 2017)

c. Stages of work and milestone

Sl. No.	Work Element	First	Second	Third
1		- Collection of Data - Field Visits - Processing of data - Progress Report	- Analyses - Report preparation	NA
	Deliverables	**Progress Report**		**Final Report**
2		December 2016	-	March 2107

4.0 Clean and safe drinking water supply to rural community using river bank filtration techniques in hard rock regions of Krishna basin, Karnataka, India.

Project team:

Project Investigator: B.K.Purandara
Project Co-investigator: Sudhir Kumar
Date of Start: 1st April, 2016
Duration of Project: 3 years
Funding: DST
Cost of the Project: 99 lakhs

About 21% of communicable diseases in India are water related and polluted water kills over 1,600 people every day38. India‟ s ability to sustain its rapidly expanding economy therefore depends heavily on improving its drinking water quality and infrastructure. Most of the water suppliers however are inefficient or do not serve in all areas, while private wells often fail prematurely. Hence, local communities need to have affordable alternatives to sustain themselves with clean drinking water at predictable quantities, qualities, and cost. The proposed project is conceived to address the issues related to safe and reliable supply of drinking water to all sections of the society. Clean drinking water supply remains a challenge, particularly in southern part of the country where most of the region is covered by hard rock with low recharge characteristics. Even though the tropical climate of this region results in plentiful streams and rivers, environmental pollution and failing infrastructure have degraded access to these waters. This is a matter of serious concern with regard to public health, in many parts of the southern India, viz. Andhra Pradesh, Kerala, Karnataka and Tamil nadu. Therefore, in the present context, it is proposed to identify some of the critical 5. Target Beneficiaries: Principle beneficiaries will be village community specially woman and children. This system will also benefit in accessing of clean and safe drinking water to low and medium income household. However exact number of people that will be benefited by RBF system is ultimately dependent on selected village. Meanwhile we anticipate that at least 2000-3000 people living along the bank of Tungabhadra River will be benefited by DST funded initial 3 years project phase and it will be increase around 10 times during following years 3 years by adapting such technology by state government. Production of clean water supports water user association in agriculture production and industry for processing. Subsequently students and researchers of Research and Development centres, Education institutes etc benefited directly through their participation and learning experience. Finally demonstrated RBF system will be help to local stakeholder‟ s concerned departments like Department of Rural Drinking Water Supply and Sanitation (DRDWSS), Gram Panchayat, Taluka Panchayat and Local NGO in accessing clean water to rural community and replicating this system in other parts of rural Karnataka 6. Objectives of the Proposal The primary aim of this project is to demonstrate that RBF is a technique capable of producing high-quality water from the low quality local river water in a economically sustainable business model. Further investigation would be hypothetically tested does supply of filtered water using RBF reduces the rate of Diarrhea disease in comparison to direct consumption.

In India, the water supply is a subject of State government and in Karnataka, the Karnataka Urban Water Supply and Drainage Board (KUWSDB), is the major agency which supply water to more than 213 towns and cities in Karnataka. In addition, there are agencies supplying water to rural areas. KUWSDB price structure heavily subsidizes water use, but does not encourage water conservation, and, because of losses generated, leaves no funds to invest in improving and expansion of services. Also, water supply is largely delivered through a top-down, non-participatory model, resulting in little social mobilization. Recent economic studies clearly demonstrate that alternative approaches are needed. This encouraged to experiment with a more systematic, scientific and user friendly approach which can address water quality issues and offers a community-centered solution based on a low-cost, low-tech water treatment system. This ultimately resulted in adopting a technology known as riverbank filtration. This is widely used in various parts of the world particularly in European countries, where the public health in a great risk due to pollution. Figure 1: Cross-section of a Riverbank Filtration (RBF) system.

Study Area and Rationale:

Tungabhadra River is the main source for drinking water and agriculture developments in Davangere and adjoining district in Karnataka. Due to the main river around or on the bank of the river Tungabhadra River many industries were developed. Lands were totally irrigated by the river water itself, the development of the Industries like Paper and Pulps and the direct damping the effluents in to the river water at Harihar belt, totally the river water polluted by the direct/indirect effluent discharges in the river water. Public facing maximum problems for causing adverse effect on their health, and on the hazards effect on the health of the animal beings. A number of studies have already been carried out on the effluents of fibre industries. The effluent generates from the conventional pulp and rayon Industries, the poly fibre manufacturing Industries are one of the major sources of water pollution for Tungabhadra River at Harihar, Karnataka state. The industries generally contain more lignin compounds, organic matters, organic halides, total organic chloride which even after treatment have much more BOD, COD, TDS and other effluent parameters. During literature survey it was seen that more detail study has to be performed on the two major wood based industry units namely, Harihar Polyfibre Factory (HPF) and Grasilence Fibre Factory (GRF) on the bank of Tungabhadra River at Kumarapatinam near Harihar, Karnataka state. These units account for more than 90%of the rayon produced in India. The raw materials used for manufacturing the polyfibre not only polluting the water but, also poisoning environment by cutting trees. Therefore, in the present proposed project, an attempt will be made to demonstrate the applicability of the RBF technology and its implications in solving the community problems related to water supply and public health. In this connection, villages in the riparian areas of Tungabhadra river covering parts of Davangere and adjoining districts in Karnataka has been selected. Detailed investigations with regard to water quality issues and resulting health hazard will be taken up in the neighboring villages located along the banks of selected stretches of river Tungabhadra.

Specific 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 tests 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.
- Performance evaluation of river bank filtration scheme (after Ghosh et al, 2015).
- Modelling of surface and groundwater interaction to understand the impact of river flow and pumping (as suggested by Ismail et al, 2013).
- to control the clogging of soil particles by using appropriately designed well screens/casings
- 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.

Work Plan

1. **Work Plan**

   It is proposed to start with a planning phase for the first 3 months, followed by the actual field implementation phase for three years (effectively three monsoon season to capture), and then 6 months for analysis, write-up

2. **Work Plan**

It is proposed to start with a planning phase for the first 3 months, followed by the actual field implementation phase for three years (effectively three monsoon season to capture), and then 6 months for analysis, write-up

Sl no	**Activity**	**2016**			**2017**				**2018**				**2019**	
		May - June	**July - Sept**	**Oct - Dec**	**Jan-March**	**April-June**	**July - Sept**	**Oct - Dec**	**Jan-March**	**April-June**	**July-Sept**	**Oct - Dec**	**Jan-March**	**April - June**
1	Reconnaissance survey													
2	Collection of Secondary information													
3	Geophysical investigation for RBF installation													
4	Selection of site													
5	Installation of RBF													
6	Interim Report													
7	Water Sampling and Analysis													
8	Health impact study													
9	Data Analysis and outreach activity													
10	Dissemination of Results													
11	Final Report submission													

5.0 Impact of Land use/Land cover Changes on Ground water – A Case Study

Project team:

a. Project Investigator B. K. Purandara
b. Project Co-investigator B. Venkatesh

Present State of Art

Impacts of LU/LC change on atmospheric components of the hydrologic cycle (regional and global climate) are increasingly recognized (Pitman et al., 2004). However, impacts of LU/LC change on subsurface components of the hydrologic cycle are less recognized, particularly groundwater recharge. The potential scale of subsurface impacts is large. Groundwater is Earth's largest freshwater resource. Reduced reliability of surface water supplies in the western US with projected climate change during the next century may result in increased reliance on groundwater. Widespread changes in LU/LC have occurred as a result of agricultural expansion. Groundwater is one of the major components of the hydrological cycle. One of the predominant factors, which affect the movement of water over and into the ground surface is the vegetation cover of the watershed. There could be several types of covers or the land uses on the soil surface, for example forests, grass, agriculture, barren land etc. Different land use will have different kinds of effect on movement of water over and under the ground surface. In the presence of forest, water movement and water action are different because of the canopy, forest flow and distinctive soils. Due to forest deep rooting system and added contribution to organic matter content of the soil have been generally found to improve the soil structure resulting in better surface recharge conditions. On the other hand, the evapo-transpiration requirements of the forest have been found relatively higher than other land uses. Therefore, the net effect of forest on ground water regime becomes an important issue for investigation by hydrologist which in turn will be useful for water resources planner and environmentalist. In this connection, it is proposed to carry out following investigations in parts of Uttarakannada, district of Karnataka.

Objectives

- To understand the relationship between rainfall-runoff and groundwater recharge under different forest types
- To estimate evapo-transpiration under different forest covers/land covers
- To determine the in-situ soil hydraulic properties (such as infiltration, saturated and unsaturated hydraulic conductivity, soil moisture retention characteristics
- To estimate the groundwater recharge under different land use/land covers as well as based on field and laboratory methods, numerical solutions and also using tracer techniques
- To develop a conceptual groundwater model based on detailed hydrogeology, soil and land use pattern

Methodology

- Groundwater level monitoring in selected watersheds in parts of North Kanara district
- Soil moisture monitoring using moisture probes and estimation of ET using the soil moisture data
- In-situ determination of soil hydraulic properties and determination of aquifer parameters across an array of land use/land covers
- Surface and groundwater balance estimates of selected watershed
- Numerical modeling using Visual Modflow/GWM systems

Research outcome from the project

- an understanding of the relative impacts of the forest/land-cover changes in the selected watersheds across an array of climate and soils.

- Development of a conceptual model which will help in greater understanding of the runoff processes and ground water response to changes in physical parameter.

Cost estimate:

a. Total cost of the project :
b. Source of funding : MoES, Govt. of India
c. Sub Head-wise abstract of the cost

d. cost towards starting the project until the fund is released : Rs. 1,00,000/-

Sl no	Activity	Cost
1	Initiating the monitoring of groundwater levels, rainfall and stream flow	60,000
2	Installation of notches	20,000
3	Travel	20,000
	Total	1,00,000

Work Schedule:

a. Date of commencement of the project April, 2016
b. Duration of the project 1 years
c. Stages of work and milestone:

Sl No.	**1st Year (April'16 to June'16)**	**July 16 to Sept'16**	**Oct'16 to Dec.'16**	**Jan 17 to March'17**
1	Monitoring and In-situ determination of soil hydraulic parameters	Data compilation and analysis	Setting up of the model in GIS environment & Calibration of the model	Application of VISUAL MODFLOW/HYDRUS & Report preparation

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

WORK PROGRAM FOR THE YEAR 2015-16

Sl. No.	Title of Study	Study Team	Duration	Funding
1	Impact of land use changes on environmental flows of Tawi river at Jammu	P Kumar MK Nema SS Rawat	03 years (Nov 2011 to Oct 2014) extn. upto Dec 2015	NIH
2	Climate change effects on hydrology of the Tawi basin in Western Himalaya	MK Nema P Kumar RJ Thayyen	03 years (Nov 2011 to Oct 2014) extn. upto Dec 2015	NIH
3	PBS: Integrated Water Resources Management (IWRM) Study in Tawi River Basin, JK	P Kumar SS Rawat	05 years (Apr 2012 to Mar 2017)	NIH
4	Estimation of sediment yield and identification of areas vulnerable to soil erosion and deposition in a western Himalayan catchment	SS Rawat P Kumar	01 year 11 months (May 2015 to Mar 2017)	NIH
5	Hydrological Investigation of Natural Water Springs of Baan Ganga watershed in Jammu & Kashmir State	SS Rawat P Kumar SP Rai	02 years 11 months (May 2015 to Mar 2018)	NIH
6	Establishment of Silt Observation Post (SOP) in the Baglihar HEP catchment	P Kumar PG Jose SS Rawat	06 months (Mar 2016 to Oct 2016)	S&WC Dept., J&K Consultancy

Internal Projects

Impact of Land Use Changes on Flow Regime and Sustenance of Environmental Flows of Tawi River at Jammu

The study was undertaken with the objectives: (i) to evaluate the land use/cover change in the Tawi basin on decadal time scale, (ii) to model the flows of Tawi river at Jammu using SWAT model; (iii) to assess the environmental flows of Tawi river at Jammu; (iv) to assess the impact of land use/cover change on sustenance of environmental flows of Tawi river.

The ArcSWAT software was selected for modelling and assessing the impact of land use change on the flow regime as this software is based on SCS Curve Number method and the land use component is nicely built in this software. For preparing the database required for calibrating the ArcSWAT model, all the data (hydro-meteorological, soil, land use etc.) have been obtained and the geospatial database for calibrating the ArcSWAT model was set up. The whole period of record (1976-2007) was broken into three decadal parts (1977-1987, 1987-1997 and 1997-2007) and the land use maps were prepared using the LANDSAT imageries separately for three decades based on the best available imageries. The ArcSWAT model has been calibrated and evaluated using the observed and simulated flows. Further, the flow series for each decade has been estimated changing the land use data of other two decades thus forming nine sets of estimations of discharge. These estimations have been compared with the observed discharges to assess the impact of land use on the flow regime of Tawi river. The synthesis of results and final report writing are being carried out.

Climate Change Effects on Hydrology of the Tawi Basin in Western Himalaya

In view of the changing climate and global warming, the study has been initiated to assess the impact of climate change on different components of hydrologic cycle of Tawi basin. Geo-database of the basin has been prepared using ASTER GDEM data in the Arc GIS software. Relevant hydro-meteorological data of the Tawi basin from different agencies (IMD, CWC, J&K I&FC etc.) have been procured and processed. Statistical Down Scaling Model (SDSM) has been used to predict the future scenarios of precipitation. Preliminary results are not very encouraging with low correlation coefficient. Hence, other options for predicting the meteorological data for future scenarios have been tried. The ArcSWAT model has been calibrated and evaluated using the observed and simulated flows. Other components of hydrologic cycle for different future scenarios have been predicted through the calibrated hydrological model (ArcSWAT). The final synthesis and report writing is being carried out.

PBS: Integrated Water Resources Management (IWRM) Study in Tawi River Basin, JK

Under the 12^{th} Five Year Plan, NIH has initiated few Pilot Basin Studies (PBS) across India. As part of the IWRM studies taken up from different regional centres of NIH on different sub-basins, WHRC has identified the Tawi basin for its first PBS study considering its high societal impact. The study has been initiated with the main objective to prepare the Integrated Water Resources Management Plan of Tawi Basin for different scenarios of Land use change and climate change.

In this regard, Status report on Hydrology of Tawi Basin has been prepared and one Stakeholders' Brainstorming Session on "Integrated Water Resources Management (IWRM) Project on Tawi Catchment" has been organized in which the representative of all State/Central Govt. organizations dealing with water resources of Tawi river participated along with the members from NGOs and Gram Panchayats. Additionally, one nodal officer (Technical Officer to the Chief Engineer, I&FC, Jammu) has been appointed by the Principal Secretary (I&FC, J&K). Assessment of water resources availability and demand under the present condition and under the future scenarios of land use change and climate change has been planned to be carried out by using Water Evaluation and Planning (WEAP) Model. The most of the geo-spatial database (hydro-meteorological, soil and land use etc.) for calibrating the WEAP model has been prepared. Only the withdrawal from Tawi River and the area under different crops during different seasons are required to be procured/assessed. Tawi River during different seasons is being collected from State Govt. agencies and the area under different crops during different seasons is being estimated using the remote sensing. It is planned to set up the WEAP model for a base year (identified on the basis of data availability) and assess the water resources allocations for different sectors under different future scenarios of land use change and climate change.

Estimation of Sediment Yield and Identification of Areas Vulnerable to Soil Erosion and Deposition in a Western Himalayan Catchment

Whether the main concern of soil and water conservation planning is towards prevention of on-site or off-site effects of erosion, there is a growing need for tools that enable to define the spatial distribution of erosion within a catchment, i.e. to identify sources of sediment erosion. Indeed, the location of sediment sources and sinks is more important than the quantification of soil losses, as it is more cost effective than over-dimensioned erosion control measures. Therefore, modelling should be focused on spatial distribution of sediment erosion within the watershed as well sediment yield at the outlet of the watershed.

River Tawi, a major River in Jammu region is the left bank tributary of River Chenab originating from the lapse of Kali Kundi glacier in Bhaderwah, flows through parts of Doda, Udhampur, and Jammu districts and finally merges into Chenab in Pakistan. The Tawi River has a very high social impact serving to almost 20% population of the whole J&K State. However, this heavy population load causes the ecological degradation (change in the land use pattern, deforestation and low growth rate of vegetation, construction of new roads and bridges) which has accelerated the severe erosion in the catchment. A very high average sediment yield is reported to be of the order of 6503300 metric tonne per year. This huge debris ultimately gets deposited in the surface of the river channel when Tawi enters in the plain area. Consequently, the channel capacity reduces significantly and river gets overflow. Therefore, a study has been initiated during 2015-16 for estimation of sediment yield in channel of Tawi River and also identify the sources of soil erosion and deposition in its catchment so that treatment measures can be prioritized accordingly. The major objectives of the study are: (i) To prepare comprehensive digital geo-database of study area; (ii) To develop a grid based spatially distributed sediment yield model for better understanding of the sediment flow through complex slop of the hills; (iii) To categorize the catchment on the basis of soil erosion and deposition prone areas for prioritizing the watershed treatment measures.

To fulfil the objectives of the study, daily discharge and sediment data of Tawi River at Jammu for the monsoon season (June to October) for the period from 1976 to 2014 has been procured from Central Water Commission. The procured data has been computerized and processed. The development of distributed sediment yield model in the form of a computer program is under progress.

Hydrological Investigation of Natural Water Springs of Baan Ganga Watershed in Jammu & Kashmir State

Baan Ganga, a small tributary of Chenab River, is the legendary river associated with the miracles and legends of Mata Vaishno Devi. It is considered sacred and as per normal Hindu traditions, devotees like to bathe in it before preceding the journey of the holy shrine of *Mata Vaishno devi.* This river is originated from the Trikuta hills and passes from the side of Katra town (main base camp for *Mata Vaishno Devi* journey). Baan Ganga travels 8 km up to Katra town and comprises 13 sq. km catchment area. Since there is no glacier present in the Baan Ganga catchment, springs are the only available source to fulfil the water demand of the livelihood of surrounding people and also to maintain the flow of the river Baan Ganga. However, due to ecological degradation in Trikuta mountain range, the discharge of these springs have significantly reduced and some of the springs have even dried-up. Consequently, people of the area are facing acute shortage of water for their livelihood and there is hardly any water flowing in river Baan Ganga during lean season which also hampers the faith of pilgrims.

Keeping these points in view, there is urgent need to conduct a systematic study on the natural water springs of Baan Ganga catchment. The proposed study has been initiated with the objectives: (i) To characterize the springs on the basis of geomorphological and hydrological features prevailing in the study area; (ii) To understand the discharge pattern of springs in relation to recharge zone characteristics and rainfall variation; (iii) To study the storage characteristics and time of depletion of the springs irrespective of rainfall pattern; (iv) To suggest a strategy for management and augmentation of spring discharge for making these springs as sustainable drinking water source for the livelihood of the local people.

For establishing the monitoring mechanism, three raingauges have been installed at different altitudes of Baan Ganga watershed and monitoring of rainfall (03 locations) and spring discharge (05 locations) is being carried out on daily basis since June 2015. The rain water and spring water samples on daily basis are also being collected for isotopic analysis at HQ Roorkee. The isotopic analysis of the rain water and spring water will be helpful in identifying the recharge area of the springs.

<u>**Consultancy Project**</u>

Establishment of Silt Observation Post (SOP) in the Baglihar HEP Catchment

The Department of Soil and Water Conservation (DSWC), Govt. of J&K has undertaken the work of Catchment Area Treatment (CAT) in the catchment of Baglihar Hydroelectric Project (HEP). The Phase-1 of the project has already been completed and the Phase-2 is ongoing. To evaluate the impacts of Baglihar CAT programme, the Department of Soil and Water Conservation (Govt. of J&K) proposed to establish the Silt Observation Posts in the treated catchments. WHRC, Jammu was formally approached for technical consultancy in this matter pursuant to the discussions held at the office of the Director, Department of Soil and Water Conservation (J&K) on 12/04/2014 and the subsequent request made by the Joint Director, Department of Soil and Water Conservation, Jammu through his letter no. JDSC/2015-16/SOP/740-42 dated 23/11/2015.

The objective of the consultancy is to establish a Silt Observation Post (SOP) in the Baglihar HEP Catchment. To achieve this, several tasks were envisaged including site selection, assessment of design discharge, field survey for Cross Section & L-Section near the selected site, design of SOP to be constructed by DSWC, J&K, procurement and installation of equipments as well as training of DSWC staff.

Tasks completed include: (i) Site selection for establishment of Silt Observation Post (SOP) in the Baglihar Catchment; (ii) Assessment of design discharge of the selected catchment; (iii) Survey for the Cross-section and longitudinal section of the selected catchment near the selected SOP site.

Tasks to be completed include: (i) Design of the SOP having facility to cover lean season and monsoon discharges both; (ii) Construction of SOP (to be executed by DSWC based on the design provided by us); (iii) Procurement and installation of equipments to monitor discharge and sediment, and handing over the SOP and related equipments; (iv) Training to the DSWC staff for operation of the established SOP and related equipments and (v) Preparation and submission of the Final Project Report.

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

NATIONAL INSTITUTE OF HYDROLOGY

राष्ट्रीय जल विज्ञान संस्थान

आपो हि ष्ठा मयोभुव

WORK PROGRAM FOR THE YEAR 2015-16

S. No.	Title of the Study	Study Group	Duration	Funding	Status
1.	Pilot Basin Studies: IWRM in Bina River Basin in Bundelkhand Region of Madhya Pradesh	T. R. Nayak T. Thomas Ravi Galkate R.K. Jaiswal	5 Years April 2012 to March 2017	Internal (NIH)	On-going
2.	Development of Decision Support System (DSS) Model for Shipra River Basin of MP	Ravi Galkate R.K. Jaiswal T. R. Nayak T. Thomas WRD Bhopal	3½ Years June 2013 to May 2016	Internal (NIH)	On-going
3.	Integrated Assessment of Drought Vulnerability for Water Resources Management in Bina Basin	T. Thomas T. R. Nayak R. K. Jaiswal R. V. Galkate	2 Years July 2014 to June 2016	Internal (NIH)	Completed
4.	Irrigation Planning and Management in the Command of Harsi Reservoir Project in Madhya Pradesh	R.K. Jaiswal, T. Thomas, R. V. Galkate, Dr. T. R.Nayak WRD Bhopal	2½Years May 2013 to Oct. 2015	Internal (NIH)	Completed
5.	Estimation of Revised Capacities of Reservoirs in Chhattisgarh state using Digital Image Processing technique	R.K. Jaiswal Dr. T. R. Nayak R. V. Galkate T. Thomas A. K. Lohani WRD Bhopal	2 Years April 2015 to March 2017	Internal (NIH)	On-going

Title of the Study: Pilot Basin Studies: IWRM in Bina River Basin in Bundelkhand region of Madhya Pradesh
(Predicting Soil Erosion for Alternative Land Uses in Bina River Basin)

Study Group: Dr. T R Nayak
Mr. T Thomas
Mr. Ravi Galkate
Mr. R K Jaiswal

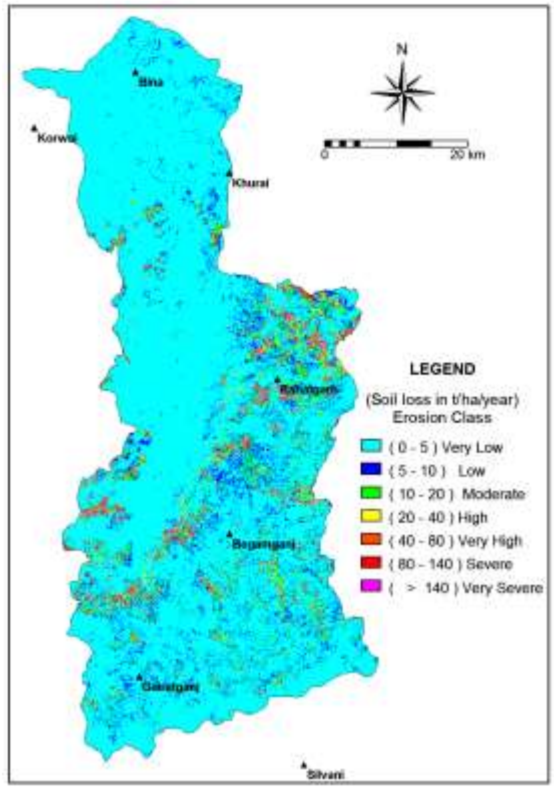
Integrated Water Resources Management (IWRM) concept provides an effective, long lasting solutions to water problems through a new water governance and management paradigm, which has been defined by the Technical Committee of the Global Water Partnership (GWP) as “a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital eco-systems”. The Bina river sub-basin of Betwa river basin in Madhya Pradesh having total drainage area of 2808.08 sq.km. has been selected as a pilot basin for the integrated water resources management study during the Five Year Plan 2012-2017. In the study during the year 2015-16, an attempt has been made to propose the alternate landuse management plan to reduce the soil erosion in the catchment and increase the agriculture production.

In the present study expected soil loss from Bina river watershed has been estimated using USLE model in GIS platform. The ancillary data on landuse/land cover was interpreted from the satellite imageries IRS LISS III digital data of the catchment area. The rainfall data collected for the rain gauge stations have been spatially distributed by moving average point interpolation technique. The rainfall erosivity factor (R) has been derived from the annual rainfall The soil erodibility factor (K) map was derived from the soil class for which the map was obtained from the NBSS & LUP, Nagpur. The LS factor map was generated from the slope map derived from the DEM created by digitizing contour lines. The C factor values were chosen based on the land use map and P factor based on slope map. Maps covering each parameter (R, K, L, S, C and P) were integrated to generate a composite map of erosion intensity based on the advanced GIS functionality. This intensity map was classified into different priority zones.

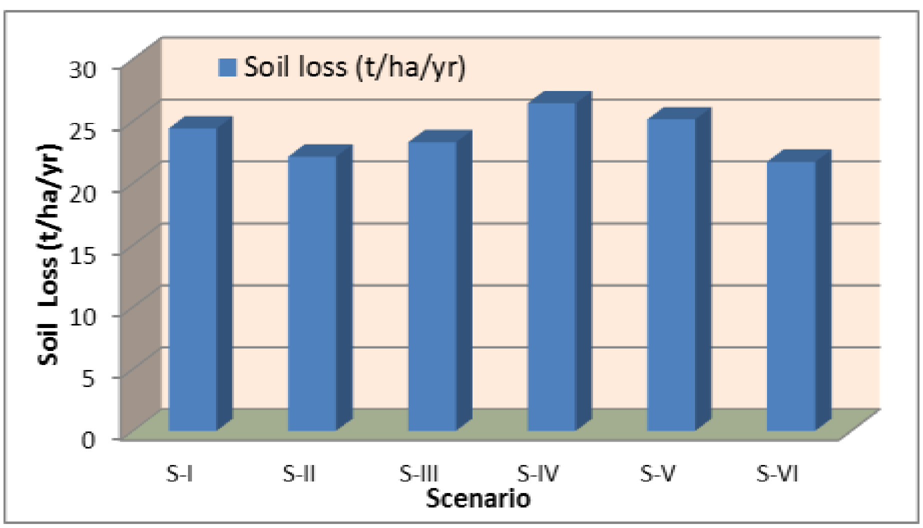
The result shows that the estimated yearly potential soil loss in the Bina river basin is 132.776 lakh tones and the expected soil loss is 24.416 lakh tones. The impact of alternate land use planning by appropriate watershed management programme has been studied by assuming six scenarios of land use change. The study shows that the expected soil loss in the basin can be reduced by 2.3 lakh tones (9.33%) if forest planting is done in the existing open forest land and scrub land. A major water resources development project has been started in the basin, which may lead to convert the wasteland (barren land) having slope < 5% into arable land, if the canal water supply is made available. This will increase the food production as well as the soil erosion by 2.03 lakh tones (8.31%). In order to maximize the food production and minimize the soil erosion, the barren land having slope < 5% may be converted into arable land and the barren land having slope > 5% and the scrub land can be converted in forest land by plantations. This will not only increase the life of the water harvesting/storage structures but also preserve the fertile lands.

Table and Map Showing Expected Soil Loss in Bina River Basin

Erosion Class	Erosion Value (t/ha/year)	Expected soil loss	
		Area (Sq.km.)	Percent to Total Area
Very Low	0 – 05	1959.90	69.80
Low	05 – 10	410.16	14.61
Moderate	10 - 20	213.55	7.61
High	20 - 40	94.49	3.36
Very High	40 - 80	69.43	2.47
Severe	80 - 140	30.12	1.07
Very Severe	> 140	30.43	1.08
		2808.08	**100.00**



The six land use change scenarios have been applied in the USLE model to highlight the effects of land use changes on soil erosion in Bina watershed. The graphical representation of soil loss for different land use conditions (scenarios) is given in the following figure.



Expected Soil loss for different scenarios

Title of Study: Development of Decision Support System (DSS) Applications for Shipra River Basin of MP

Study Group:

National Institute of Hydrology, Regional Centre, Bhopal

Mr. Ravi Galkate, Scientist-D
Mr. R.K. Jaiswal, Scientist-C
Dr. T. R. Nayak, Scientist-E
Mr. T. Thomas, Scientist-C

Water Resources Department, BODHI, Bhopal

Dr. Jitendra Jain, SE, Ground Water Survey
Mr. Sanjeev Das, Dy. Director, State Water Data Centre
Mr. Sanjay Kumar Gupta, Sr. Geophysists, BODHI, Bhopal
Mr. Brajendra Baghel, Scientific Officer, Ground Water Survey

Date of Start: June, 2013

Duration of Study: 3½ Years

Funding: In house

Objectives:

- Assessment of droughts in Shipra Basin
- Rainfall runoff modeling for Shipra river basin
- Development of Mike Basin model for Shipra basin and development of DSS applications under changing hydrological conditions
- Assessment of climate change
- Assessment of declining monsoon and lean period flow in Shipra

Brief Methodology:

- Preliminary analysis of meteorological and hydrological data.
- Assessment of drought situation in Shipra basin and Quantification of precipitation deficit using Standardized precipitation index (SPI)
- Trend analysis of meteorological and hydrological data using Mann-Kendall test for assessment of climatic changes.
- Rainfall runoff modeling using MIKE11 NAM model.
- Development of River Basin Model of Shipra using MIKE BASIN/MIKE HYDRO software
- Development of DSS applications using MIKE BASIN/MIKE HYDRO or DSS software
- Sub-basin wise water availability study using flow duration curve technique.
- Supply demand analysis using Shipra basin Mike Basin Model.
- Assessment of declining monsoon and lean period flow in Shipra.

Progress/Present Status:

The present has been taken up under the sustainability program of DSS (P) under HP-II project in collaboration with BODHI, Water Resources Department, Govt. of MP, Bhopal for integrated water resources planning, development and management in Shipra basin. During the period 2015-16 work carried out so far in the present study includes assessment of climate change situation and development of Shipra basin model and DSS applications for water availability assessment and supply demand analysis under changing hydrological conditions.

A GIS based MIKE BASIN model developed for Shipra river basin for water resource planning and management was successfully used for development of various decisions supporting application in Shipra basin. Three different scenarios to meet its water demand and maintain the water quality in the river were developed in MIKE BASIN. The analysis of first scenario application without Khan Diversion and Narmada-Shipra link shown that the Shipra at

Ujjain is having flow only in monsoon season and river runs dry in non-monsoon season under natural conditions. In second scenario, to avoid polluted Khan water entering in to Shipra, a Khan diversion was added in the model. The dependable flow was found decreased due to Khan diversion at Ujjain and its magnitude was seen significant. In the third scenario Narmada-Shipra link was is added to the Shipra so that the Shipra can be supplemented from Narmada to meet its water demand and to make available assured water for various occasions such as Kumbh on which holy bath is being taken by number of pilgrims on the Ghats of Shipra. This arrangement was found helpful to meet various water demands. A flow of 2.5 m^3/s was added through the link to Shipra which in turn have found improved the water availability at Ujjain and results have shown that a minimum of 1.7 m^3/s dependable flow would be available even in non-monsoon months at very high probability. The water availability analysis in Shipra at Ujjain under different hydrological conditions as mentioned in scenario 1, 2 and 3 was carried out using Mike Basin simulated flow and it was concluded that the there was no flow in non-monsoon period in Shipra under natural condition which further again become critical due to Khan Diversion. The water availability at Ujjain was found improved significantly during non-monsoon period due to Narmada-Shipra link.

The present study also aimed at assessment of climate change and its impact on catchment hydrology in Shipra basin. The analysis was carried out to identify the trends of annual and seasonal rainfall at eight different stations in Shipra river basin as well as maximum and minimum temperatures at Indore. From the trend analysis of rainfall data by straight line method it was observed that there was decrease in rainfall at few stations like Dewas, Indore however station like Ujjian has shown rising trend. According to Mann-Kendall test result, it was observed that over the period from 1956 to 2012, 50% stations of the basin have observed falling trend for annual rainfall time series and 60% station have observed falling trend for monsoon rainfall time series but trend was not found significant. Exceptionally, Dewas station was observed as a critical station showing significant falling trend for the annual rainfall, non monsoon rainfall and for the rainy days as well at 95% level of significance. The trend analysis of long term monthly temperature data indicated significant rising trend for mean maximum temperature (Mmax), highest maximum temperature (Hmax), mean minimum temperature (Mmin) and lowest minimum temperature (Lmin). The trend was observed significant during most of the months indicating overall temperature rise in the Shipra basin. From the study it was also concluded that if rainfall in Shipra basin been subjected to adverse impact of climate change such as significant falling trend, it would definitely affect the runoff yield of the river. Climate change will have severe impact on catchment hydrology and falling rainfall trend will not only reduce the runoff yield but also reduce the peak flows, low flows and it would have adverse impacts on the total water resource scenario of the basin. The basin may face huge water scarcity and reduction in dependable flow in river which may ultimately increases the demand deficit and may alter the economical activity of the region.

Expected Date of Completion: December 2016.

Title of the Study: Integrated Assessment of Drought Vulnerability for Water Resources Management in Bina Basin

Study Group: **Mr. T Thomas**
Dr. T R Nayak
Mr. R K Jaiswal
Mr. Rani Galkate

Water resources management in arid and semi-arid regions is a challenging proposition due to large number of hydrologic, environmental and management factors to be considered to maintain supply of adequate water. The Bundelkhand region in Central India is facing regular and continuous droughts since the last two decades with the drought frequency varying between 1 in 3 years to 1 in 5 years. The climatic variability is one of the principal reasons for the prevailing situation which is expected to further get enhanced under the impacts of the climate change. The climate model predictions (IPCC 2007) indicate that the global climate change will lead to increase in occurrences of dry events in large parts of the planet which is more likely to increase the vulnerability to drought, more so in South Asia.

The Bina river basin located in Sagar district of Madhya Pradesh has been selected as a pilot basin to develop a methodology for the integrated assessment of the drought vulnerability. The indicator based approach has been used to evaluate the various types of drought characteristics including meteorological, surface water and ground water droughts in the basin. The drought vulnerability has been conceptualised to comprise of three major components viz., the spatially varying basin indictors, the temporally varying climatic indicators and the social indicators. The spatially varying indicators include basin reaches, soil texture, land use/land cover and water demands; whereas the temporally varying factors include annual rainfall departures, soil moisture deficits, surface water deficits, groundwater deficits and consecutive number of dry days during the monsoon season; and the social indicators include population of children aged below 6 years, marginal workers, illiterate population and rural population. The drought characteristics have been evaluated using the Standardised Precipitation Index (SPI), Surface water Drought Index (SDI) and Groundwater Drought Index (GDI). The analysis has been performed in the GIS environment and thematic layers for each of these indicators have been prepared. Appropriate weights have been assigned to all the subclasses of each indicator and subsequently integrated. The integrated drought vulnerability index (DVI) has been derived the integrated drought vulnerability maps have been prepared for the identified drought years in the Bina basin. The drought vulnerability maps during the drought year of 2002-03 are given in Figure 1. It has been observed that the drought vulnerability varies from mild to moderate classes. During 2002-03, most of the basin area (97%) was under moderate vulnerability class during July 2002 whereas in September 2002 about 58% was under mild vulnerability class and remaining 48% was under moderate vulnerability class. The assessment of the areas vulnerable to drought in Bundelkhand will facilitate the decision makers to use this information for devising measures for drought proofing of the region through appropriate water resources management strategies.

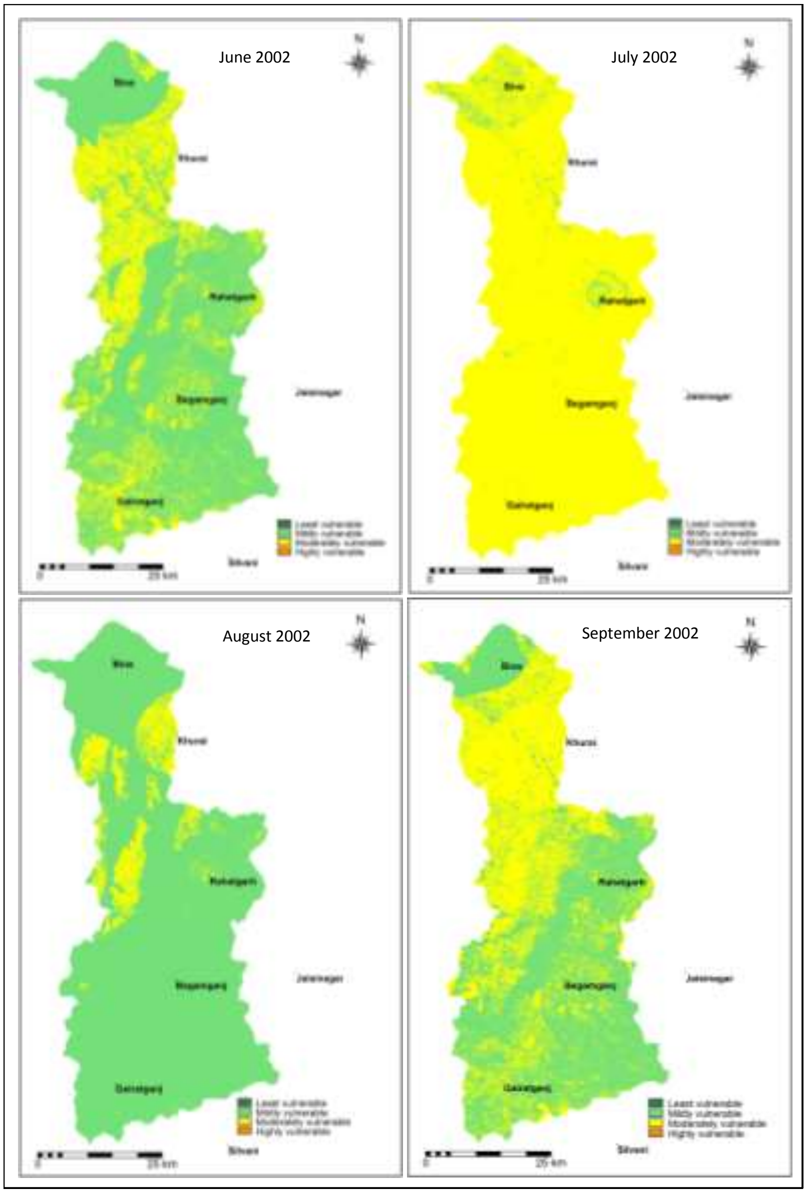


Fig. 1: Integrated drought vulnerability map of Bina basin during the drought of 2002-03

Irrigation Planning and Management in the Command of Harsi Reservoir Project in Madhya Pradesh

Study Group : **NIH RC Bhopal**
R.K. Jaiswal, T. Thomas, R. V. Galkate, Dr. T. R. Nayak
WRD Bhopal
Dr. Jitendra Jain, Brijendra Baghel

Date of Start : July 2013
Duration of the Study : 2½ years
Funding : In-house

Objectives:

- Preparation of GIS based database for the study area
- Estimation of revised capacities using remote sensing and GIS approach
- Rainfall Analysis and computation of irrigation water requirement in the command area
- Development of MIKE BASIN based model for irrigation management
- Scenario based assessment of demand and supply of water for irrigation planning
- Preparation of management plan for irrigation planning in the command
- Impact assessment of modernization on irrigation potential

Brief Methodology

- Preparation of integrated GIS based system for command of Harsi reservoir consisting different thematic maps including drainage network, canal network, geology, soils, road network map, prevailing land use map, slope map and other important features.
- Collection and analysis of meteorological, crops and hydrological data pertaining to reservoirs and its command.
- Estimation of revised capacity of reservoir using digital image processing technique of multi temporal remotes sensing data.
- Analysis of rainfall data for identification of dry, average and wet rainfall years and assessment of deficit rainfall periods during kharif season.
- Computation of irrigation water requirement using CROPWAT for existing cropping pattern.
- Demand-supply analysis for Harsi project considering all demands and supplies from different sources.
- Development of MIKE basin model for Harsi reservoir project consisting for irrigation management.
- Scenarios based assessment of for sixteen scenarios separately for design and existing cropping pattern considering climatic variability, field losses and conjunctive use options.
- Impact assessment of modernization works in Harsi command with the help of supervised and unsupervised classification of remote sensing data
- Management plan for intensification of irrigation in the command enhanced yield of crops.

Progress/Present Status

The present study has been taken in collaboration with State Water Data Centre, Water Resources Department, Govt. of M.P. for development of management plan for efficient reservoir operation of Harsi command and scenarios based demand-supply assessment under variable climatic and efficiencies conditions. The Harsi command situated in Gwalior district of M.P. (India) with design cropping pattern of 62675 hectare receives supplies from Harsi reservoir and other sources. A digital data base consists of thematic maps and supporting data for Harsi reservoir system and its command was developed in GIS environment. As Harsi reservoir was commissioned in 1935 and 78 years of its operation was completed, the revised capacity assessment was carried out using digital image analysis technique of remote sensing data. The normalized deviation water index (NDWI), band ratio, false color composite (FCC) of multi-temporal remote sensing data have been used to estimate revised capacities at different levels of Harsi reservoir. From the analysis, it has been observed that 44.16 Mm^3 of gross storage which is more than 20% of capacity of Harsi reservoir has been lost in 78 years (1935 to 2013) with average rate of 0.6 Mm^3/year.

The probability analysis of seasonal rainfall were carried and rainfall in wet, average and dry rainfall years have been computed as 878.08 mm, 674.90 mm and 570.68 mm respectively. The rainfall data of 1974, 1993 and 2011 have been used as representative data for dry, average and wet rainfall year respectively. and a simple demand supply analysis for Harsi command was carried out in which crop water requirements for design and existing cropping pattern were computed using CROPWAT and firm supplies from different sources including Harsi dam, Kaketo reservoir, Madikheda dam and Mohin Pickup weir were determined to estimate demand deficit in the system. The design cropping pattern in Harsi command may require 432.5 Mm^3 irrigation water in wet year to 474.7 Mm^3 in dry years under present condition (77% conveyance and 71% application efficiency). The supply analysis to Harsi reservoir confirmed an average availability of 427.2 Mm^3 water in the system and there is need of improvement in system to fulfill all the demands.

The simple demand supply does not account variable availability status, reservoir and canal capacity, operation rules, spatial distribution of crops and groundwater application, a MIKE BASIN model for Harsi reservoir and its command was developed for irrigation management and planning releases. Considering variability of climate, soils, cropping patterns, efficiency criterions and conjunctive use of surface and groundwater, sixteen different scenarios were generated separately for design and present cropping pattern. The MIKE BASIN model for Harsi project and results of simulation runs for design cropping pattern have been presented in Fig. 1. The simulation results confirmed the demand of design cropping pattern may vary from 313.6 Mm^3 (MB-DCP-1 & 2) in wet rainfall years to 372.4 Mm^3 (MB-DCP-9 & 10) in dry or drought years. The demand deficit of 41.2 Mm3 water under existing 77% conveyance and 71% application efficiencies without using groundwater in wet years can be reduced to 2 Mm^3 by improving conditions of canals (81% conveyance and 76% application efficiencies), conjunctive use (10% demand from groundwater if possible) and operation of reservoir as suggested by model. Different MIKE BASIN simulation runs for present cropping pattern indicated little deficit of demand which can be met through improved water management in the command.

For impact assessment analysis of modernization works taken place during 2009 to 2014 in Harsi command, multi- date remote sensing LISS IV data prior (2009) and after (2014) modernization works were analyzed using normalized deviation vegetation index (NDVI) technique. The NDVI images has been used to detect changes in vegetation vigor by classify the image in 5 different classes less than 0.0 (water/cloud), 0.0 to 0.025 (bare soil), 0.025 to 0.25 (grass), 0.025 to 0.50 (scars vegetation) and 0.50 to 0.70 (dense vegetation). From the analysis, it has been found that the dense vegetation increase from 150.62 ha to 14764.05 ha during the same period due to restoration, repair and renovation (RRR) works in the command. The final report including all important aspects has been sent for review.

Date of Completion: Completed and final report submitted for review

Estimation of Revised Capacities in Reservoirs of Chhattisgarh State using Digital Image Processing technique

Study Group : **NIH RC Bhopal**
R.K. Jaiswal, Dr. T. R. Nayak, R. V. Galkate, T. Thomas, A. K. Lohani
WRD Chhattisgarh
Akhilesh Verma, D. K. Sonkusale and others

Date of Start : July 2015
Duration of the Study : 2 years
Funding : In-house

Objectives:

- Preparation of GIS based database for the study area
- Collection and analysis of reservoir details and other information
- Selection and digital image processing of remote sensing data
- Estimation of revised capacities of reservoirs and trend assessment in selected reservoirs
- Knowledge dissemination and development of awareness

Brief Methodology

- Discussion with partner organizations and field officials for selection of reservoirs for the study
- Preparation of GIS based data base of reservoirs selected for the analysis including different thematic maps including drainage, reservoir, road and rail network
- Collection and analysis of reservoir details and reservoir levels for selection and procurement of remote sensing data
- Digital image classification of multi-date remote sensing data for determination of revised water spread areas
- Estimation of revised capacities and loss in capacities from these reservoirs
- Estimation of average rate and trend of sedimentation in selected reservoir

Progress/Present Status

During the periods, detail discussions with partner organization and water resources engineers were made Ravishankar Sagar, Maramsilli, Tandula and Dudhawa were selected for sedimentation study in the first year. The field visits of study area were made to collect information regarding reservoir details, maps and reservoir levels etc. Considering the reservoir levels and pass of different satellite from NRSC website, 10 different remote sensing data of LISS 3 were selected and procured for analysis. All the scenes were imported and geo-referenced for further analysis. The normalized deviation water index (NDWI), image ratio (IR), false color composite (FCC) with the help of field truth information were used to differentiate water pixels from rest of the image. The revised water spread areas at different levels obtained from this analysis were used to compute revised capacities between these levels which in turn gave cumulative capacities and loss in storages at different levels of reservoir. From the analysis of sediment analysis of Tandula reservoir, it has been observed that more than 8% of gross storage has been lost till 2015. The study is under progress.

Date of Completion: July 2017

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 D
4	Dr. P C Nayak	Scientist D
5	Mr. B. Krishna	Scientist C
6	Mr. R. Venkata Ramana	Scientist C

REGIONAL CENTRE, KAKINADA

2015 – 2016

S. No.	Project	Project Team	Duration	Status/Funding
1	Evaluation of urban storm water network in Hyderabad using SWMM	R.Venkata Ramana, Sc. ‘C’ (P.I.) Y.R.Satyaji Rao, Sc. ‘F’ S.V.Vijayakumar, Sc. ‘F’ V.S. Jeyakanthan, Sc. ‘D’	April 2013 to March 2016	Ongoing/ Internal
2	Statistical downscaling and assessment of climate change impact on hydrology of Mahanadi river basin	P.C.Nayak, Sc. ‘D’ (P.I.) Y.R.Satyaji Rao, Sc. ‘F’ B. Venkatesh, Sc. ‘F’ T. Thomas, Sc. ‘D’	April 2013 to March 2016	Ongoing/ Internal.
3	IWRM Studies (2013-2017): Assessment of water availability in the upper Yerrakalva Basin	Y.R.Satyaji Rao, Sc.‘F’ (P.I) S.V.Vijayakumar, Sc.‘F’ J.V.Tyagi, Sc. ‘G’ R.Venkata Ramana, Sc.‘C’ B. Krishna, Sc.’C’	April 2014 to March 2016	Ongoing/ Internal.
4	Identification of submarine groundwater discharge and sea water intrusion zones in Godavari Delta using integrated approach	Y.R.Satyaji Rao, Sc.‘F’ (P.I) M.S.Rao, Sc.‘D’ R.Venkata Ramana, Sc.‘C’	August 2014 to March 2017	Ongoing /Internal
5	Identification of Ground Water Recharge zones in Vaippar Basin, Tamilnadu using Remote Sensing and GIS techniques	V.S. Jeyakanthan, Sc.‘D’(P.I) J.V. Tyagi, Sc.‘G’ R Venkata Ramana, Sc.‘C’	April, 2015 to March, 2017	New /Internal
6	IWRM Studies (2013-2017): Development of hydrological management practice plans for IWRM in the Lower Yerrakalva Basin	S.V.Vijaya Kumar, Sc.‘F’ (P.I) Y.R.Satyaji Rao, Sc.‘F’ V.S.Jeyakanthan, Sc.‘D’	April, 2015 to March, 2017	New /Internal
7	Development of groundwater level forecasting model using high frequency groundwater level data in the Srikakulam District of Andhra Pradesh	B. Krishna, Sc.‘C’ (P.I) Y.R.Satyaji Rao, Sc.‘F’ R Venkata Ramana, Sc. ‘C’	April, 2015 to March, 2016	New /Internal

1. Evaluation of urban storm water network in Hyderabad using SWMM

Principal Investigator	:	R. Venkata Ramana, Scientist 'C'
Type of study	:	Internal
Date of start	:	May, 2013
Schedule Date of completion	:	March, 2016
Status of the study	:	Completed

Objectives:

- Adequacy verification of existing storm water drainage network to the design storm of various return periods.
- To develop the outfall hydrograph and water surface profiles along the drains.
- Design of the alternative drainage network.

Brief information of the study:

Five rain gauges and one automatic water level recorder have been installed in the study area. Short term rainfall and water level data have been processed and analyzed. Thematic maps of storm water drains network, land use/cover, soil and slope have been prepared in GIS frame work and estimated SWMM model input parameters. Intensity Duration Frequency (IDF) curves for various return periods (2010-2014) using IMD hourly rainfall data have been prepared. Model has calibrated and validated with observed data. It was observed good estimation of water level hydrograph in the basin. Simulated results calibrated with observed data and its shape of the water level graph and peak water level well match with observed data. Existing drainage network in the study area has been evaluated against 2 year and 5 year return periods storms. It was found that even 2 year return period design storm cannot be drained with the present section and causes flooding at different locations. The drainage network sections has been modified mainly with respect to width, depth and proposed new drain dimensions to improve the carrying capacity and also to prevent flood. Study has been completed and report is under progress.

2. Statistical downscaling and assessment of climate change impact on hydrology of Mahanadi river basin

Principal Investigator	:	P. C. Nayak, Scientist 'D'
Type of study	:	Internal
Date of start	:	May, 2013
Scheduled date of completion	:	March 2016
Status of the study	:	Completed

Objectives:

- To downscale the GCMs output
- Assessment of change in hydrology by employing statistical significance testing to detect trends in hydrological data.
- Hydrological assessment using WEAP/ SWAT model
- To predict climatic projection for Mahanadi River Basin

Brief information of the study:

In the present study a statistical trend analysis for the precipitation and runoff time series was carried out for Mahanadi river basin of Odisha. Daily discharge trends were analyzed for different gauging sites and it is observed that Tel tributary is experiencing increasing trend where as Ong tributary is experiencing decreasing trend. Daily, monthly and seasonal rainfall trends were analyzed for the period between 1961 and 2001. No trend is found for daily and monthly rainfall data but there is significant evidence of decreasing trend in precipitation during monsoon period for two stations (Salebhata and Sundergarh) in the catchment area using sign test. During the non-monsoon season decreasing trend is observed for all stations but these are not significant. Variation of rainfall shows that number of rainy days and total annual rainfall is decreasing. The total number of rainy days is decreasing over the years and Kesinga sub-basin observed highest decrease in rainfall events in the Mahanadi basin. From the analysis, it is found that though there is a decrease in number of rainy days simultaneously, rainfall intensity is increasing over Tel river basin. In this study, Change Factor Methodology (CFM) has been implemented for downscaling rainfall data from future time scale from year 2006 to 2049. Combinations of 75 GCM outputs have been used for downscaling rainfall data for four sub-basins of Mahanadi River. SWAT model has been set up for 4 sub-basin using observed data. The SWAT model has been run with the climate scenarios with combination 75 downscaled data for the low emission scenario (RCP 2.6 and 4.5) and high emission scenario (RCP8.5). The simulated outflows obtained from the SWAT model under these alternate climate scenarios have been analyzed further to detect the changes in the extreme events and water availability in the basin. The dependable flow analysis have been performed by fitting an empirical distribution (Weibull, 1951) to the simulated flows, and the dependable flows at 5%, 10%, 20%, 50%, 75%, 90% and 95% dependability have been identified. The dependable flows corresponding to 5% and 10% dependability are indicative of the extreme flood events, 50% dependability indicates the median flow, 75% dependable flow corresponds to the water availability for agriculture, and higher dependable flows corresponds the water availability for domestic drinking requirement. The extreme flood events in Mahanadi basin with no hydraulic interventions are expected to increase in the basin as compared to the current scenario based on the probability analysis of the annual stream flow values at few gauging sites. The preparation of draft report is under progress.

3. IWRM Studies (2013-2017): Assessment of water availability in the upper Yerrakalva basin

Principal Investigator	:	Y.R.Satyaji Rao, Scientist ‘F’
Type of study	:	Internal
Date of start	:	May, 2015
Scheduled date of completion	:	March 2016
Status of the study	:	Ongoing (Proposed to be extended up to September 2016)

Objectives:

- Assessment of water availability in sub basins of Upper Yerrakalva basin
- Assessment of soil erosion in sub basins and estimation of sediment rate into Yerrakalva reservoir

Brief information of the study:

The assessment of water balance would be taken up using GEC norms and also using distributed model (SWAT). Soil erosion from sub basins and rate of sedimentation in Yerrakalva reservoir has been estimated by USLE and remote sensing techniques. Main input parameters for SWAT model have been obtained from spatial information thematic layers and also hydrological observations measured in the basin. These spatial information are mainly drawn from: DEM, land use/cover, soil, daily weather data, Elevation-Area-Capacity curves of the reservoir, daily outflow from reservoir and daily discharge data at Gauge-Discharge site. Total 19 watersheds have been delineated for water availability assessment units and seven watersheds for soil erosion rate assessment. SWAT model is being calibrated and assessment of water balance components/water availability is under progress. Sub basin wise soil erosion rate in seven sub basins are 0.44, 0.54, 0.62, 0.57, 0.39, 0.47 and 0.44 tones/acre/yr. The average annual soil loss of Yerrakalva Reservoir Catchment area is 0.49 tones/acre/yr or 121 tones/sq km/yr or 0.864 ha-m /100 sq km /yr or 0.000782 TMC/yr. The average soil erosion rate has been converted into rate of sediment at into Yerrakalva reservoir using sediment delivery ratio. This rate of sediment into reservoir is validated with remote sensing based assessment of sediment rate along with original hydrographic survey. In order to get better validation of the model it is proposed to extend the study period up to September 2016 so that the detailed analysis of water balance and water availability would be incorporated in the report.

4. Identification of submarine groundwater discharge and sea water intrusion zones in Godavari delta using integrated approach

Principal Investigator	:	Y.R.Satyaji Rao, Scientist 'F'
Type of study	:	Internal
Date of start	:	August, 2014
Schedule Date of completion	:	March, 2017
Status of the study	:	Ongoing

Objectives:

- To identify Submarine Groundwater Discharge zones (SGD) and Seawater Intrusion (SI) in Central Godavari delta
- Aquifer characterization in Godavari delta
- Geochemical and isotope characteristics of groundwater in Central Godavari Delta

Brief information of the study

In the present project it is proposed to map the safe zones, vulnerable zones and potential risk zones for groundwater withdrawal by delineating areas of SI and SGD through a detailed coastal survey, field based data generation and modeling. SI and SGD will be assessed by analyzing groundwater for physico-chemical parameters (EC, temperature, Major Ions etc) and isotopes (stable isotope - δD & δ^{18}O and 222Rn) of groundwater samples. Gradients and fluctuations in these parameters in different seasons along various geologic cross-sections will be interpreted in terms of temporal and spatial fluctuations in the SI and SGD pattern. Long term data on water table, rainfall pattern, pattern of coastal algal bloom etc will also be collected to interpret the effect of SI and SGD on the coastal environment. Based on the extensive literature survey, a review report will be prepared. Sensitive parameters to fingerprint SI and SGD will be identified. The data generated will be modeled for its use to sustainable management of Godavari delta groundwater aquifer system. Geology map of the study area is prepared. Intensive literature review has been carried out on SGD using integrated approach. The satellite thermal data have been down loaded for the study area. Preparation of coastal morphology and analysis of temperature anomalies have been completed. The groundwater data pertains to Godavari delta has been collected from A.P State Groundwater Department. The present salinity level in the coastal aquifer is demarcated in the delta. The preparation of interim report is in progress.

5. Identification of ground water recharge zones in Vaippar Basin, Tamilnadu using Remote sensing and GIS techniques.

Principal Investigator	:	V.S Jeyakanthan, Scientist 'D'
Type of study	:	Internal
Date of start	:	August, 2015
Schedule Date of completion	:	March, 2017
Status of the study	:	Ongoing

Objectives:

- The core objective of this project is to identify and map the ground water recharge zones using hydro-geomorphology and hydro-geology of the study area.

Brief information of the Study:

Precipitation, landuse/landcover, lineament density, drainage pattern, water level, soil characteristics and slope data will be used to generate percolation, surface runoff and water capacity maps, which represent the recharging process of the study area. Sub-pixel methodology will be used for classifying landuse/landcover of the study area. Runoff will be estimated using SCS methodology. Hydro-geological and other above said input maps will be prepared from the satellite data. Remote sensing data will also be used for the identification of geological structure such as faults, joints, dikes etc that controls the groundwater flow pattern in the study area. Slope map will be prepared from DEM (Digital Elevation Model) obtained from satellite data. GIS platform will be used for analysis of spatio-temporal data. These maps and data will be combined and ranked to produce a recharge potential index, from which ground water recharge zones in the study area will be identified.Thematic maps of land use/cover, drainage network, soil, DEM, geology and lineaments have been prepared for the study area in GIS frame work. These raster maps have been resampled with uniform spatial grid size. Assigning theme weight is under progress for all the input data according to their respective recharge potential characteristic. Ground truth verification is under progress. GIS environment would be used to overlay the thematic maps and to obtain the final integrated output of groundwater recharge zones of Vaippar basin.

6. IWRM Studies (2013-2017): Development of hydrological management practice plans for IWRM in the Lower Yerrakalva Basin

Principal Investigator	:	S.V.Vijaya Kumar, Scientist ‘F’
Type of study	:	Internal
Date of start	:	August, 2015
Schedule Date of completion	:	March, 2017
Status of the study	:	Ongoing

Objectives:

- To understand water users and stake holders and their experiences on participatory management
- To study availability and suitability from different sources in the study area
- To estimate water requirement for various uses in the study area
- To develop suitable hydrological management practice plans for different uses

Brief information of the study:

A review of present practices of IWRM and methods of preparing developmental plans to manage different stake holder has been reviewed. The existing setup for IWRM in the study area is compiled. In Andhra Pradesh Farmers Management of Irrigation Systems Act was enacted in the year 1997. Groundwater development falls under AP WALTA Act. Accordingly, Water Users Associations and Distributory Committees were formed in the year 1997. To form Water Users Association (WUA) with the farmers, there will be managing committee consisting of 12 or 6 Territorial constituency members in major and medium WUAs/Minor WUAs and President and Vice President are elected by them. They in turn elect distributary committee members who elect the Project committee members. The study area is part of Godavari western delta project committee, though it drains the Yarrakalva river water. The study area has about ten WUA’s and two distributory committees. After the expiry of old team a few years ago the WUA’s are formed in December 2015. Also, there are other stake holders from Fisheries and Rural Water Supply departments. The river flow from 2000-2015 at Gollalakoderu gauge site, the most downstream site, is analysed. It is observed that due to unilateral way of providing irrigation for 2 to 3 crops in the study area lying in Godavari delta command area system, there is interference with natural flows in Yerrakalva river and on its drainage, that has gone unnoticed. Further investigations are underway to compile information at WUA level so as to prepare appropriate IWRM strategies.

CENTRE FOR FLOOD MANAGEMENT STUDIES GUWAHATI

Scientific Manpower

S N	Name	Designation
1	Dr. S K Sharma	Scientist B
2	Mr. Gulshan Tirkey	Scientist B

WORK PROGRAM FOR THE YEAR 2015-16

S.No.	Title of study	Study Group	Duration (Month/Year)	Funding
1.	Application of the Arc-SWAT Model for the Prediction of Runoff within Kulsi River Basin (Assam / Meghalaya)	Gulshan Tirkey Sanjay Sharma C. K. Jain	2 years (07/13-03/15) Extended upto 03/16	Internal (Completed)
2.	Status Report on Soil Erosion and Sedimentation in Brahmaputra River Basin	Gulshan Tirkey C. K. Jain	1 year (07/13-03/14) Extended upto 03/16	Internal (Completed)
3.	Flood Inundation Mapping using RRI Model for Kulsi River Basin (Assam / Meghalaya)	S. K. Sharma Gulshan Tirkey C. K. Jain	1 year (04/15-03/16)	Internal (Completed)

Application of the Arc-SWAT Model for the Prediction of Runoff within Kulsi River Basin (Assam/Meghalaya)

The Kulsi river sub basin is a part of Brahmaputra river basin is situated on the south bank of the mighty river Brahmaputra. The sub-basin spreads in the Kamrup district of Assam as well as west Khasi hills and Ribhoi district of Meghalaya. The river Kulsi drains out a total area of 2806 sq.km within the Kamrup district of Assam as well as west Khasi hills and Ribhoi district of Meghalaya.

Soil and Water Assessment Tool (SWAT) model has been in use world over during the recent past. It has the efficacy to address wide range of river basin problems at different spatial and temporal scales. The main objectives of this report how to perform sensitivity analysis of different data input of parameters for estimation of runoff and to calibrate and validate the Arc-SWAT model for the prediction of runoff in Kulsi river basin.

To meet the objectives, SWAT model setup was carried out using Arc-SWAT interface. The land cover, soil layers, and DEM were used to generate HRUs. Using the observed monthly runoff data available at Kulsi site for 2001-2002, the SWAT was calibrated for its parameters soil conservation service (SCS) curve number, plant uptake compensation factor, soil evaporation compensation factor, base-flow alpha factor, groundwater delay time, effective hydraulic conductivity in main channel alluvium, Manning's "n" value for the main channel and surface runoff lag coefficient. The model performance was evaluated using the indices such as coefficient of determination (R^2), Nash-Sutcliffe Coefficient (E_{NS}), percent bias (PBIAS), and RMSE-observations standard deviation ratio (RSR). SWAT model was calibrated (2001) and validated (2002) for the surface runoff flow for Kulsi Basin with good accuracy. For runoff calibration, the values of R^2, E_{NS}, PBIAS and RSR were found to be 0.75, 0.45, -35.97 and 0.70, similarly, for the period of validation 0.87, 0.85, -9.02 and 0.37 respectively

The sensitivity analysis indicated CN, ESCO, and soil available water capacity (SOL_AWC) to be the most crucial. Sensitivity analysis was carried out using the combined method of Latin Hypercube (LH) sampling and One-Factor-At-a-Time (OAT) inbuilt in SWAT. The sensitivity analysis indicated CN, ESCO, SOL_AWC, SOL_Z, REVAPMN, GWQMN, Ch_K2, ALPHA_BF, EPCO, CH_N2, GW_DELAY, SURLAG, SOL_K and GW_REVAP are the most sensitive parameters for the study area.

Status Report on Soil Erosion and Sedimentation in Brahmaputra River Basin

The river Brahmaputra has been the lifeline of northeastern India since ages. This mighty river runs for 2880 kms through China, India and Bangladesh. It is a major river system that flows through very distinct regions: the Tibetan Plateau, the Himalaya Mountains, the Assam Plains, and the delta in Bangladesh. Each of these has its own geology, climate, tectonics, and culture. Compared with other major river basins of Asia, the basin of the Brahmaputra, particularly its upper section, is pristine. Limited accessibility to a number of tributaries of the Brahmaputra, however, has led to a restricted number of studies on the system. The Brahmaputra plays an important role in the sediment yield and element budgets of the globe. It supplies 670 km^3 of water, 1000 million tons of particulates, and 100 million tons of dissolved material annually to the Bay of Bengal.

Erosion by the Brahmaputra and its tributaries has been causing considerable damages each year. The extent of loss of damage due to erosion in the valley varies from year to year depending on the severity of floods. The eroded soil in the catchment area and the debris of landslides pour in to the river during rains when the river carries not only enormous discharge but also excessive silt load. In this report an attempt has been made to prepare a status report on Soil Erosion and Sedimentation of River Brahmaputra in North-East Region and its effect on river basin.

The problems of flood, erosion and drainage congestion in the Brahmaputra basin are gigantic. The Brahmaputra river is characterized by its exceedingly large flow, enormous volume of sediment load, continuous changes in channel morphology, rapid bed aggradations and bank line recession and erosion. The river has braided channel in most of its course in the alluvial plains of Assam. The lateral changes in channels cause severe erosion along the banks leading to a considerable loss of good fertile land each year. Bank oscillation also causes shifting of outfalls of its tributaries bringing newer areas under waters. Thousands of hectares of agricultural land is suffering from severe erosion continuously in the Brahmaputra basin covering parts of states like Assam, Arunachal Pradesh, Meghalaya, Nagaland and Manipur.

In order to tackle the problem of floods and erosion various agencies including state, central government and autonomous institutions are engaged in planning and execution of flood management programs in the north eastern region. To achieve effective flood management programs a variety of structural and non structural measures are adopted. However, due to the inherent widening characteristic of the Brahmaputra river they do not sustain and adversely affect the benefits anticipated while implementing the flood control and anti-erosion works.

The soil erosion and sediment yield problems are mainly due to varying of topographical and geological conditions, pressures of human and animal populations on the land resources and because of small land holdings. In this report, efforts have been made to highlight the problems of erosion and subsequent sediment yield as they affected by various land uses. Thus if protective measure is to be recommended, various information about the stream such as ecology, river morphology, and soil characteristics is required. Considering various problems faced due to the river erosion and sedimentation, various suggestions have been advised to counter these problems.

Flood Inundation Mapping using RRI Model for Kulsi River Basin (Assam/Meghalaya)

Topography affects different aspects of the water balance in a catchment. Different sources of Digital Elevation Model (DEM) characterizing the topography are available online and their suitability for hydrologic simulation needs to be accessed. The removal of noise from DEM using smoothing filters also influences spatial distribution of flood inundation mapping needs to be quantified.

Centre for Flood Management Studies, National Institute of Hydrology, India has identified Kulsi River Basin for undertaking Pilot Basin Study (PBS) as a component of Integrated Water Resource Management (IWRM). The basin has experienced severe flooding in 2007 and 2008. Rainfall-Runoff-Inundation (RRI) hydrological model was used in this study to simulate discharge and inundation extent for the flood events. The objectives of the study were a) to evaluate the sensitivity on hydrologic simulation using SRTM (Shuttle Radar Topography Mission), ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) and CARTO (CARTOSAT-1) DEM and b) to evaluate the impact of smoothing of DEM using low pass filter, enhanced lee filter (window size 3 and 5) and denoising filters o on discharge and flood inundation extent. Result of flood area from RRI were verified with flood extent from MODIS derived Modified Land Surface Water Index (MLSWI).

Sensitivity analysis showed that RRI Model is highly sensitive to Manning's roughness coefficient values for flood plain, followed with source of DEM and then soil depth among the input parameters. The simulated inundation extent was found to be more influent by smoothing filters than its simulated discharge at the outlet. RRI model simulations of discharge and inundation area showed good agreement with the MODIS derived flood extents. Combination of ASTER DEM with denoising algorithm performed better hydrologic simulations of discharge and inundation extent among all other input combinations for Kulsi River Basin.

WORK PROGRAMME FOR THE YEAR 2016-17

S.No.	Title	Study Group	Duration (Month/Year)	Remarks
1.	Evaluation of Ground Water Quality with more Emphasis on Arsenic Contamination in Nalbari District of Assam	C. K. Jain S. K. Sharma GulshanTirkey Babita Sharma	2 year (04/16-03/18)	Internal
2.	Short Term Flood Forecasting Using Bootstrap based Artificial Neural Networks within Kulsi River Basin (Assam/Meghalaya)	S. K. Sharma GulshanTirkey C. K. Jain	1 year (04/16-03/17)	Internal
3.	Application of USLE Model for Estimation of Soil Loss in Kulsi River Basin using Remote Sensing and Geographic Information System	GulshanTirkey Sanjay Sharma C. K. Jain	1 years (04/16-03/17)	Internal

Evaluation of Ground Water Quality with more Emphasis on Arsenic Contamination in Nalbari District of Assam

In the North Eastern region of India, natural springs and dug wells are the only cost effective and viable means of fulfilling the needs of freshwater for present population. In hilly areas, most of the drinking water is used to be harnessed from rivers, ponds and natural springs. Many springs are reportedly becoming seasonal. In valleys, most of the domestic water is harnessed from groundwater through shallow tube wells and dug wells. Availability of drinking water in summers is severely marred and the overall quality is questionable.

Information on ground water quality of North Eastern India is scanty. These alarming pictures of the water quality in the region and continuous consumption of this water has the potential of posing serious health hazard to the local population. The observation warrants an extensive and exhaustive study to identify the contamination sites both from the standpoint of protecting public health and preserving the natural resources. Recognizing the enormity and severity of the problem, ground water quality survey will be conducted within the Nalbari District of Assam to identify the suitability of ground water quality for drinking purposes with more emphasis on arsenic contamination in ground water of Nalbari District of Assam and recommendations will be made for remedial measures.

Short Term Flood Forecasting Using Bootstrap based Artificial Neural Networks within Kulsi River Basin (Assam/Meghalaya)

The temporal and spatial variability that characterizes a river system makes flow forecasting a very demanding task. Flow forecasting is a crucial part of flow regulation and water resources management, as it is related to issues such as drought prevention, flood forecasting for dam and human safety and ecosystem sustainability. Different types of flood forecasting techniques and models are being used by many investigators, viz., deterministic models, stochastic and statistical models and iii) Artificial Neural Network (ANN) and fuzzy logic techniques.

Artificial Neural Networks (ANN) has emerged as a powerful technique for mapping highly complex input output relationship. However, due to deputation of Dr. Sharma for one year training at Japan, the study could not be completed and is being shifted to 2016-17. In this study flood modeling for short term forecasts for different lead times will be carried out using different ANN models. The developed ANN models will be further coupled with bootstrap technique to develop BANN models which will help in quantifying the uncertainty of the model predictions. The bootstrap method is a data driven simulation method that uses intensive resampling with replacement to reduce uncertainties. The technique based on resampling with replacement of the available dataset and training an individual network on each resampled instance of the original dataset will be used to expand upon a single realisation of a distribution or process to create a set of bootstrap samples that will provide a better understanding of the average and variability of the original unknown distribution or process. On a query from a member, Dr. Sharma informed that ANN is an advanced mathematical model compared to linear regression model and do not require slope, soil etc. as necessary input.

Application of USLE Model for Estimation of Soil Loss in Kulsi River Basin using Remote Sensing and Geographic Information System

Soil erosion is a widespread problem in the developing countries. Serious soil erosion is occurring in most of the world's major agricultural regions and the problem is growing as more marginal land is brought into production. For maintaining and improving soil productivity, high priority should be given for conservation of soil resources by promoting optimum land use. Due to the complexity of the variables involved in erosion it becomes difficult to measure or predict the erosion in a precise manner. The latest advances in remote sensing technology have provided very useful methods of surveying, identifying, classifying and monitoring several forms of earth resources. Remote sensing data provide accurate, timely and real time information on various aspects of the watershed such as land use/cover, physiography, soil distribution, drainage characteristics etc. It also assists in identification of the existing or potential erosion prone areas and provides data inputs to many of the soil erosion models.

The USLE model applications with GIS would allow us to analyze soil erosion in much more detail since the process has a spatially distributed character. It is obviously more reasonable to use the USLE on a physical basis than to apply it to an entire watershed as a lumped model. A recent and emerging technology represented by GIS provides the tools to generate manipulate and spatially organize disparate data for sediment yield modeling. The GIS and Remote Sensing (RS) provide spatial input data to the model, while the Universal Soil Loss Equation (USLE) can be used to predict the sediment loss from the basin.

Keeping this in view, the present study was taken up to estimate the magnitude and spatial distribution of soil erosion in Kulsi River Basin using USLE, GIS and RS, so that the critical areas, which need to be provided with adequate soil and water conservation measures can be identified.

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
5	Mr. R Venkataraman	Scientist C

WORK PROGRAM FOR THE YEAR 2015-16

SI	Title of the study	Study Team	Duration	Status
1.	Pilot Basin Studies (PBS) for Mahi River Basin in Ghaghra-Gandak Composite Basin	B Chakravorty NG Pandey Pankaj Mani	04/12-03/17 (XII Plan Year)	
2.	Development of flood forecasting system based on rainfall information obtained from satellite data	Pankaj Mani Rakesh Kumar	3 year (Started in 2013-14)	
3.	Time Series analysis of Monthly Rainfall in Mahi Basin	NG Pandey B Chakravorty Sanjay Kumar	2 year (2014-2016)	
4.	Demonstration scheme on Riverbank Filtration in Gagatic plain of Bihar	B Chakravorty NG Pandey	2 year (2015-17)	
5.	Spatial and Temporal Distribution of Geochemical Characteristics and Environmental Stable Isotopes in Groundwater of North Bengal	SR Kumar, MS Rao and SWID	1 year (2015-16)	

1. Pilot Basin Studies (PBS) for Mahi River Basin in Ghaghra-Gandak Composite Basin

Thrust Area under XII 5-year plan: Integrated Watershed Management for Flood Control

Study Group: (a) Biswajit Chakravorty, Sc. 'G'
(b) N. G. Pandey, Sc. 'D'

Objectives:

(iii) Development of water balance model of Mahi basin and decision support system for increase in irrigated agriculture and productivity.

(iv) Increase in livelihood and betterment of socio-economic condition of the inhabitants.

Statement of the problem:

Under its 12th Plan program (2012-17), the Institute has been given the responsibility to take up PBS for Integrated Water Resources Management (IWRM) in different hydrological regions in the country. These PBS are expected to evolve a participatory model of addressing the water-related issues in the basin based on IWRM concept. The program will involve detailed studies on various components of the Hydrologic Cycle as well as on the identified water-related problems for a small basin through establishment of advanced instrumentation for data collection, storage, processing, and analyses using state-of-art models. The basin identified for this program would be studied in detail for a period of next five years, and the results and findings of the study would be shared with the State Government for their use in planning and effective management of water resources in the State.

Study area:

Govt. of Bihar has approved and selected basin is Mahi basin falling under Gandak-Ghaghra composite basin for the Pilot Basin Studies.

Present state of art:

For a river basin predominantly farmers are the target group and planning is mainly meant for their betterment. Presently this is done through water users' association/farmers' organizations in participatory mode. Farmer's interest is to get sustainable income growth. The socio-economic and political complexities always put barrier in their upliftment. Farmers seldom get fair price and the middle men engulf the cream. Mahi basin is situated in highly fertile tract of Gangetic plain of North Bihar. Where irrigation facility exists 3 crops per year can be grown but due to waterlogging and drainage congestions lower part of Mahi basin is without any crop.

Methodology:

Water balance study is performed to assess the water surplus/water deficit areas. Planning is to be made for providing water through irrigation either surface or lift in water deficit areas. Similarly identifying the waterlogged pockets in the basin necessary drainage clearance is to be planned. Integrated approach involving agriculture, horticulture, cattle rearing, fish culture, duckery, goatery etc. is to be encouraged making credits made available through farmers organization.

Work schedule:

(c) Date of commencement of the project: April 2013

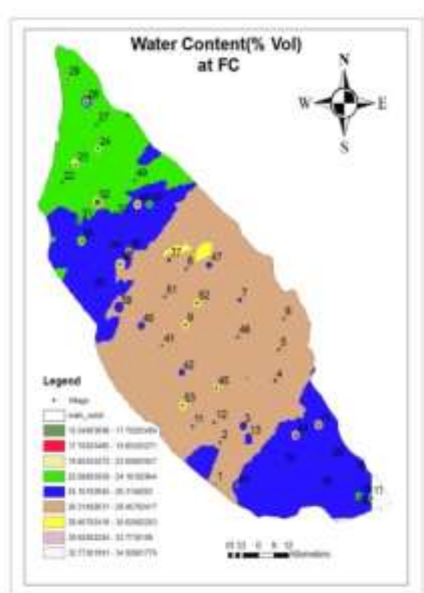
(d) Duration of the project: 4 year.

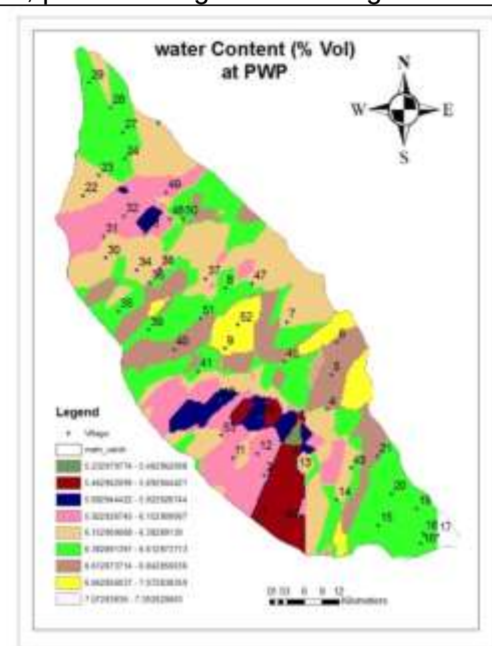
(e) Stages of work and milestone:

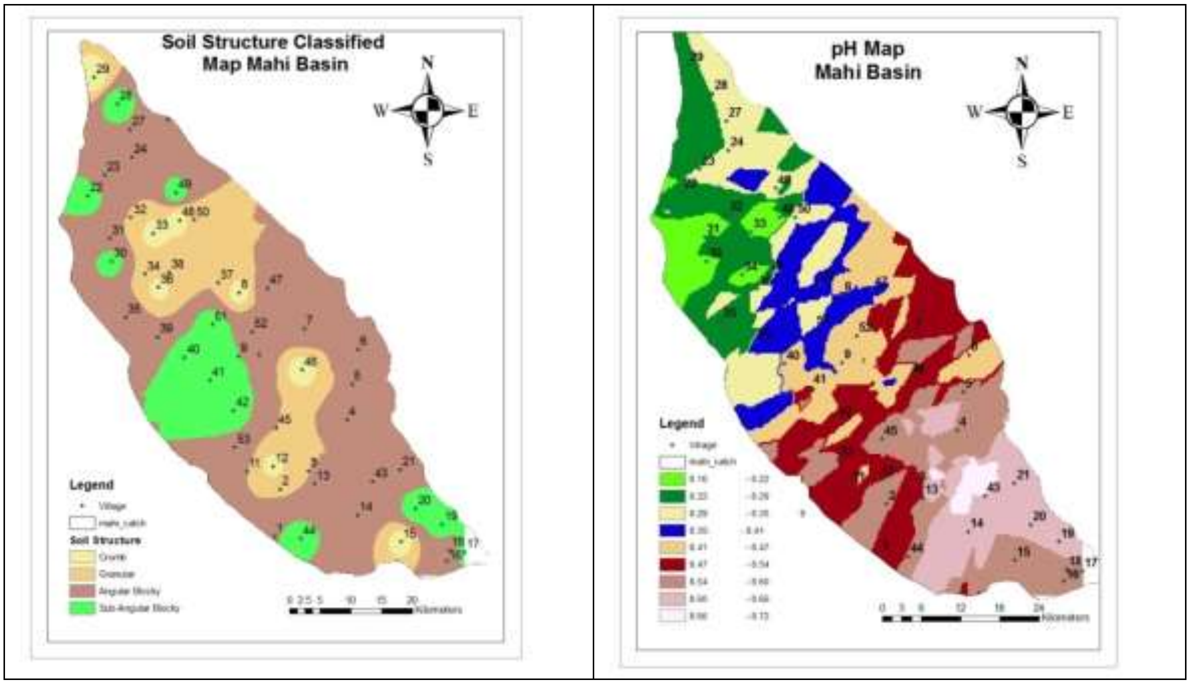
SN.	Work Element	2014	2015	2016	2017	Status
1.	Literature review, meetings					Completed
2.	Pilot Basin selection					Completed
3.	Stake holders meetings					Completed
4.	Collection of hydro-meteorological data					Completed
5.	Collection of water/soil samples and in-situ field tests in study area. Laboratory analysis					In progress
6.	Water balance studies					In progress
7.	Formation of farmers groups/associations					To be done
8.	Report preparation					To be done

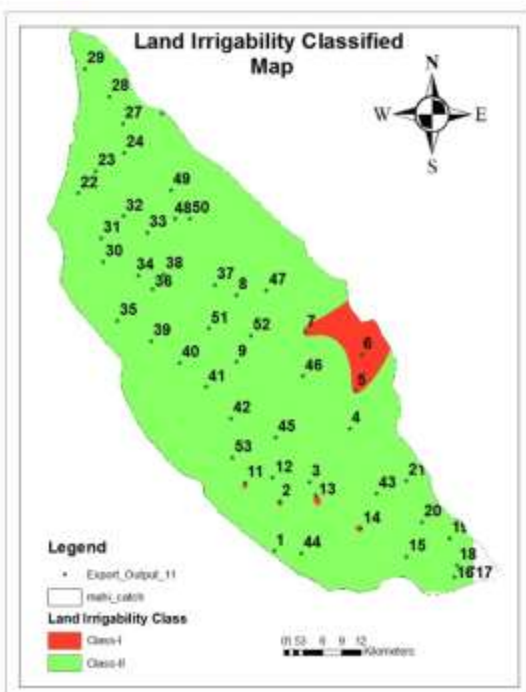
Progress:

Participatory Irrigation Management (PIM) concept and lesson learnt from Sone Irrigation Scheme in Paligunj distributary, Govt. of Bihar was followed. Accordingly Field visits were made and primary data through sampling is in progress and other secondary data from different sources are being collected. So far 53 soil samples were collected and tested in lab. Some soil properties like water retention, soil structure, pH etc. are given in the figures below.









Research Outcome from the project:

(iv) Water balance study report, identification of water deficit and water surplus area and planning productive utilization of water.

(v) Development of strategy and management plan for better livelihood.

2. Development of flood forecasting system based on rainfall information obtained from satellite data.

Thrust area under XII five year plan: Non Structural Measures of Flood Management

Study Group: (a) Pankaj Mani, Sc. 'D'
(b) Rakesh Kumar, Sc. 'G', SWHD, NIH Roorkee
(c) Jagadish Prasad Patra, Sc. 'C', SWHD, NIH Roorkee

Objectives:

(i) Development of IFAS for Bagmati basin which is partly in Nepal (majority of mountainous catchment) for which rainfall data is limited.

(ii) Evaluation of Model performance wrt the observed discharge and water level/ discharge of Bagmati river at Hayaghat GD sites

Introduction:

Floods are common natural hazards in the alluvial plains of Ganga which spread across the international boundaries and mountainous region. Accurate estimates of rainfall are needed in order to minimise the impacts of floods. In mountainous and transboundary areas of Bagmati basin, measuring stations are often sparse or data are unavailable for predicting rainfall derived floods. The first gauge data on Bagmati river is available at Dhen Bridge site when the river enters into India and the present practice of flood forecasting is based on the Gauge to Gauge correlation thus providing limited lead time. With the possibility of using satellite based rainfall estimates and also to estimate future rainfall, the accuracy and lead time of forecast will improve substantially.

Study area:

Bagmati is an international and perennial river originating near Kathmandu from the shivpuri range of hills in Nepal at an elevation of 1500 m above MSL. It traverses nearly 195 Km in Nepal and rest 394 Km in Bihar and outfalls in the Kosi at Dumrighat and finally falls into the river Ganga at Krushela. It enters India in Sitamarhi district of Bihar about 2.5 Km north of Dheng railway station. The catchment area of Bagmati basin (including Adhwara) is 14,384 km^2, out of which 6,500 km^2 is in India and rest in Nepal. The main tributaries are; Lalbakeya(R), Lakhandei(L), Darbhanga-Bagmati(L), Old kamla(L), Hasanpur Bagmati(R).

Present state of art:

In India, Central Water Commission is mainly responsible for issuing flood forecast. The various flood forecasting centres are using different forecasting models, based on availability of hydrological and hydro-meteorological data, the basin characteristics, computational facilities available at forecasting centres, warning time required and purpose of forecast. However, some of the common methods being used by these centres are given below:

i). Simple correlation – based on stage-discharge data.

ii). Co-axial correlation – based on stage, discharge and rainfall data etc.

iii). Routing by Muskingum method and Successive routing through sub-reaches.

Recently, Flood Management Improvement Support Centre (FMISC), Water Resources Department, Government of Bihar has engaged DHI (India) Water & Environment to develop the Flood Forecast and Inundation Modeling System in Bagmati-Adhwara Basin. Hydrological modeling has been developed using NAM (Rainfall-Runoff) module of MIKE11 11 system. The NAM model computes catchment runoff from Nepal and Bihar. Model parameters are calibrated for both Bihar and Nepal catchments. Hydrodynamic Model is developed based upon the schematization of river network, river cross-section, model boundaries; cross-section extracted from DEM. DEM is developed from available LIDAR data for some area and SRTM data for the rest of the basin. The entire model has been designed to give a lead time of 72 hours along with the inundation maps showing depth, time of travel etc.

Methodology:

IFAS stands for "Integrated Flood Analysis System". IFAS is a concise tool kit with a Graphic User Interface for building Distributed Rainfall-Runoff analysis model, which runs on Windows operated personal computers and connected to internet. The hydrological analysis model is Public Works Research Institute Distributed Hydrological model (PWRI-DHM). The model consists of a distributed hydrological model based on the tank model and a routing model based on a kinematic wave hydraulic model. The purpose of using IFAS is its ability to develop a flood forecasting and flood warning systems especially in insufficiently gauged river basin for which most of the input data are available online (except GD data).

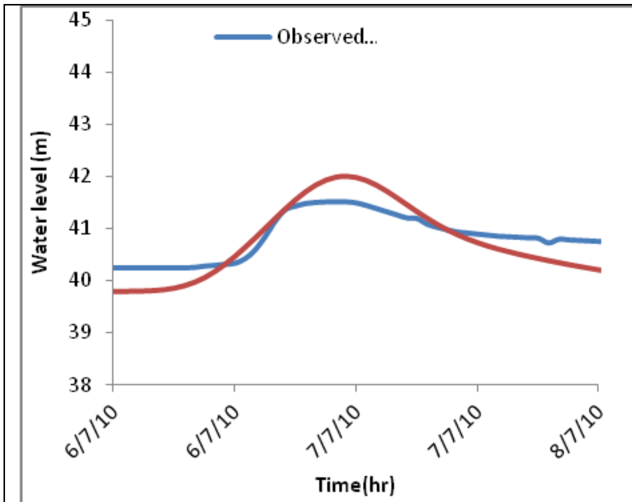
Work schedule:

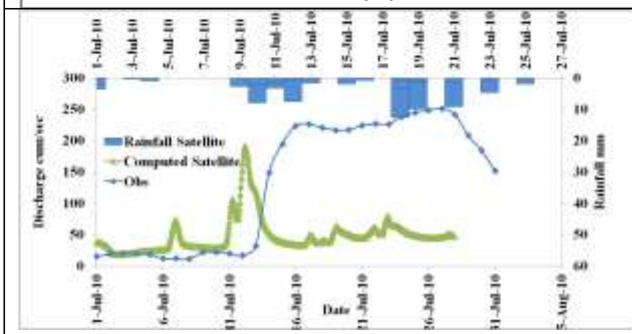
(a) Date of commencement of the project: April 2013
(b) Duration of the project: Three year.
(c) Stages of work and milestone:

S. No.	Work Element	2013 (6 M)	2013 (6 M)	2014 (6 M)	2014 (6 M)	2015 (6 M)	2015 (6 M)	Status
1.	Literature review							Completed
2.	Software downloading & learning							Completed
3.	Selection of study area							Completed
4.	Collection of hydrological meteorological data							Completed
5.	Development of GIS data base for study area							Completed
6.	IFAS model development and evaluation of its performance							In progress
7.	HEC HMS model setup and analysis & its result comparison							To be done
8.	Report preparation							To be done

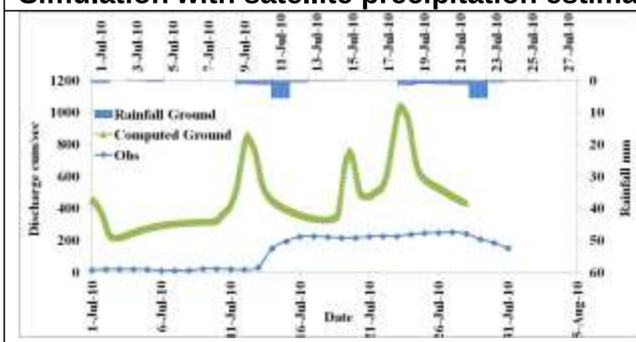
Progress:

IFAS model for Bagmati basin has been setup using open source basin characteristics data like DEM, landuse class, soil class. More detailed SRTM data has been used instead of 1 km GTOPO30. The model calibration has been done for the observed water level of July 2010 at Hayaghat GD site. Further, the simulation has been carried out with three rainfall input, (i) satellite based, (ii) ground rainfall data and (iii) satellite correction based on ground rainfall data. The study is completed.

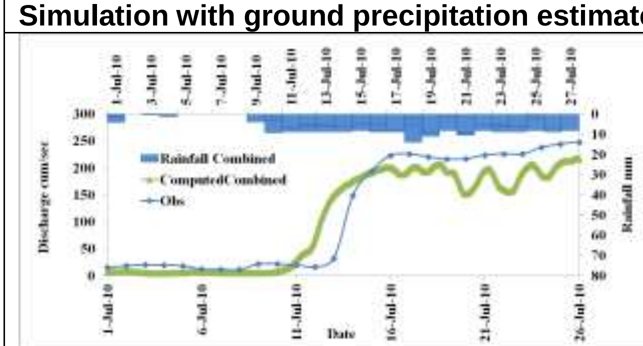




Simulation with satellite precipitation estimates only



Simulation with ground precipitation estimates only



Simulation with modified precipitation estimates based on ground observation

Research Outcome:

(i) Evaluation of satellite rainfall estimate for flood forecast.

(ii) Improvement in model performance by combining ground rainfall data with satellite rainfall estimates.

3. Time Series analysis of Monthly Rainfall in Mahi Basin

Thrust Area under XII five year plan: Non Structural Measures of Flood Management

Study Group:
(a) N. G. Pandey, Sc. 'D'
(b) Biswajit Chakravorty, Sc. 'G'
(c) Sanjay Kumar, Sc. 'D', SWHD, NIH Roorkee

Objectives:

(i) The main objective is to investigate the annual and seasonal rainfall data and to make inferences regarding trends and postulating a model that fits these trends in the data.

(ii) Development of relationship to convert monthly to daily rainfall and to find out the anomalies.

Statement of the problem:

Time series analysis of rainfall data helps in identifying the trends in rainfall over the catchment. In this study the historical monthly rainfall records of IMD stations located in the districts of Chapra, Siwan and Gopalgunj of Mahi basin (a sub basin of Ghagra-Gandak composite basin) of North Bihar has been taken up for investigation. The annual and seasonal trends would be examined using available past rainfall data in the Mahi basin. The main objective is to investigate the annual and seasonal rainfall data and to make inferences regarding trends and postulating a model that fits these trends in the data. The statistical characteristics of the available annual and seasonal data have been evaluated and anomalies have been plotted to identify trends in the annual rainfall at some stations. Work is in progress to investigate these annual and seasonal trends at other stations.

Study area:

Mahi basin a tributary to river Ganga.

Present state of art:

Time series analysis of rainfall data helps in identifying the pattern of rainfall over the catchment. The identified pattern is extrapolated or extended to forecast the future events with the assumption that the pattern identified from the historical record is continuous and prevails in future. To know the properties of the historical record the time series is broken up into individual components and then each component is analyzed separately to understand the mechanism of different components.

Methodology:

In this study the historical monthly rainfall records of IMD stations located in the districts of Chapra, Siwan and Gopalgunj of Mahi basin (a sub basin of Ghagra-Gandak composite basin) of North Bihar has been taken up. Analysis of monthly time series data is to understand the mechanism that generates the data so that the future sequences may be simulated or forecasted over a short period of time (forecasting). These are attempted by making inferences regarding the underlying laws of the stochastic process from the historical data and then by postulating a model that fits the data. ARIMA model will be used and effort will also be made to generate daily rainfall data from the monthly data by analyzing the daily rainfall trends.

Work schedule:

(a) Date of commencement of the project: April 2014

(b) Duration of the project: Earlier it was for 2 year but now extended for 2016-2017.

(c) Stages of work and milestone:

SN	Work Element	2014	2014	2015	2015	Status
1.	Literature review					Completed
2.	Software downloading & learning					Completed
3.	Selection of study area					Completed
4.	Collection of hydro-meteorological data					In progress
5.	Development of ARIMA model					To be done
6.	Validation and evaluation of its performance					To be done
7.	Report preparation					To be done

Progress:

The literature review has been carried out. The meteorological data (monthly rainfall) for the study area have been collected from IMD, Pune. Collection of daily rainfall data of Chapra, Siwan and Gopalgunj are in progress. The model development, model calibration and validation would be completed during the current year.

Research outcome:

A relationship among the 3 rainfall stations would be developed after removing trend and seasonality taking previous time steps using ARIMA model. This relation will be used to forecast the future events for Mahi basin.

4. Demonstration scheme on Riverbank Filtration in Gangetic plain of Bihar

Thrust Area under XII five year plan: Water resources planning and management

Study Group:

(a) Biswajit Chakravorty, Sc. 'G'
(b) N. G. Pandey, Sc. 'D'

Objectives:

(i) Study and improve natural water treatment systems.
(ii) Popularize them among the various stakeholders.

Statement of the problem:

Bank Filtration is a natural pre-treatment technology, which enables the utilization of surface water sources such as lakes or rivers. The water passes through the natural porous sub-surface (aquifer) to the production well. The porous media serves as a natural filter and reduces the amount of suspended solids and pathogens. Bank filtrate from the production wells shows a significantly higher quality compared to water abstracted directly from surface or groundwater sources. BF is advantageous as a pre-treatment in order to reduce the necessary doses of chlorine prior to flocculation. Additional advantages of BF may also be seen during the monsoon season, principally in the removal of turbidity and pathogens, as well as in the removal of colour and dissolved organic carbon (DOC), UV absorbance, turbidity, and total thermo tolerant coliform counts.

NIH proposes to develop pilot demonstration schemes on BF for sustainable drinking water supply.

Study area:

It is proposed to develop pilot demonstration schemes on BF on the right bank of Ganga river in and around Ara locality 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.

Present state of art:

A collaborative European Union research project on river bank filtration under 'Saph Pani' started in October 2011 with duration of 36 months involving a consortium of 20 partners from India, European Union, Switzerland, Sri Lanka and Australia. Its full name is "Enhancement of natural water systems and treatment methods for safe and sustainable water supply in India" and it addresses the water challenges of the 21th century in India. The Saph Pani project aimed to study and improve natural water treatment systems such as bank filtration (BF), managed aquifer recharge (MAR) and constructed wetlands (CW) in India building Indian and European expertise in those fields. All the above three technologies have vast potential in the Indian context, and the objective under Saph Pani was to strengthen the scientific understanding of the technologies and their processes, and popularize them among the various stakeholders in India. The project focused on a set of specific case studies in India, and sustainability assessment was also performed for those case study sites, covering human health, environmental, economic, institutional and social aspects. Three thematic training courses, one each on the three technologies mentioned above, were also organized for the stakeholders in addition to practitioners' exposure tours. Water management plans for natural treatment systems were developed and suitable policy frameworks prepared.

Methodology:

RBF is the influx of River water to the aquifer induced by a hydraulic gradient. Collector wells along banks in a certain distance from the river create a pressure head difference due to drawdown between the River and the well, which induces water from the river to flow through the porous media into the pumping wells. By this process, the water from the river passes through the porous material between the river and the well acting as a filtration media removing undesirable constituents from the river water. By applying this system of drinking water extraction, two different water resources are used namely surface water from the river percolating towards the well and the groundwater of the surrounding aquifer. It means the site selected for RBF is to be located where porous material is present between the River and the well to act as a filtration media to remove undesirable constituents from the River water. At the same time the yield of such well need to be reasonable high so that it caters the water supply need.

Work schedule:

(a) Date of commencement of the project: April 2015

(b) Duration of the project: 2 year.

(c) Stages of work and milestone:

S. No.	Work Element	2015	2016	2017	Status
1.	Literature review				done
2.	Site selection				identified
3.	Execution of demonstration well				To be done
4.	Performance of well				To be done
5.	Sampling and water quality analysis				To be done
6.	Report preparation				To be done

Research outcome:

Study and improve natural water treatment systems through bank filtration and after successful implementation the effort would be to popularize them among the stakeholders and to other places.

5. Spatial and Temporal Distribution of Geochemical Characteristics and Environmental Stable Isotopes in Groundwater of North Bengal using GIS and its Assessment with the help of Water Quality Index (WQI) and Existing Classification Systems

Thrust area under XII five year plan: Water Quality assessment in specific areas

Study Group: (a) S.R. Kumar, Scientist 'D',
(b) M.S. Rao, Scientist 'D' from HQ and
(c) Officials from SWID

Objectives:

The main objective of the study was to assess the groundwater quality through thematic maps using GIS.

Statement of Problem:

Systematic study is necessary to evaluate the suitability of the groundwater on the basis of various specifications for various designated uses like drinking, domestic, bathing, irrigation, industrial etc. In this context, an attempt has been made to bring out the groundwater quality status maps for the study area under north Bengal.

Methodology:

Krigging raster interpolation technique of spatial analyst module has been used in the present study to delineate the spatial distribution of various water quality parameters. Apart from these, irrigation suitability maps are also prepared.

The Study Area:

Under North Bengal region.

Analysis and Results:

The thematic maps of different water quality parameters were generated to check the location specific suitability of groundwater for its drinking, domestic and irrigation purposes because no such information was available for the study area.

Research outcomes:

Understanding the spatial distribution of different water quality can help to identify the quality of groundwater for different usages such as drinking and irrigation and also as a precautionary indication of potential environmental health problems. The produced groundwater quality maps could aid as information source to decision makers, local managements and municipal authorities.

<u>APPENDIX 69.4.2</u>

LIST OF PAPERS PUBLISHED/ ACCEPTED FOR PUBLICATION DURING JUNE, 2015 – MARCH, 2016 & APRIL, 2016– JUNE, 2016

LIST OF PAPERS PUBLISHDED

		June, 2015 – March, 2016	April, 2016 – June, 2016
S.No.	**Item**	**Published**	**Published**
1.	International Journal	55	18
2.	National Journal	16	03
3.	International Conference/ Seminar/ Symposium	46	06
4.	National Conference/ Seminar/ Symposium	91	-
5.	Books/ Chapter Published	09	-
	Total	217	27

Research papers published during June, 2015- March, 2016

International Journal
Published

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3. Dimri, A. P., Thayyen, R. J., Kibler, K., Stanton, A., Jain, S. K., Tullos, D., & Singh, V. P. (2016): A review of atmospheric and land surface processes with emphasis on flood generation in the Southern Himalayan rivers. Science of The Total Environment, 556, 98-115.
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Published

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APPENDIX 69.4.3

**LIST OF WORKSHOPS/ TRAINING COURSES/
SYMPOSIA ORGANISED
DURING JUNE, 2015 – MARCH, 2016 &
APRIL, 2016 – JUNE, 2016**

Organisation of Workshop/ Training Courses/ Seminars/ Symposia during June, 2015 to March, 2016

S.No.	Name of Course	Period	Place
1.	राजभाषा सुग्राहिकरण	June 3, 2015	Roorkee
2.	Training course “Introduction to HEC based modeling solutions” (SKJ)	June 01-05, 2015	NIH Roorkee
3.	Training Course on ‘Flood Risk Mitigation and Management’	Sept. 7-11, 2015	Roorkee
4.	Training on ‘Integrated Water Resources Development & Management’	Sept.14-18, 2015	Roorkee
5.	Training on ‘Integrated Water Resources Development & Management’	Sept.18-23, 2015	Roorkee
6.	Indo-German Workshop on ‘Consolidation and Future of Riverbank Filtration Projects in India’ (NCG)	Sept. 28, 2015	Roorkee
7.	Workshop on ‘Integrated Water Resources Development & Management’ (AKL)	Sept.28-Oct.3, 2015	Roorkee
8.	Training Course on ‘Remote Sensing and GIS Applications in Water Sector’(SKJ)	Nov.2 – 6, 2015	HIRMI, Kurukshetra
9.	Training program on ‘Basic Hydrology’	Nov.2 – 7, 2015	WALAMTARI, Hyderabad
10.	International workshop on ‘Changes in Water Resources and Adaptation options in the Indian-Himalayans Basins’ jointly organized by NIH, SMHI & SEI, Sweden (SWH)	Nov.16-17, 2015	Roorkee
11.	Training Course on ‘Planning and Management of Hydropower Projects (Hydrological Aspects)’ for officers of Meghalaya Electricity Corp., Umiam (SKJ)	Nov.17-19, 2015	Umiam, Meghalaya
12.	पाँचवीं राष्ट्रीय जल संगोष्ठी "बदलते परिवेश में जल संसाधन प्रबंधन की भूमिका"	Nov.19-20, 2015	Roorkee
13.	Training on “Integrated Water Resources Development & Management”	Nov. 30 – Dec.5, 2015	Roorkee
14.	National Seminar on ‘R & D Perspective for Rejuvenation of River Ganga’	Dec 16-17, 2015	Roorkee
15.	National Conference on ‘Mointoring and Management of Drinking Water Quality (NCMMDWQ)-2015	Dec.21-23, 2015	UCOST, Dehradun
16.	Symposium of Hydrology in collaboration with IAH, NIH & CWC	Dec.22-23, 2015	New Delhi
17.	Hands on training on “Advanced Instruments of Water Quality Testing” (CKJ)	Jan. 11-15, 2016	Roorkee
18.	Disaster Risk Reduction and Resilient Livelihoods as a part of the Kosi Basin Program (KBP)	Feb.4-5, 2016	Patna
19.	Training on ‘Investigations, Assessment, and Management for sustainable groundwater development of coastal aquifers’	Feb. 9-13, 2016	Kakinada
20.	‘Training Needs Assessment (TNA) & PDS’	Feb. 15, 2016	Roorkee

	under NHP		
21.	'Training Needs Assessment (TNA) & PDS' under NHP.	Feb. 19, 2016	Chandigarh
22.	'Training Needs Assessment (TNA) & PDS' under NHP	Feb. 25, 2016	CWPRS, Pune
23.	'Training Needs Assessment (TNA) & PDS' under NHP	Feb. 26, 2016	Kolkata
24.	'Training Needs Assessment (TNA) & PDS' under NHP	March 3, 2016	Bangaluru
25.	Training course on 'Application of Isotopes in Hydrology & water Resources'	Feb.29- March 4, 2016	Roorkee
26.	Training Needs Assessment and Purpose Driven Studies	March 2, 2016	WRDO, Anand Rao Circle
27.	Training course on "Application of CROPWAT Software".	March 8-11, 2016	HIRMI, Kurukshetra
28.	Training course on 'Hydrologic Modeling using RS/GIS with special Reference to Climate Change' funded by National Water Mission	March 28-31, 2016	Roorkee
29.	Workshop on 'Water Quality Assessment and Management of Lentic Water Bodies'	March 9-11, 2016	Belgaum
30.	Himalayan River basins: Hydrology and Glacial regimes	Nov. 5, 2015	Roorkee

Organisation of Workshop/ Training Courses/ Seminars/ Symposia during April, 2016 to June, 2016

S.No.	Name of Course	Period	Venue
1	Instrumentation and Techniques for Operation of Silt Observation Post (SOP)	25-29 April, 2016	WHRA, Jammu
2.	Training course on "Use of modeling techniques, GIS and remote sensing" for state irrigation engineers of Rajasthan state.	May 02-06, 2016	NIH. Roorkee

APPENDIX 69.4.4

PROGRESS OF LABORATORY WORK DURING THE PERIOD JUNE, 2015 – JUNE, 2016

1. **Nuclear Hydrology Laboratory**
2. **Water Quality Laboratory**
3. **Soil-Water Laboratory**

Analysis carried out in Isotope Laboratory
(June 2015 to June 2016)

- H2 Analysis on DI-IRMS – 4861
- O18 Analysis on CF-IRMS – 4771
- H2 & O18 Analysis on LGR Laser IRMS – 1557

Analysis of Water Samples in Water Quality Laboratory
(June 2015 to June 2016)

	No. of samples from Scientific Divisions ay HQ (NIH, Roorkee)	**No. of samples from Regional Centre (NIH Roorkee)**	**No. of samples from Outside Agencies on payment basis / Consultancy**
Physico-chemical analysis	1359	-	1569
Bacteriological analysis	175	-	-
Metal analysis	-	-	-
Pesticide analysis	-	-	-

Soil Water Laboratory
Laboratory Analysis carried out during the period June 2015 to June 2016.

Sl. No.	Name of the studies	No. of Samples	Parameters Measured
1.	Infiltration Behaviour under various Land use and its modeling in kulsi Pilot Basin (Assam/ Meghalaya).	Eleven	Determination of soil texture using laser based particle size analyser.
2.	Coastal Groundwater Dynamics and Management in Saurashtra Region, Gujarat.	Twenty nine One	Determination of soil moisture retention characteristics using disturbed soil samples. Determination of soil texture using sieve shaker and laser based particle size analyser
3.	Coastal Groundwater Dynamics and Management in Saurashtra Region, Gujarat.	Forty one	Determination pH and EC
4.	Water Resources status and Availability of North West Himalayas.	Twenty seven	Determination of soil texture using sieve shaker and laser based particle size analyser. Determination of soil moisture retention characteristics using disturbed soil samples.
5.	Management of water quantity & quality in Yamuna – Hindon Inter basin.	Twenty nine Seven Twenty six Twelve	Determination of soil texture using sieve shaker and laser based particle size analyser. Determination of soil moisture content and bulk density using Undisturbed soil samples. Determination of soil moisture content and bulk density using Undisturbed soil samples. Determination of soil moisture retention characteristics using disturbed soil samples.
6.	Petroleum Product Contamination at Akolner village, District-Ahmednagar, Maharashtra.	Ten	Determination of soil texture using sieve shaker and laser based particle size analyser. Determination of soil moisture retention characteristics by disturbed soil samples.
7.	Project work of Mr. Vikrant, M.Tech(IWRM) student in Karunya university, Coimbatore.	Seven	1.Determination of soil texture using sieve shaker and laser based particle size analyser. 2.Determination of soil moisture retention characteristics

8.	Peya Jal Suraksha Project (sampling year-2016). Location –Agra (U.P)	Thirty Thirty Fifteen	1.Determination of soil texture using sieve shaker and laser based particle size analyser. 2.Determination of dry density and soil moisture content. 3. Determination of pH and EC.
9.	Baseline Hydrogeological and hydrological data collection and analysis in Mewat, Haryana.	Eight	Determination of soil texture using sieve shaker and laser based particle size analyser.

APPENDIX 69.4.5

LIST OF ACTIVITIES UNDER IEC SCHEME ORGANISED DURING JUNE, 2015 – MARCH, 2016 & APRIL – JUNE, 2016

Mass Awareness Programmes at Headquaters, Regional Centres and CFMS:

The following activities have been taken under media programme by NIH, at the regional centres of NIH and its CFMS during June, 2015 – March, 2016 & April – June, 2016:

SN	Details	Period	Place
1.	Mass Awareness Programme on Swachh Bharat Abhiyan - Cleanliness Drive	22-26 June, 2015	CFMS, Patna
2.	Mass Awareness on Yoga Day	June 20-21, 2015	CFMS, Patna
3.	Hindi Week	Sept. 15, 2015	RC, Belgaum
4.	Hindi Month	17 Aug. – 16 Sept, 2015	NIH, Roorkee
5.	Vigilance Awareness week 2015	Oct. 26-31, 2015	NIH, Roorkee
6.	Preventive Vigilance and Role of Vigilance in Good governance	30 Oct., 2015	RC, Belgaum
7.	Mass awareness program on ‘Preventive Vigilance as a tool of Good Governance’	3 Nov., 2015	CFMS, Patna
8.	Mass awareness program on Kedarnath Floods	Jan. 19-20, 2016	GIC, Guptkashi
9.	On **Pey Jal Suraksha -** Problems of Safe Drinking Water and its solution using River Bank Infiltration Technique	19 Feb., 2016	Ara, Patna

APPENDIX 69.5.1

MINUTES OF 43rd MEETING OF THE WORKING GROUP OF NIH

MINUTES OF THE
43RD MEETING OF WORKING GROUP OF NIH
HELD AT NIH, ROORKEE, DURING DECEMBER 8-9, 2015

The 43rd meeting of the Working Group of NIH was held at NIH, Roorkee, during December 8-9, 2015 under the Chairmanship of Director, NIH. The list of the participants of the meeting is given in Annexure-I.

ITEM NO. 43.1: OPENING REMARKS BY THE CHAIRMAN

Er R D Singh, Director, NIH & Chairman, WG welcomed the Working Group members and the Scientists of the Institute. The Chairman informed that the Ministry of WR, RD & GR, is directing the Institute to take up more and more action-oriented research for benefit of the stakeholders. Also, he mentioned that many new projects are expected to commence in the Institute, namely- National Hydrology Project, Neeranchal Watershed Project, NMSHE Project, “Water RAIN-Him” project under support from Swedish Meteorological and Hydrological Institute (SMHI), a project under Newton-Bhabha Program of MoES.

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

S N	Member	Suggestion(s)
1	Dr N B N Prasad	▪ Reports of completed projects should be shared with CWC, CGWB, MoWR, etc. ▪ Stakeholders benefits should be specified ▪ Improve presentation of slides ▪ Improve inter-divisional communications ▪ Have pre-Working Group discussions
2	Dr R D Deshpande	▪ Do dependable research ▪ Convert observations into inferences and implications ▪ Form Research Coordination Groups for integration of projects/studies ▪ Limit number of slides for presentation ▪ Attendance of Scientists in Working Group meeting should be mandatory
3	Dr. M Perumal	▪ Bring good publications on snow and glacier hydrology ▪ Focus on urban hydrology studies
4	Dr Ritesh Arya	▪ Improve communication skills
5	Dr D V Reddy	▪ Include abstract of studies in Division’s work program table ▪ Avoid duplication of studies ▪ Establish a databank of available data at NIH
8	Er R K Khanna	▪ Identify end users for all projects/studies ▪ Work on forecasting and management of natural disasters ▪ Hold a training course on EIA ▪ Hold a seminar on IWRM ▪ Initiate a PG Diploma/Certificate course on IWRM

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. 43.2: CONFIRMATION OF THE MINUTES OF 42nd MEETING OF THE WORKING GROUP

The 42nd meeting of the Working group was held during March 19-20, 2015. The minutes of the meeting were circulated to all the members and invitees vide letter No. RCMU/WG/NIH-10 dated April 8, 2015. No Comments were received. The members confirmed the Working Group minutes.

ITEM No. 43.3: 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 42nd working group meeting.

ITEM Nos. 43.4: PRESENTATION AND DISCUSSION ON THE STATUS AND PROGRESS OF THE WORK PROGRAMME FOR THE YEAR 2015-16

The Member-Secretary requested the respective Divisional Heads to present the progress of studies carried out during 2015-16. Accordingly, the progress of various studies and sponsored projects was presented by all Scientific Divisions on their turn during the two day deliberations of the Working Group. The Division wise minutes of each study/project presented during the meeting are given below:

ENVIRONMENTAL HYDROLOGY DIVISION

S.No.	Title of the Project/Study, Status, Study Team, Duration	Recommendations/Suggestions
	Internal Studies	
1.	Water Quality Modelling using Soft Computing Techniques Status: In progress Study group: Rama Mehta (PI), C. K. Jain Duration: 2 Years (05/14-05/16)	No comments
2.	Himalayan River Water Quality Assessment in a Stretch from Gangotri to Haridwar. Status: In progress Study group: Rajesh Singh (PI) , C. K. Jain , M. K. Sharma, S. P. Rai , Renoj J. Thayyan, J. P. Patra Duration: 3 Years (07/14-06/17)	• Dr. G. P. Juyal, CSWCRTI, Dehradun suggested correlation of contamination with domestic effluents.
	Internal Studies (New)	
3.	Status Report on Phytoremediation of Wastewater Study group: Rajesh Singh (PI) , C. K. Jain Duration: 6 Months (11/15 – 04/16)	No comments
	Sponsored Projects	
4.	Ionic Enrichment Dynamics of Glacial Sediment and Melt water of Gangotri Glacier, Sponsored by DST, New Delhi Status: Ongoing Team: M. K. Sharma (PI), C. K. Jain, Renoj Thayyan, Manohar Arora, Naresh Kumar, Jatin Malhotra, Rakesh Goyal, Dayanand, Shyamlal Duration: 3 Years (04/14-03/17)	• Dr. Ghosh suggested to consider travel time between different sties of the study area while interpretating the results. Dr. Bartarya recommended to incorporate ammonia in the list of parameters analysed. Dr. Guyal and Dr. Deshpande appreciated the study.

GROUND WATER HYDROLOGY DIVISION

Dr. N. C. Ghosh, Scientist 'G' & Head presented an overview and progress of studies and activities carried out by the division during the period April 2015 - November 2015. While presenting the technical activities carried out and progress made on different studies during last six months, he gave an account of scientific personnel available at the division and the sponsored and consultancy projects being pursued by the Division. He informed that three in-house R&D studies approved for the year 2015-16, which are being continued and three new studies have been proposed for the year 2015-16, out of these two are sponsored and one is in-house study.

He also informed that the division has organized a one-day workshop on "*Indo-German Workshop on "Bank Filtration in India" under Indo-German Competence Centre for Riverbank Filtration*" on 28th September, 2015 at NIH, Roorkee. In addition, the "Centre of Excellence for Advanced Groundwater Research" was officially inaugurated by the Hon'ble Union Minister for Water Resources, River Development and Ganga Rejuvenation, Sushri Uma Bharati on 26th October, 2015. As professional scientific outputs, scientists of the division have published a number of research papers in various journals/conferences and delivered lectures in various training courses during the period.

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

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

P.I. of the project, Mr. C. P. Kumar (PI) was on leave and hence the progress of the study could not be made. Dr. N. C. Ghosh informed that the study would require funding from M/o WR, RD & GR. Since, no funding and official confirmation were received from the Ministry, the project activities has been deferred. Director, NIH, however, informed that the fund for the project would be made by MoWR, RD & GR in future.

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

Dr. Anupma Sharma (PI) presented the progress of the study. She informed that the groundwater levels in the area have been declined and the presence of harmful contaminants in some portions of the shallow groundwater system was evident. The depletion in water table in Baghpat district along with possible impacts on river flow was also highlighted. Suggestions were made about using CGWB water level data for the study area in addition to the State Department data for better representation.

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

Mr. Sumant Kumar (PI) presented the objectives, progress and future plans of the study. Mr. Sumant Kumar informed that team member Mrs. Shashi Poonam Indwar has been replaced by Mrs. Suman Gurjar and one new member (Mrs. Anju Chowdhary) has been included in team members. It was advised by Dr. Prasad and Dr. Bartarya that health survey should be done for vulnerable risk zone mapping. Dr. V.C. Goyal suggested that IRMA, Anand can be contacted for doing vulnerable mapping. Dr. Reddy suspected that duration of study is short. Dr. N.C. Ghosh informed that as per the need of the study, it can be extended phase-wise.

Project Ref. Code: 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**

Dr. N. C. Ghosh (PI) presented the objectives, mechanism of riverbank filtration (RBF), potential of RBF under different geological settings and future plans of the study. He informed that six pilot riverbank filtration demonstration schemes would be developed under this study at Laksar (Uttarakhand), Agra and Mathura (Uttar Pradesh), Sahebganj (Jharkhand), Bhojpur (Bihar) and Vizag (Andhra Pradesh) in consultation with the respective State departments. The funding for the study would exclusively be provided by the Ministry of Water Resources, River Development and Ganga Rejuvenation under the NIH's Plan Fund.

Dr. Surjeet Singh presented the progress made so far under the study mainly on the preliminary data collection on Yamuna river flows at Agra and Mathura from Central Water Commission and groundwater level and quality data from U.P. Groundwater Department, Lucknow. He also explained about the general soil type and geology of Agra and Mathura area, and presented the results of water quality and isotopic analysis.

Project Ref. Code: NIH/GWD/NIH/15-16: **Web Enabled "Groundwater Recharge Estimation Model (WE-GREM)"**

Ms. Suman Gurjar (PI) demonstrated the Web Enabled "Groundwater Recharge Estimation Model (WE-GREM)" and explained about objective, methodology and scope of the project. Dr. Reddy enquired about the data requirement for the model and also suggested to validate the model with other methods. In reply to his query, Dr N. C Ghosh (Co-PI) answered that it has validated with the observed field data. In reply to Working Group Members's query about the applicability of the model, Dr Ghosh said this model has been developed for estimating groundwater recharge from surface waterbody. It was informed that it would first made available online and on the basis of feedback from the users it would further be enhanced.

Project Ref. Code: NIH/GWD/NIH/16-17: **Groundwater fluctuations and conductivity monitoring in Punjab**

Dr. Gopal Krishan (PI) presented the objectives, methodology and future plans of the study. Dr. R.D. Deshpande (PRL, Ahmedabad) suggested to change/modify the objectives. Dr. D.V. Reddy (NGRI) suggested to plot conductivity, water level and rainfall together Dr. D.V. Reddy (NGRI) enquired about how data would be helpful for the whole study area. On this Dr. N.C. Ghosh replied that the baseline data has already been generated and these will help in conceptualizing the groundwater modeling aspect.

The work program of the division for the year 2015-16, as recommended by the Working Group, is given at Appendix-I.

Appendix-I

WORK PROGRAM OF GROUND WATER HYDROLOGY DIVISION FOR THE YEAR 2015-16

S. No.	Project	Project Team	Duration & Status	Funding Source
1. NIH/GWD/NIH/ 15-18	Development of Website and e-Portal on "Mitigation and Remedy of Arsenic Menace in India"	C.P. Kumar (PI), Anupma Sharma, Suman Gurjar, Sanjay Mittal	3 years (04/15 – 3/18) **Status**: **In progress**.	Internal Funding.
2. NIH/GWD/NIH/	Management of Water Resources for Quantity and	Anupma Sharma (PI) N. C. Ghosh	3 years	Internal Funding.

14-17	Quality in Yamuna-Hindon Inter-basin	Groundwater Hydrology Division in association with Prof. Deepak Kashyap, IIT Roorkee, as Technical Consultant	(December, 2014 –Nov., 2017) Status: **In progress**.	
3. NIH/GWD/NIH/ 15-16	Alternate water supply management strategies in arsenic affected/ vulnerable areas: Mapping of Arsenic affected zones/regions in Eastern U.P	Sumant Kumar (PI) N.C. Ghosh, Rajesh Singh, R.P. Singh, Suman Gurjar, S.L. Srivastava, Anju Choudhary	1 year (04/15 – 3/16) **Status: In progress.**	Internal Funding.
Proposed New Study				
4. NIH/GWD/NIH/ 15-18	**Peya Jal Suraksha -** Development of Six Pilot Riverbank Filtration Demonstrating Schemes in Different Hydrogeological Settings for Sustainable Drinking Water Supply.	N.C. Ghosh (Project Coord. & Leader) C.P. Kumar, B. Chakraborty, Y.R.S. Rao, Anupma Sharma, Surjeet Singh, Sumant Kumar, Suman Gurjar, S.P. Indwar, R.P. Singh, Anju Choudhary, Sanjay Mittal, Ram Chandar, Staff SW Lab	2.5 year (11/15 – 4/18) **Status: New.**	Sponsored by MoWR, RD & GR under Plan Fund.
5. NIH/GWD/NIH/ 15-16	Web Enabled "Groundwater Recharge Estimation Model (WE-GREM) ".	Suman Gurjar (PI), N.C. Ghosh, Sumant Kumar, Surjeet Singh, Anupma Sharma	1 year (08/15 – 3/16) **Status: New.**	Internal Funding.
6. NIH/GWD/NIH/ 16-17	Groundwater fluctuations and conductivity monitoring in Punjab.	Gopal Krishan (PI), N.C. Ghosh, Surjeet Singh, Dan Lapworth (PI from UK) Alan MacDonald (Project Coordinator)	1 year (01/16 – 12/17) **Status: New.**	Sponsored by BGS, UK.

HYDROLOGICAL INVESTIGATIONS DIVISION

Dr. Sudhir Kumar, Scientist G and Head, presented an overview and progress of studies and activities carried out by the Hydrological Investigations Division during the year 2015-16. He informed that out of 7 internal R&D studies approved for the year 2015-16, 2 studies have been completed. Out of the 5 sponsored studies, one study on sponsored by IAEA has been successfully completed, while 3 studies are being continued, and one has not been started as the sanction of the project is awaited from DST. He further informed that the scientists of the division have also completed 3 consultancy projects. During the last 8 months, 8 new consultancy projects have been started by the Division. The division has also completed one training programs and published more than 30 papers in Journals and conferences.

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

INTERNAL STUDIES:

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

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

Dr. Sudhir Kumar (PI) informed that progress of the work done upto March, 2015 was presented in the last meeting wherein it was informed that analysis of the noble gases for 12 samples has been completed from IAEA Vienna and that the results indicated a good correlation between the age of groundwater with built up of He in the groundwater.

He further informed that the remaining samples from Haryana side have been collected and have been sent to IAEA Vienna for analysis. As the analysis process is delayed, the results are expected by the end of December 2015.

Keeping in view the delay in analysis, the PI requested to extend the study till 31 March 2016.

Working group noted the progress of the work done under the study and extended the study till 31st March, 2016.

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

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

Sh. S. K. Verma, the principal investigator of the study, presented the study before the members of the WG meeting. He mentioned about the objectives of the study along with the location of study area, brief methodology, action plan, achievement so far received for the study etc. He also mentioned that there were no comments or suggestions raised during the last working group meeting i.e. 42nd meeting of working group held during 19-20 March, 2015.

While discussing the progress of the study, he informed that 1st objective of the study has been achieved. The groundwater samples collected from intermediate/deep tube wells from 7 districts located in the study area have been analysed for radon concentration. The radon concentrations monitored in these districts were found within the maximum permissible limit for drinking water as per the guide lines of WHO. Sh. Verma further informed that 2nd objective of the study has been achieved partially as the analysis of environmental tritium in 15 groundwater samples which were collected during the latest field trip is in progress to identify the location of old groundwater.

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

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

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

Dr M. S. Rao as a PI of the study informed that due to release of the budget in November, 2015, the project could only be initiated from the last week of November, 2015. A field work to east-coast of India from Bakkhali in West Bengal to Puri in Odisha state was conducted in the last week of November, 2015. Total 45 seawater and groundwater samples together were collected along10 cross sections. Field parameters EC, Temp, pH and dissolved radon were measured at the time of sampling. Out of 10 cross sections only at two sites (at Noagarh and a site near Chandipur beach in Odisha) groundwater was observed saline otherwise, at all sites even at locations within 200 meters from sea the groundwater was found within salinity value of 1500 mS/cm. Along all the cross sections, radon was observed to decrease towards the coast. The deep sea water collected from Puri coast was having salinity 39mS/cm. The collected samples were brought to laboratory at NIH for further analysis. He also informed that the next field work to southern stretch of Puri will be conducted during Jan-Mar 2016. The working group noted the progress of the study. No comments were received.

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

Title of the Study: Isotopic investigation of benchmark Himalayan glaciers

Dr M. S. Rao, PI of the project informed that due to delay in release of funds, the work was mainly relied on the glacial core and snow melt samples extended to NIH by Prof. AL Ramanathan, JNU, New Delhi who is also a member of the study group. The collected samples were from Chhota Shigri glacier. Due to unavailability of long corer, only 4m glacial core could be raised for the analysis. The samples received at NIH are getting processed for isotopic analysis. Dr Rao informed that for systematic study to achieve objectives of the project a corer to raise glacial core of size 10 m, insulation box to transport the core to laboratory without the core getting melted and glacial preservation unit may be required Based on analysis of Chhota Shigri glacial samples, the 1st interim report will be submitted. The working group noted the progress of the study. No comments were received.

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

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

Dr. Sudhir Kumar briefed about the study and informed that the study was undertaken with the objectives to assess the presence of radon in groundwater in Haridwar district. He informed that the study has been completed and final report shall be submitted soon.

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

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

Dr. Khobragade, PI, presented the progress made under the study. He informed that the water quality sampling of the lake was carried out during the month of July 2105 and presented the analysis. It informed that, in genera,l the lake water quality of Rewalsar Lake is good, indicating absence of organic pollution. This according to him could be due the dilution effect caused by the water received from the rain as direct fall over the lake, as the sampling was done during monsoon. However, keeping in view the death of fish reported for the lake during summer, he informed that sampling shall be carried out during winter and summer months also, to analyse the seasonal variation and also informed that heavy metals shall also be considered for analysis in future sampling. He also presented the analysis of the isotopic investigations and caesium dating of sediment. It was informed that the rate of sedimentation for the Rewalsar lake as per caesium-137 dating techniques comes out to be 0.82 cm/year.

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

7. _PROJECT REFERENCE CODE: NIH/HID/INT/2015-18/1_

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

The progress of the study was presented by Dr. S. D. Khobragade, PI of the study. He presented the variation in daily water levels of the lake for the post monsoon period of 2011-2014 and informed that the variation is due to variation in seepage losses, which in turn depends upon the water level reached by the lake at the end of the monsoon season. He informed that, based on water balance, the seepage losses from the lake are 10-40% of the total losses from the lake. He also presented water quality data such as temperature, pH, EC etc of the lake water and the two piezometers upstream and downstream of the lake, which also indicate seepage losses from the lake. He further informed that daily water level of the lake and the two piezometers is being monitored for further detailed analysis. The data collected during the period of July, 2015 to October, 2015 was presented and it was observed that long term data shall be needed for further detailed analysis of seepage problem. Seepage rates obtained from analysis of water balance of post monsoon months for the period of 2011-2014 were also presented and discussed.

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

SPONSORED PROJECTS:

8. _PROJECT REFERENCE CODE: NIH/HID/MOES/2012-15_

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

Dr. S. P. Rai presented the study. Based on results of stable (δ^2H and $\delta^{18}O$) and radio-isotope (δ^3H) and hydrogeological data, Dr. S. P. Rai presented the progress study. The main highlights of the presentation were the identification of recharge source of the shallow and deeper groundwater aquifer. On a query from Dr. R. D. Deshpande, Dr. S. P. Rai informed about status of groundwater dating using ^{14}C. Mr. Arya asked about the possibilities of recharge from the snow and glacier, Dr. Rai informed that isotopic signature reveals that source of recharges to groundwater through local rain and canal networks upto sampling depth.

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

Title of the Study: The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India

The study was presented by Dr. M. S. Rao, Sc-D and PI of the project. He informed that the study has been completed and the results were presented in the final review meeting held at IAEA, Vienna, Austria and also that the final report of the study in the format provided by the funding agency will be submitted before the end of December, 2015. He told that as per the objectives of the project, extent of and distribution of groundwater exploitation in the Bist Doab region has been examined. Response delay between monsoon and recharge pick-up in deep aquifer is investigated, causes (transpiration, climate, direct withdrawal etc) resulting into groundwater depletion have been examined, isotopic characteristic of rainwater (LMWL), reservoir water, river waters and groundwater were developed to understand interconnectivity between shallow and deep aquifers and to map the surface & groundwater interaction zones and river interaction with groundwater in shallow & deep aquifer is examined for the purpose of augmentation of the falling groundwater levels. All the objectives of the project have been accomplished and the project is successfully completed. The working group noted the progress of the project. No comments were received.

10. *PROJECT REFERENCE CODE: NIH/HID/IAEA-2/2012-15*

Title of the Study: **Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques**

Dr. S. P. Rai presented the progress of the study. The results of the isotopes were presented in detail along with details of hydrogeological conditions. Dr. Rai also presented findings of surface water groundwater interaction, spatial variation of baseflow contribution to river in the study area. He further explained about the recharge source and zones of the groundwater in the study area.

The working group noted the progress of the study and appreciated the progress of the study.

11. *PROJECT REFERENCE CODE: NIH/HID/IAEA-3/2013-15*

Title of the Study : Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains

Dr. Sudhir Kumar (PI) informed that progress of the work done. He further informed that the remaining samples from Haryana side have been collected and sent to IAEA Vienna for analysis. As the analysis process is delayed, the results are expected by the end of December 2015. The IAEA has extended the project by a period of 9 months, i.e. upto 9th March, 2016.

Working group noted the progress of the work done under the study and extended the study till 9th March, 2016.

12. *PROJECT REFERENCE CODE:*

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

Dr. Sudhir Kumar informed that this study is being proposed under the NMSHE project which is under the process of finalization by the Institute as a sponsored project by DST. The study would be started once the project is approved.

WORK PROGRAMME OF THE HYDROLOGICAL INVESTIGATIONS DIVISION FOR THE YEAR 2015-2016

S. No.	Study	Team	Duration/ Status
INTERNAL STUDIES			
1.	Isotopic Studies for the Identification of Different Aquifer Groups and their Dynamics in Upper Yamuna River Plains	Sudhir Kumar (PI); C K Jain; SP Rai; SD Khobragade; P. K. Garg; CGWB, Lucknow & Chandigarh)	2 years (07/13-06/15) Continuing Study
2.	Estimation of Radon Concentration in Waters and Identification of Paleo-groundwater in Part of Punjab Located in Satluj River Basin using Isotopes	S. K. Verma (PI) S. P. Rai (Co-PI) M. S. Rao C. P. Kumar Mohar Singh	2 years (10/13-09/15) Completed
3.	Interaction between groundwater and seawater along the northern part of east coast of India	M. S. Rao (PI), Sudhir Kumar Pankaj Garg	2 years (01/15 - 12/16) Continuing Study
4.	Isotopic investigation of benchmark Himalayan glaciers.	M. S. Rao (PI) S.P. Rai, Sudhir Kumar Pankaj Garg	2 years (01/15 - 12/16) Continuing Study
5.	Assessment of dissolved radon concentration for groundwater investigations in Haridwar district	Pankaj Garg (PI) Sudhir Kumar, M. Someshwar Rao	1 year (01/15 – 12/15) Completed
6.	Status Report on Rewalsar Lake, Himachal Pradesh	SD Khobragade (PI) Sudhir Kumar, C. K. Jain	1 year (04/15 – 03/16) New Study
7.	Lake-Groundwater Interaction Studies for Sukhna Lake, Chandigarh	SD Khobragade (PI); Sudhir Kumar; Senthil Kumar; Pankaj Garg	3 year (04/15 – 03/18) Continuing
SPONSORED PROJECTS			
8.	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates	S. P. Rai (PI); M. S. Rao; Surjeet Singh; S. K. Verma; C. P. Kumar; Sudhir Kumar	3 years (06/12-03/16) Continuing Study
9.	The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India	M. S. Rao (PI) C. P. Kumar S. P. Rai	3 years (09/12-12/15) Continuing Study
10.	Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques	S. P. Rai (PI) R. V. Kale M. S. Rao C. P. Kumar Sudhir Kumar	3 years (10/12-04/16) Continuing Study
11.	Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains	Sudhir Kumar (PI); S. P. Rai; S. D. Khobragade; C. K. Jain; P. K. Garg	2 years (05/13-03/16) Continuing Study

S. No.	Study	Team	Duration/ Status
12	Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques	S. P. Rai (PI); Sudhir Kumar; Rajesh Singh; S. D. Khobragade; M. Arora; Dr. R. J. Thayyen; Sh. P. K. Garg	*To be under taken under NMSHE project*

CONSULTANCY PROJECTS

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

SURFACE WATER HYDROLOGY DIVISION

Dr. Rakesh Kumar, Head, Surface Water Hydrology Division gave a brief overview of the various scientific and other technical activities carried out by the Division after the previous meeting of the Working Group. Thereafter, the Scientists of the Surface Water Hydrology Division presented the progress achieved in carrying out the various studies as mentioned below.

Work Programme of Surface Water Hydrology Division for the Year 2015-16

S.No. & Ref. Code	Title	Study Group	Duration
1. NIH/SWD/NIH/12-15	Sedimentation Studies for Pong Reservoir, Himachal Pradesh	A. R. Senthil kumar Manohar Arora Suhas D Khobragade Avinash Agarwal Sanjay Jain	3½ years (April 2012 to September 2015)
2. NIH/SWD/NIH/13-15	Application of DSS (P) for Integrated Water Resources Development & Management	A.K. Lohani Surjeet Singh Rahul Jaiswal D.K. Sonkusale Akilesh Verma	2¼ years (April 2013 to June 2015)
3. NIH/SWD/NIH/13-16	Quantitative assessment of uncertainties in river discharge estimation	Sanjay Kumar Sharad Jain	3 years (April 2013 to March 2016)
4. NIH/SWD/NIH/13-16	Evaluation and modeling of hydrological support system for watersheds of Garhwal, Uttarakhand hills.	Avinash Agarwal Manohar Arora R.K. Nema	3 years (November 2013 to October 2016)
5. NIH/SWD/NIH/14-15	Estimation of Water Balance for Integrated Water Resources Management in Yerrakalva Pilot Basin, A.P.	J.V.Tyagi Y.R.S. Rao,	2 years (April 2014 to March 2016)
6. NIH/SWD/NIH/14-17	Hydrological modeling of Brahmani Baitarani River basin using eWater Source plantform	J.P. Patra Rakesh Kumar Pankaj Mani	3 years (April 2014 to March 2017)
7. NIH/SWD/NIH/14-17	Study of Rainfall Patterns and Comparison of Rainfall Data from different Sources for Uttarakhand State	Archana Sarkar Vaibhav Garg, Sc C, IIRS, Dehradun Rakesh Kumar N.K. Bhatnagar	3 years (April 2014 to March 2017)
8. NIH/SWD/NIH/14-17	Monitoring and modelling of streamflow for the Gangotri Glacier	Manohar Arora Rakesh Kumar	3 years (May 2014 to March 2017)
9. NIH/SWD/NIH/14-17	Effect of climate change on evaporation at point scale	Digambar Singh A. R. Senthil kumar Manohar Arora	3 years (June 2014 to March 2017)
10. NIH/SWD/NIH/15-18	Generalization and parameter estimation of GEV distribution for flood analysis specific application in Indian data	S.K. Singh	1 year (April 2015 to March 2016)
11.	Analytical Solution for Meeting of two	S.K. Singh	1 Year

NIH/SWD/NIH/15-16	surges or bores		(April 2015 to April 2016)
12. NIH/SWD/NIH/15-18	Flood and Sediment studies in Himalayan basin using MIKE-11 Model	A.K. Lohani S.K. Jain	3 years (April 2015 to March 2018)
13. NIH/SWD/NIH/15-18	Snowmelt Runoff Modelling and Study of the Impact of Climate Change in Sharda River Basin	Achana Sarkar T. Thomas Vaibhav Garg	3 years (April 2015 to March 2018)
14. NIH/SWD/NIH/15-18	Study on effect of climate change on sediment yield to Pong reservoir	A. R. Senthil Kumar J. V. Tyagi Avinash Agarwal Suhas Khobragade Manohar Arora	3 years (April 2015 to March 2018)
15. NIH/SWD/NIH/12-15	Study of regional drought characteristics and long term changes in supplemental irrigation water requirement in Seonath Basin in Chattisgarh	R.P. Pandey Rakesh Kumar	3 years (April 2012 to March 2015)
New Study			
16. NIH/SWD/NIH/15-17	Effect of Changing Global Tropospheric Temprature on Asia-Pacific Mansoon Circulation and rainfall fields acrss the India	Ashwini Ranade	2 years (October 2015 to March 2017)

S.N.	Title of Project/Study, Study Group, Start/ Completion Dates	Status and Recommendations/Suggestions
1.	Sedimentation Studies for Pong Reservoir, Himachal Pradesh **Study Group:** A. R. Senthil kumar Manohar Arora Suhas D Khobragade Avinash Agarwal and Sanjay Jain DOS: April 2012 DOC: September 2015	Dr. A. R. Senthil Kumar, PI of the project, presented the objectives, methodology and results of the study. The PI presented the development of sediment yield model for pong dam using ANN and the simulation of sediment yield for future 25, 50, 75 and 100 years using the generated series of rainfall and flow volume. The PI presented the results of the computation of unit weight of sediment, consolidated unit weight of sediment, trap efficiency of the reservoir, consolidated sediment volume and loss of reservoir capacity for future 25, 50, 75 and 100 years by different methods such as particle size distribution of suspended sediment concentration, porosity of the settled sediment, hydrographic survey and frequency analysis. The PI presented the computation of elevation-area-capacity table for the consolidated sediment volumes computed by different methods. The PI presented the results of sediment yield computed from dependable series of rainfall and flow volume and ANN ensembles. Dr. R. D. Deshpande, Scientist F, PRL, Ahmadabad inquired about the possibility of verification of the predicted elevation-area-capacity table. The PI replied that the whole computation was based on the historical data of rainfall, flow volume and sediment yield and the assumption of the present sediment generation process would continue for the prediction period. the elevation-area-capacity computation based on the historical was verified by the hydrographic survey conducted by BBMB. Shri Ritesh Arya, Dehradun suggested to consider the man made effect in the simulation of sediment yield. The PI Replied that the observed data of sediment yield used for the development of the model considers the man effect of sediment generation.
2.	Application of DSS (P) for Integrated Water Resources Development & Management **Study Group:** A.K. Lohani Surjeet Singh Rahul Jaiswal D.K. Sonkusale Akilesh Verma DOS: April 2013 DOC: June 2015	Dr. Surjeet Singh mentioned that the DSS(P) software which was developed under HP-II is being applied for Arpa basin of Seonath river basin to demonstrate the capabilities of the DSS(P) model. Dr. Surjeet Singh mentioned that the various data have been collected from Chhattisgarh for the application of DSS(P) software. Dr Surjeet Singh further mentioned that the collected data have been computerized and a NAM rainfall-runoff model has been setup in Mike basin and Mike-11 RR. He further mentioned that the cropping pattern data is still awaited from the Water Resources Department, Chhattisgarh. After getting these data the DSS model will be applied for the selected basin.

3.	Quantitative assessment of uncertainties in river discharge estimation **Study Group:** Sanjay Kumar Sharad Jain DOS: April 2013 DOC: March 2016	Dr. Sanjay Kumar presented the study on "Quantitative assessment of uncertainties in river discharge estimation". He explained the background and objectives of the study and informed that study is a part of the systemic review of uncertainty clause of the ISO 9123 document. He explained the methodology based on ISO documents GUM (Guide to the expression of uncertainty in measurement), HUG (Hydrometric uncertainty guidance) and presented the progress of the study. He informed that the review comments received on the working draft of ISO 9123 were discussed in the ISO meeting held during May 2015 in Tokyo. He mentioned that, based on the discussions in the Tokyo meeting, all the comments and suggestions from member countries were incorporated in the working draft. The updated draft (DIS) has been submitted to BIS/ISO for uploading on ISO website for further comments from member countries. After the presentation, Chairman suggested that the draft ISO document may be presented in the WG meeting after its finalization. There were no comments from other members.
4.	Evaluation and modeling of hydrological support system for watersheds of Garhwal, Uttarakhand hills **Study Group:** Avinash Agarwal, Manohar Arora R.K. Nema DOS: November 2013 DOC: October 2016	Dr. Manohar Arora presented the progress of the study. He informed the experts that the PI of the study is superannuating in the month of May 2016. The major objectives of the study have been achieved and the remaining period will be used for the final submission of the report and papers. The results included for two watersheds in the Himalayas and the recommendations of the study will be forwarded to the stakeholders.
5.	Estimation of Water Balance for Integrated Water Resources Management in Yerrakalva Pilot Basin, A.P. **Study Group:** J.V.Tyagi Y.R.S. Rao DOS: April 2014 DOC: March 2016	Shri J.P. Patra presented the progress made in carrying out the study. He explained that the objectives of the study are: (i) to calibrate and validate SWAT model for Yerrakalva pilot basin, and (ii) to compute water balance components of the hydrologic cycle for the basin. Shri Patra mentioned that SWAT is one of the most recent models developed by the USDA and it is being used to analyze and quantify the water balance of the Yerrakalva river basin. It is an integrated river basin scale, physically based, continuous-time, long-term simulation, distributed watershed model. Also, its suitability to different parts of the world has been well established. The SWAT model uses physically based inputs such as weather variables, soil properties, topography, land use characteristics and land-management practices occurring in the catchment. The hydrologic cycle as simulated by SWAT is based on the water balance equation. Model outputs all water balance components (surface runoff, evaporation, lateral

		flow, recharge, percolation, sediment yield, etc.) at the level of each watershed and are available at daily, monthly or annual time steps. It was presented that the daily rainfall data of the study area have been collected. Soil samples have been collected from the field and analyzed in the lab for determination of soil texture. Spatial maps viz. DEM, soil map and land use map have been prepared for the study area. Preparation of attribute data for the SWAT model is completed. Model set up for the study basin is completed. Extension for six months i.e. up to March 2016 is required was requested for completing the study.
6.	Hydrological modeling of Brahmani Baitarani River basin using eWater Source plantform **Study Group:** J.P. Patra Rakesh Kumar Pankaj Mani DOS: April 2014 DOC: March 2017	Mr. Jagadish Prasad Patra, PI of the study presented the objectives, brief methodology with progress made during last six months. Various statistical analysis and trend analysis of stream flow data were presented. The catchment model setups in eWater source for the Baitrani basin was presented with preliminary calibration results and inter comparison of various objective functions and optimization methods. The members enquired about the different rainfall inputs to be used in the rainfall–runoff simulation. It was informed that presently the model is being calibrated with .25° grid daily rainfall data of IMD. It was also informed that the station rainfall will also be use in the model, but it is has may data gaps. There were no specific comments from the members.
7.	Study of Rainfall Patterns and Comparison of Rainfall Data from different Sources for Uttarakhand State **Study Group:** Archana Sarkar Vaibhav Garg, Sc C, IIRS, Dehradun Rakesh Kumar N.K. Bhatnagar DOS: April 2014 DOC: March 2017	Mrs. Archana Sarkar, PI of the study presented the background, objectives, methodology and expected deliverables of the new study. Mrs Sarkar informed that the study area is the Uttarakhand State, often referred to as the "Land of the Gods" due to the many holy Hindu temples and pilgrimage centres found throughout the state which observed a massive flood disaster in June 2013. Mrs. Sarkar informed the house that a good knowledge of local rainfall-regime is crucial for planning and management of domestic, urban as well as industrial water use, irrigation and crop practices besides forecasting and management of extreme events like floods and droughts. She further informed that in view of the recent flood disaster in the Uttarakhand state, it becomes all the more important to carry out a scientific analysis of the rainfall regime of the region. Mrs. Sarkar also informed that a comparative accuracy assessment of various data sources of rainfall viz, Rain gauges, satellite sensors (TRMM), and high resolution gridded re-analysis rainfall (APHRODITE) is of prime importance as the rainfall data from these data sources are further provided to hydrological models to produce forecasts. Mrs. Sarkar presented the progress of the study with results of trend analysis of historical rainfall data (annual, seasonal and monthly) as well as number of rainfall events of various intensity (annual and monsoon) by parametric and non-

		parametric methods for ten rainfall stations (grid centres) five each in Kumoan and Garhwal regions using IMD gridded rainfall data of 113 years (1901 to 2013). Mrs Sarkar informed about the further work that will be carried out for rainfall comparison for different sources if rainfall. Working group members noted the progress of the study as well as appreciated the work.
8.	Monitoring and modelling of Gangotri Glacier melt runoff and simulation of streamflow under different climatic scenarios **Study Group:** Manohar Arora Rakesh Kumar DOS: May 2014 DOC: March 2017	Dr Manohar Arora presented the progress of the study. He informed the house that the data collected for the ablation period of 2015 has been analyzed and the results were presented. He informed the house that the total volume of water from the glacier for the entire melt season was 882 MCM with the date of peak discharge on 7th August 2015. The GCM future scenarios were also presented before the experts. Dr Ritesh Arya wanted to know whether the paleo records of recession were being analysed. In its response it was informed that this project is a part of Integrated Study of Gangotri Glacier and NIH has the responsibility of hydrological study only. The paleo records are being analysed by JNU and the results are submitted to DST.
9.	Effect of climate change on evaporation at point scale **Study Group:** Digambar Singh A. R. Senthil kumar Manohar Arora DOS: June 2014 DOC: March 2017	Shri Digambar Singh, PI of the study, presented the objectives, methodology and progress of the study from April 2015 to November 2015. The PI explained the computation of evaporation by different methods such as Meyer, Penman and empirical equation and evapotranspiration using Hargreaves method. The PI presented the deviation of evaporation from the mean by different methods for winter, pre monsoon, and monsoon and post monsoon periods. The trend of evaporation computed by different methods was also presented. Dr. N B N Prasad, Executive Director, CWRDM, Kunnamangalm suggested to see the correlation of evaporation with wind velocity and radiation data and conclusion of trend of evaporation could be drawn based on that. Dr. S K Baratarya suggested to check the computed evaporation with the observed data nearby monitored by IMD or other organizations. Dr. R. D. Deshpande inquired about the reason for the decreasing trend of evaporation. The PI Replied that it is because of new built up buildings nearby the observatory.
10.	Generalization and parameter estimation of GEV distribution for flood analysis specific application in Indian data **Study Group:** S.K. Singh DOS: April 2015 DOS: March 2016	Dr. S. K. Singh presented the study highlighting the intended objectives of the study. The GEV distribution as is widely used has two different forms (Type 2 and Type 3) as used in flood frequency analysis. The mathematical unification of Type-2 and Type-3 GEV distribution, which are respectively used for analyses of high flow and low flow, is complete. Its testing on few widely used data sets along with the development of both a simple and optimization method for the estimation of its parameters is in progress. Dr. Perumal inquired about the advantages of the unification in terms of using this unified one vis-à-vis using

		GEV-2 and GEV-3 in isolation for the analyzing high flows, and low flows, respectively. Dr. Singh informed that the unification gives the physical uniqueness and a better interpretation of the parameters in case of the respective analyses of high flows and low flows, as these pertains to the same unified distribution. In principle, when we united two equations by a single equation, the work quanta, however the specific advantages would be brought out after the testing part. The chairman suggested to present the results of testing in the next Working- group and opined that this study would be a very good one if the unification is justified and workable. Dr S. K. Singh proposed to have a separate new study of one year duration covering the multiple- application of developments in this study to extensive Indian data-set available/collected at NIH and CWC, with commencing the study in Dec 2015 and collecting the data till March 2016 then completing the application-part and the report by March 2017.
11.	Analytical Solution for Meeting of two surges or bores **Study Group:** S.K. Singh DOS: April 2015 DOC: April 2016	Dr. S. K. Singh presented the study highlighting the intended objectives of the study as developing analytical equations/solutions in case two surges or bores in rectangular channel intersection from opposite direction, avoiding the currently used iterative solution, with a systematic treatment of surges. An abrupt change in discharge or depth of flow causes a surge or bore in channels. This abrupt change may be due to a sudden opening or closure of gate, part-blockage of a channel due to landslide or tidal effect. The mathematical development for the analytical approach is complete and the testing of the solution on the published data-sets is in progress. There was no suggestion from the members at this stage.
12.	Flood and Sediment studies in Himalayan basin using MIKE-11 Model **Study Group:** A.K. Lohani Sanjay K. Jain DOS: April 2015 DOC: March 2018	Dr. Rakesh Kumar explained that the objectives of the study are: (i) to model the floods generated due to cloud burst events, (ii) to develop discharge-sediment relationship, and (iii) to assess sediment dynamics in the river system. The methodology of the study includes: (i) analysis of available precipitation data for different return period for the identified sub basin, (ii) historical study of cloud bursts in the Himalayan Region, (iii) study of phenomenon of cloud bursts, (iv) quantification of cloud burst phenomenon into flood hydrograph at the critical section in the river stream, (v) flood routing of cloud burst flood and (v) development of MIKE-11 based sediment model to assess the sediment dynamics of the river system. It was also mentioned collection of data/ information related to cloud burst and sediment is in progress. Central and State organizations working in the area have been contacted for the required data/ information. Model for flood modeling is being setup for the hypothetical cases

		and the study is under progress.
13.	Snowmelt Runoff Modelling and Study of the Impact of Climate Change in Sharda River Basin **Study Group:** Achana Sarkar T. Thomas Vaibhav Garg DOS: April 2015 DOC: March 2018	Mrs Archana Sarkar, PI of the study presented the background, objectives, methodology and expected outcomes of the study. Mrs Sarkar informed the house that the National Action Plan for Climate Change has launched 8 missions including National Water Mission. The Prime Minister's Council on Climate Change, in its first meeting decided that MoWR should initiate studies for major rivers whose waters come from snow melt. Accordingly, MoWR chalked out an Action Plan to take up related studies on Indus, Ganges and Brahmaputra River basins through CWC, NIH and Brahmaputra Board. Mrs Sarkar informed that the Institute has already carried out related studies for the Ganges basins mostly in the Garhwal Himalayas but the proposed study would be the first one for the Kumaon Himalayan River basin. Mrs Sarkar told that rainfall data collected for the Sharda River basin in a previous study would be utilized in addition to other procured data during study. Degree day approach along with soft computing would be followed for hydrological modeling including snowmelt runoff modelling. Various scenarios of precipitation and temperature would be considered to study the impact of climate change on the hydrological regime of the study basin using GCM outputs. Mrs. Sarkar presented the progress of the study with results showing various basin maps (drainage, DEM etc). She also informed about the snow cover maps being prepared using the MODIS data. Mrs. Sarkar informed that technical reports would be prepared after every year of the study. Working group members noted the progress of the study.
14.	Study on effect of climate change on sediment yield to Pong reservoir **Study Group:** A. R. Senthil Kumar J. V. Tyagi Avinash Agarwal Suhas Khobragade Manohar Arora DOS: April 2015 DOC: March 2018	Dr. A. R. Senthil kumar, PI of the project, presented the objectives, methodology and the progress made during April 2015 to November 2015. The sediment inflow to Pandoh reservoir located in the upstream of the reservoir is not observed and it is an important input to the SWAT model. The trap efficiencies of Pong and Bhakra reservoir are 97.11 % and 99.34 % respectively. PI presented the possibility of using the average of trap efficiencies of the reservoirs and the sediment yield observed at Manali, downstream of Pandoh reservoir, to compute the inflow of sediment into the reservoir. The PI also informed to the house that he would like to change the study area from Pong to Tehri if the computation of sediment yield into Pandoh reservoir is not representative of the reservoir.
15.	Study of regional drought characteristics and long term changes in supplemental irrigation water requirement in Seonath Basin in	The Head Surface Water Hydrology Division reported an over view about the progress of studies and subsequently invited Dr R.P. Pandey, PI of the project to make presentation and explain the details of the work done and the progress of study. Dr Pandey presented the complete progress of data collection, analysis and results of various

	Chattisgarh **Study Group:** R.P. Pandey Rakesh Kumar DOS: April 2012 DOC: March 2015	sections of analysis and the work done under this study. He informed that the various parts of Seonath basin faced crop failure and acute water shortages from time to time specially due to drought and failure of monsoon rains. He informed that the Seonath river basin is the longest tributary of the Mahanadi basin draining three districts of Chhattisgarh namely Durg, Rajandgaon and Bilaspur. The drainage area of the Seonath river basin is 30,860 Sq km. which comprises nearly 25% of the upper catchment of the Mahanadi basin. In the presentation the progress of preparation of base Maps, preliminary analysis of the long-term-rainfall variability, trends of annual and seasonal rainfall, temperature, humidity and wind speed were shown to the working group. Dr Pandey informed that the study will be carried out in next two years to achieve the objectives of the study and to determine Long Term Trend in net irrigation requirement and changes in total Irrigation Water Demand (IWD). Also, Dr Pandey presented a brief state of art on the studies conducted in other parts of the world related to the climate change and indicated that any change in meteorological variables adversely affects the crop productivity and thereby the regional economy. This study will yield the quantification of changes in irrigation water demand over past 50 years and projections for the next 50 years. He informed that the progress of the study is satisfactory.
16.	'Effect of Changing Global Tropospheric Temperature on Asia-Pacific monsoon Circulation and Rainfall Fields across India'. **Study Group:** Ashwini Ranade DOS: Oct 2014 DOS: March 2017	Dr. Ashwini Ranade, PI of the project presented the study and explains about the motivation, objectives, dataset and the methodology of the project. She has also presented some of the preliminary results of the study. Dr. R.D. Deshpande asked about the TRMM rainfall data and recommended to use rain gauge data also. PI has informed that the data set is satellite and rain-gauge merged dataset and the data development is such that, the un-gauge areas are filled with satellite observations. He has advised to make more focus on the objectives of the study. Dr. Ritesh Arya well appreciated the approach of the research problem of studying extreme rain events (EREs) using changes in atmospheric general circulation and suggested to study Ladakh and Uttarakhand EREs as a special case. Overall working group has commented positively and express their views regarding the need of such type of study of Monsoon, EREs and Climate Change in NIH.

WATER RESOURCES SYSTEM DIVISION

Dr. Sharad 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. He also informed about the upcoming National Hydrology project (NHP) and National Mission for Sustainable Himalayan Ecosystem (NMSHE), and involvement of different scientists of the division. Following are the comments received from working group on the presentations of the various studies.

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

Dr. M. K. Goel (MKG) presented the progress of the study. He informed that envisaged objectives of the study included modifications in the modeling methodology and development of WINDOWS interface named as **NIH_Basin** (**NIH_Basin Simulation**) of the model. MKG informed that gaining insight and experience from a recently awarded project in the Krishna river basin, a number of further modifications have been made in the model methodology (and the source code) for making it more practicable and realistic. Some of these modifications (which were not envisaged earlier) include:

a) Outlet from hydropower can now join any d/s stream segment or go outside of the basin. The river segment needs to be specified in the hydraulic structure attribute file.
b) GW potential factors are now specified for two conditions – Temporal (GWPFT) which depends on change in GW development with time and Position of current average GW table in the sub-basin (which is computed daily in each sub-basin).
c) Population of cities with known population (say, Pune) within a district are added and compared with the specified population in the district (also within basin and with percent urban concept) and the rest of urban population is then uniformly distributed across various cities (with unknown population) in that district. A few checks are made and if required, city populations are revised or percent urban value is revised.
d) If a city takes water from a river segment, a diversion structure needs to be specified at the end of river segment for diversion of water to the city. So river network file needs to be created after considering the city diversions.
e) Variable name for Initial abstraction parameter Ia in the SCS CN equation (0.3 or 0.1) is specified. It needs to be provided for various soil types and AMC conditions.
f) For the conditions when there is no crop on a grid (say, intermediate period between the Kharif and Rabi season), a landuse characteristic is defined in the crop attribute file for consideration during intermediate period.

Prof M. Perumal expressed that the methodology appears to be quite close to that of VIC model. MKG informed that a number of concepts in the model have been taken from different sources, say CPSP/BHIWA model of ICID, Mike Basin model and DSS of DHI etc. The aim is to integrate and use the huge database available in platforms such as India-WRIS for river basin planning and management. Dr. Sharad K. Jain added that model is planned to serve as a tool for supporting management and policy decisions at basin scale.

PI: Dr. Sanjay K. Jain (SJ), Scientist “G”

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

Dr. Jain presented the objectives and the progress. Three sub-basins of Upper Satluj basin have been taken for this study. He informed that glacier change work has been completed and modelling work is under progress. Dr. Bartarya informed that GSI has studied glaciers in Satluj basin and this can also be reviewed. Dr. Jain informed that for climate scenarios, Dr. A P Dimri, JNU, New Delhi was contacted and results for the study area have been obtained from him. The climate change scenarios are being finalized. Dr. Jain also informed that due to glacier recession, a lake has been formed in one of the glaciers which is continuously expanding over the years. Mr. Ritesh Arya asked when the lake was noticed; Dr Jain said that since the year 2000 the lake is seen and increasing in size. Mr. R K Khanna informed that the Baspa project is coming up in the area. The information was noted down.

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

P K Mishra (PKM) presented the status as well as the progress of the study. He informed that Hydro-meteorological data and Hydrological data have been procured from IMD, Pune, and Central Water Commission, Bhopal respectively. The reservoir inflows data have been collected from Water Resources Department, Bhopal and computerized. Mr. Mishra informed about the Part II of the training on GWAVA Model Setup during June 2015 at Wallingford, UK. All the mandatory input files viz., Physical Parameter files, Water Demand Files and Climate Files in the required format have been completed. The virgin calibration run have been carried out, however some issues are being sorted out with regular interaction with CEH. He also emphasized that presently the model is being run based on the EXE file and the Tutorial exercise given by CEH. Many a times the understanding of the errors/messages that come up during the process of the model run is difficult. These issues has been shared with CEH.

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

In absence of DSR, the progress of the work in the study was presented by Dr Surjeet Singh.

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

A Decision Support System (Planning) was developed under Hydrology Project - II and case studies were done for pilot basins selected for States. In this study further development of applications and interfaces, porting of models to Mike Hydro is being carried out for Upper Bhima basin. Streamflow drought index (SDI) was computed for inflow to catchments and water quality modelling was carried out. Pollutant load was calculated source wise using population (interpolated values for rural, urban: municipal corporation, cumulative value for towns), livestock population and per unit load and total pollutant for agriculture source. Effluent pollutants were considered as diffuse source. Population fraction contributing to untreated sewage was based on pumped and generated sewage. Measured (BOD) and assumed (N, P, E Coli) concentrations and discharges were used in computing effluent pollutant load. Simulation was carried out for year 2006. Simulated and observed (average) values of water quality variables for Daund and Koregaon were matched in calibration. STP Effluent average BOD concentration is nearly 10 and 16 mg/l in Pune and PCMC respectively. The simulated water quality concentrations were compared at Koregaon and Daund stations. Simulated BOD values at Koregaon and Duand were 3 and 6 mg/l and measured values are 6 and 7.3 mg/l. For E Coli values were 200, 100 and 240, 194 MPN/ 100 ml respectively. NO3-N values were 0.6, 1.5 and 0.4, 0.5 respectively. Simulated NH3-N value for Koregaon was 0.2 mg/l. Simulated and observed values of NH3- N for Daund were 1 and 0.4 mg/l respectively. Simulated values of Total- P for Koregaon and Daund were 0.4 and 1.5 mg/l respectively. Observed Average Phosphate-P for Daund was 0.9 mg/l. Dr Ghosh enquired which scenario will be developed in the decision support system. Dr. Singh Singh replied that presently modeling work is in progress and subsequently, scenario will be developed.

PI: D. Chalisgaonkar (DC), Scientist "F"
Mrs. Deepa Chalisgaonkar presented one ongoing study.

1. Development of Ganga Information Portal
DC presented the ongoing study on development of Ganga Information Portal, which is envisaged to provide a unique platform comprising multisource data and information on Ganga basin. The major objective is to develop a knowledge/ information e-portal with detailed information on Ganga basin. GIP is being developed using World Wide Web (WWW) technology in HTML and java script language. The main and drop down menus will allow the user to interact with the system very easily. The information relating to the Ganga will be collected from different sources and will be arranged between the time-spaces, and it will be possible to share, to search, to display, and to output (print) it. Dr Deshpande suggested to include a 'search window' in the system. Dr. Sharad Jain also suggested to have a 'search window' in the main screen. Mrs. Deepa informed that as the data of Ganga basin is restricted, only the information will be provided on the portal with proper references.

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

1. Glaciological studies of Phuche Glacier, Ladakh Range (Completed- Sponsored)
This SERB sponsored project started in January 2010 and was completed in June 2015. RJT presented the completion report and important findings of the project. Generation of five years of summer and winter mass balance data of two glaciers in the cold-arid climate regime for the first time is a major achievements. New insights on huge precipitation gradient and summer mean temperature gradients of 10K/km is also developed in the study. Modeling of Slope environmental lapse rate of temperature (SELR) and summer mass balance is also achieved in the project. It is stated by RJT that the May –June temperature and precipitation is very critical for mass balance response of the studied glacier. R.D Deshpande appreciated the effort made to execute this project and appreciated the new insights generated through this project.

2. Cryospheric system studies and runoff modeling of Ganglass catchment, Leh, Ladakh Range (Ongoing)
This project is aimed to evaluate the catchment scale hydrologic processes of the cold-arid regime. RJT informed about the damage occurred to the new discharge station at Gonpa near Leh by the flood on 5 August 2015. NIH station recorded 44 mm precipitation on 4th August 2015 at South Pullu monitoring station. RJT informed that the discharge measurement at 4700 m a.s.l. and meteorological data collection 3700 m a.s.l. is carried out during the reporting period and analysis is in progress. No specific suggestions were received for this project.

3. Runoff modeling of Shyok River, Karakorum Range (Ongoing)
This project is executed in coordination with border Roads Organisation (BRO) at Km 150 of Durbuk—DBO axis. The project has initiated in January 2015. RJT informed that a MoU is signed with BRO-HIMANK for the successful execution of this project. RJT informed that the Radar Water Level Recorder installed at Km 150 has given water level data of 5 minutes interval for the entire summer melt period. Stream cross section at KM 150 and stream velocity data is also generated with the help of BRO and discharge is calculated. RJT informed that this data set is the first discharge data of the Shyok river and this one data is used by the HIMANK-BRO to fine tune the proposed bridge design at this site. RJT informed that steps for procurement of AWS is in progress. Prof. Perumal enquired about the quality of the velocity data generated as it will impact scour depth estimate. RJT also agreed about the need to

improve the velocity measurement at the site and expected it happen once the collaboration and instrumentation matures at this site. Mr.Khanna from CWC highly appreciated the project and effort of NIH in helping the activities of border roads at the highly important and difficult border areas of the country. No specific suggestions received for this project.

PI: Shri L N Thakural (LNT), Scientist "C"
Shri Thakural presented one ongoing study.

1. Study of Hydrological Changes in selected watersheds in view of Climate Change in India (Ongoing)
LNT presented the background, objectives, methodology and the expected deliverables of the study and informed that 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) in India have been selected. While selecting the watersheds data availability and ease of accessibility to the watersheds were kept in mind. The status of the hydro-meteorological data viz. daily rainfall, daily temperature, discharge and ground water data collected for these river basins was also presented. The drainage network and watershed boundary maps generated for these watersheds using digital elevation model data of SRTM in GIS environment were also presented in the meeting. No specific suggestions were received for this project.

PI: Shri M. K. Nema (MKN), Scientist "C"
Mr. Nema presented one completed study and one ongoing study.

1. Variability of the Hydro-climatic variables in Punjab Plains of lower Satluj (Completed)
The final results of the study were presented by MKN. Dr. RD Deshpande suggested that some more inferences and their implications on agriculture should be drawn from the results and those may be included in the final report.

2. Hydrological Processes and Characterization of Lesser Himalayan Catchments (Ongoing)
MKN presented the progress of the study, which is experimental in nature and requires setting up instruments in the proposed watersheds, which is a time-taking and challenging job particularly in Himalayan conditions. He informed that the stream gauging structure at one stream is almost completed and is underway for another stream. On instruments part, work order for AWS has been placed and tendering process for AWLR is underway. The project team has also identified the location and piece of land for AWS installation.

PI: Dr. P. K. Singh (PKS), Scientist "C"
Dr. Singh presented one new study.

1. Studies on Temporal Variation of Sediment Yield in Hilly Watershed of Upper Ganga Basin, Uttarakhand (New study)
The study aims at estimation of temporal distribution of sediment yield and its total volume on storm basis. The study also explores the impacts of geo-morphological characteristics of basin and soil moisture accounting on temporal distribution of sediment yield. The storm data (runoff & sediment) gauged at Henval watershed (an ideal catchment to be established by WRS division) will be used for the study. Dr. N.C. Ghosh asked about the role soil moisture accounting (SMA) in sediment yield estimation. PKS briefed on the SMA during the presentation. The proposal was approved in its present form.

PI: Shri P. K. Mishra (PKM), Scientist "B"
Study title: Assessing Climate Change Impact across KBK (Kalahandi-Bolangir-Koraput) region of Odisha (Ongoing)

PKM presented the objective-wise progress made in the study since inception as well as during last six months (April '15-December '15). Shri Mishra presented the future rainfall and temperature downscaled from HadCM3 A2 and HadCM3 B2 GCM data utilizing SDSM model for the KBK region. He also presented the water availability and utilization for the Tel basin. He also informed about the completion of preparation of input files to run the Soil and Water Assessment Tool (SWAT) model.

PI: Shri P. K. Agarwal (PKA), Scientist "B"
Study title: Hydrologic Modelling of a part of Satluj Basin using SWAT Model (Ongoing)
The progress of the study was presented by PKA. He informed that informed that the GIS layers required for SWAT model have been prepared. Meteorological data has also been downloaded and preparation of meteorological data base for the model is almost completed. No comments on the study have been received from the members of the working group.

WORK PROGRAMME FOR THE YEAR 2015-2016

SN	Title	Study Team	Duration	Funding (Rs. Lakhs)
	Completed Sponsored/ Internal Studies			
1.	Glaciological studies of Phuche Glacier, Ladakh Range, India	Renoj J. Thayyen M K Goel, S P Rai	5 Years 1/10-06/15	DST (56)
2.	Assessment of Environmental flows for Himalayan River	S. K. Jain, Pradeep Kumar, P. K. Agarwal, P. K. Mishra	1 Year 07/14-11/15	MOES (13.74)
3.	Variability of the Hydro-climatic variables in Punjab Plains of Lower Satluj	M. K. Nema Sharad K. Jain	2 Years (11/13-10/15)	NIH (11.34)
4.	Ganges Aquifer Management for Ecosystems Services (GAMES-IWMI)	Sharad K. Jain; N C Ghosh; Sudhir Kumar; M K Goel; Sanjay K. Jain; Surjeet Singh; Anupama Sharma;	1 year (06/2014-05/2015	IWMI (16.9 lakh)
	Ongoing Internal Studies			
1.	NIH_Basin – A WINDOWS based model for water resources assessment in a river basin	M. K. Goel, Sharad K. Jain, Deepa Chalisgaonkar Prabhash K. Mishra	3 Years (04/13-03/16)	NIH (16)
2.	Assessing climate change impact across KBK region of Odisha	P. K. Mishra, Sharad K. Jain, Sanjay K. Jain	3 Years (04/13-03/16)	NIH (28)
3.	Glacier change and glacier runoff variation in the upper Satluj river basin	Sanjay K. Jain, Sharad K. Jain, Renoj J. Thayyen	2.5 Years (10/13-03/16)	NIH (12)
4.	Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh	Renoj J. Thayyen S. P. Rai, Sanjay K Jain Sudhir Kumar	3 years (04/14-03/17)	NIH (48)
5.	Hydrologic Modelling of a part of Satluj Basin using SWAT Model	P. K. Agarwal, Sharad K. Jain, T. Ahmad, M. K. Goel, Sanjay K. Jain, M.	2 -3/4 Years (06/14-3/17)	NIH (23)

		K. Nema		
6.	Decision Support System for Water Resources Planning in Upper Bhima basin, Maharashtra	D. S. Rathore, M. K. Goel, R.P. Pandey, Sanjay Kumar, Surjeet Singh	2 years (07/14-06/16)	NIH (34)
7.	Modeling of Narmada basin by using the GWAVA model	Sanjay K. Jain, Sharad K. Jain, T. Thomas (RC-Bhopal), P. K. Mishra, P. K. Agarwal, M. K. Nema	2.25 years Dec. 2014 – Mar 2017	NIH
8.	Runoff modeling of Shyok River, Karakorum Range	Renoj J.Thayyen Sanjay K.Jain	3 years 12/14 – 11/17	NIH (38)
9.	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	NIH+
10.	Development of Ganga Information Portal	D. Chalisgaonkar, Sharad K. Jain, D. S. Rathore, Sanjay K. Jain, Sudhir Kumar, P. K. Mishra, P. K. Agarwal, M. K. Nema	3 years (04/15-03/18)	MoWR (65.55)
11.	Study of hydrological changes in selected watersheds in view of climate change in India.	L. N. Thakural, D. S. Rathore, Surjeet Singh, T. Ahmad, Sanjay K. Jain, Sharad K. Jain	3 years (04/15-03/18)	NIH (44.30)
Proposed New Internal Study				
1.	Studies on Temporal Variation of Sediment Yield in Hilly Watershed of Upper Ganga Basin, Uttarakhand	P.K. Singh, Sharad K. Jain Sanjay K. Jain, M. K. Nema	2 Years 01/16-12/17	NIH (8.20)

RESEARCH MANAGEMENT AND OUTREACH DIVISION (RMOD)

S.No.	Title of Project/Study, Study Team	Recommendations/Suggestions
1.	**Study- 1 (RMOD/2015-16/TS-1)** Water conservation and management in Ibrahimpur Masahi village of Hardwar district (Uttarakhand) **Team:** Omkar Singh, V.C. Goyal, C.K. Jain, J.V. Tyagi and Rajesh Singh DOS: April 2013, DOC: March 2016	The study was presented by Er. Omkar Singh (PI). Dr N. B. Narasimha Prasad (CWRDM) inquired about water demand estimation for different uses. The PI has responded to his queries. The WG members have appreciated the efforts to collect the household level base survey data for the preparation of village water conservation plan.
2.	**Study- 2 (RMOD/2015-16/TS-2**) Customization of WEAP model for application in Ur river watershed in Tikamgarh district of Bundelkhand region. **(Under TIFAC Project)** **Team:** R V Kale (PI), T Thomas- RC Bhopal, Jyoti Patil, Rajesh Agarwal DOS: April 2014, DOC: January 2016	The study was presented by Dr. R.V. Kale (PI). The PI has requested permission to extened the study by four months which was accepted by the WG commitee memebrs.
3.	**Study-3 (RMOD/2015-16/TS-3)** WEAP Model set up for four sub-basins under Pilot Basin Studies (PBS) Programme, jointly with the RCs/CFMSs **NIH HQs:** V C Goyal (PBS Leader), Jyoti Patil and R V Kale **Co-investigators from NIH RCs/CFMSs:** Chandramohan T (RC-Belgaum), Y R S Rao (RC-Kakinada), T R Nayak (RC-Bhopal), B Chakravorty (CFMS-Patna) DOS: April 2015, DOC: March 2017	The study was presented by Dr. R.V. Kale. There were no any specific comments in this study.

Dr. V C Goyal thanked the members for their valuable contributions during deliberations in the Working Group meeting.

The meeting ended with vote of thanks to the Chair.

ANNEXURE-I

List of Working Group Members who attended the 43rd WG meeting

1.	Er. R.D. Singh, Director, NIH	Chairman
2.	Dr. S.K. Bartarya, WIHG, Dehradun	Member
3.	Dr. Dinesh Chand, Min.of Drinking Water & Sanitation, New Delhi	Member
4.	Sh. Anurag Khanna, CGWB, Dehradun	Member
5.	Dr. R. D. Deshpande, Sc.SF, PRL, Ahmedabad	Member
6.	Dr. N.B. Narasimha Prasad, Ex. Director, CWRDM. Kozhikode	Member
7.	Dr. D. V. Reddy, CSIR-NGRI, Hyderabad	Member
8.	Dr. G. P. Juyal, CSWCRTI, Dehradun	Member
9.	Dr. S. K. Mittal, CSIR-CSIO, Chandigarh	Member
10.	Dr. V.V. Rao, NRSC, Hyderabad	Member
11.	Er. Niladri Naha, SWID, Kolkata	Member
12.	Dr. Ritesh Arya, Panchkula, Haryana	Member
13.	Er. R.K. Khanna (Retd.) CWC, New Delhi	Member
14.	Dr. M.Perumal, IIT, Roorkee	Member
15.	Er. Rishi Srivastava, CWC, New Delhi	Member
16.	Dr. Sharad K. Jain, Sc. G & Head WRS Division, NIH	Member
17.	Dr. N.C. Ghosh, Sc. G & Head GWH Division, NIH	Member
18.	Dr. Rakesh Kumar, Sc. G & Head SWH Division, NIH	Member
19.	Dr. Sudhir Kumar, Sc. G & Head HI Division, NIH	Member
20.	Dr. V C Goyal, Sc. G & Head, RMO Division, NIH	Member-Secretary

Scientists from National Institute of Hydrology, Roorkee

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

APPENDIX 69.5.2

MINUTES OF 44th MEETING OF THE WORKING GROUP OF NIH

MINUTES OF THE
44TH MEETING OF WORKING GROUP OF NIH
HELD AT NIH, ROORKEE, DURING APRIL 18-19, 2016

The 44th meeting of the Working Group of NIH was held at NIH, Roorkee, during April 18-19, 2016 under the Chairmanship of Director, NIH. The list of the participants of the meeting is given in Annexure-I.

ITEM NO. 44.1: OPENING REMARKS BY THE CHAIRMAN

Er R D Singh, Director, NIH & Chairman, WG welcomed the Working Group members and the Scientists of the Institute. The Chairman informed the house about the additional responsibilities assigned to the Institute by the Ministry of WR, RD & GR. Also, he mentioned that some new projects have been sanctioned to commence in the Institute, namely- NMSHE Project (DST funded), National Hydrology Project (World Bank funded), and the Neeranchal Watershed Project (World Bank funded through DoLR, GoI) is likely to be approved soon.

The Chairman then requested the Member-Secretary to take up the agenda of the meeting.

ITEM No. 44.2: CONFIRMATION OF THE MINUTES OF 43rd MEETING OF THE WORKING GROUP

The 43rd meeting of the Working group was held during December 8-9, 2015. The minutes of the meeting were circulated to all the members and invitees vide letter No. RCMU/WG/NIH-10 dated January 22, 2016. No Comments were received. The members confirmed the Working Group minutes.

ITEM No. 44.3: 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 43rd working group meeting.

ITEM Nos. 44.4 & 44.5: PRESENTATION AND DISCUSSION ON THE STATUS AND PROGRESS OF THE WORK PROGRAMME FOR THE YEAR 2015-16 AND FINALIZATION OF THE WORK PROGRAMME FOR THE YEAR 2016-17.

The Member-Secretary requested the respective Divisional Heads to present the progress of studies carried out during 2015-16 and work programme for the year 2016-17. Accordingly, the progress of various studies and sponsored projects was presented by all Scientific Divisions on their turn during the two day deliberations of the Working Group. The Division wise minutes of each study/project presented during the meeting are given below:

ENVIRONMENTAL HYDROLOGY DIVISION

Progress of Work Programme 2015-16

S.No.	Study	Recommendation / Comments
	Internal Studies	
1.	Water Quality Modelling using Soft Computing Techniques Study Group: Rama Mehta (PI), C. K. Jain, Anju Choudhary Duration: 2 Years (05/14-05/16)	Extension granted for 3 months and report will be submitted by Aug. 2016.
2.	Himalayan River Water Quality Assessment in a Stretch from Gangotri to Haridwar Study Group: Rajesh Singh (PI), C. K. Jain, M. K. Sharma, S. P. Rai, Renoj J. Thayyan, J. P. Patra Duration: 3 Years (07/14-06/17)	Report will be submitted by May 2016 and further work will be Continued under NMSHE Project.
3.	Status Report on Phytoremediation of Wastewater Study Group: Rajesh Singh (PI), C. K. Jain Duration: 6 Months (11/15 – 04/16)	Extension granted for 1 month and report will be submitted by May 2016.
	Sponsored Projects	
1.	Ionic Enrichment Dynamics of Glacial Sediment and Melt water of Gangotri Glacier Study Group: M. K. Sharma (PI), C. K. Jain, Renoj Thayyan, Manohar Arora, Naresh Saini, Jatin Malhotra, Rakesh Goyal, Shyam Lal Duration: 3 Years (04/14-03/17)	No comments
2.	Low Cost Technology for Purification of Arsenic and Microbes Contaminated Water using Nanotechnology Study Group: Vijaya Aggarwala, IITR (PI) Rama Mehta, NIH (Co-PI) Duration: 2 Years (04/14-03/16); Extended granted for 6 months by DST.	No comments

Approved Work Programme for the year 2016-17

S.No.	Study	Remarks
	Internal Study (New)	
1.	Assessment of suitable habitats for the aquatic species of Western Himalayan Streams Study Group: Pradeep Kumar and C. K. Jain Duration: 2 Years (04/16-03/18)	It was decided to change the title to "Development of habitat suitability curves for the aquatic species of Western Himalayan Streams"
	Sponsored Projects (Continuing)	
2.	Ionic Enrichment Dynamics of Glacial Sediment and Melt water of Gangotri Glacier Study Group: M. K. Sharma (PI), C. K. Jain, Renoj Thayyan, Manohar Arora, Naresh Saini, Jatin Malhotra, Rakesh Goyal and Shyam Lal Duration: 3 Years (04/14-03/17)	-
3.	Low Cost Technology for Purification of Arsenic and Microbes Contaminated Water using Nanotechnology Study Group: Vijaya Aggarwala, IITR (PI) Rama Mehta, NIH (Co-PI) Duration: 2 Years (04/14-03/16); Extended for 6 months by DST.	-
	Sponsored Projects (New)	
4.	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) Sponsored by DST under NMSHE Project Cost: 2.25 Crore	-
	Consultancy Projects (Continuing)	
5.	Petroleum Product Contamination at Akolner Village, District Ahmednagar, Maharashtra and Suggesting Remedial Measures Study Group: C. K. Jain (PI), Sudhir Kumar, B. K. Purendra, Anupma Sharma, M. K. Sharma and Rajesh Singh Duration: One Year (10/15 – 09/16) Sponsored by: MPCB, Mumbai Amount: Rs. 54.72 Lacs	-
	Consultancy Projects (New)	

6.	Study on Ash Disposal from Ramagundam STPS and Telangana STPP into Mine Void of Medapalli Open Cast Mines Study Group: C. K. Jain (PI), Sudhir Kumar, Y. R. S. Rao, Anupma Sharma, M. K. Sharma and Pradeep Kumar Duration: 15 months (03/16 – 05/17) Sponsored by: NTPC Amount: Rs. 54.96 Lacs	-

GROUND WATER HYDROLOGY DIVISION

Dr. N. C. Ghosh, Scientist 'G' & Head presented an overview and progress of studies and activities carried out by the division during the period December 2015 to March 2016. While presenting the technical activities carried out by the division and progress made on different studies during last four months, he gave an account of scientific personnel available at the division and the sponsored projects being pursued by the Division. He informed that five in-house R&D studies and one sponsored study approved for the year 2015-16, which are being continued. Five new studies were proposed for the year 2016-17, out of these three were sponsored studies and two were in-house studies.

He also informed that , scientists of the division had published a number of research papers in various journals/conferences and delivered lectures in various training courses during the period and also guided/guiding M.Tech/Ph.D students.

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

1. Project Ref. Code: 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**

Dr. N. C. Ghosh (PI) briefed about the necessity of the study and described about the six demonstration sites to be developed at Laksar (Uttarakhand), Agra and Mathura (Uttar Pradesh), Sahebganj (Jharkhand), Bhojpur (Bihar) and Visakhapatnam (Andhra Pradesh) under the Peya Jal Suraksha Project sponsored by Ministry of Water Resources, River Development and Ganga Rejuvenation, Govt. of India. Dr. Surjeet Singh presented the objectives, mechanism of riverbank filtration (RBF) and the progress of the study made so far for the Agra, Mathura and Laksar sites. The progress for the other three sites at Sahebganj, Bhojpur and Visakhapatnam was reported by Dr. N.C. Ghosh. No comments were received.

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

Dr. N. C. Ghosh informed that the study requires funding from Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR) and also confirmation on ownership of the developed portal by MoWR. Since, no funding and official confirmation were received from the Ministry, the project activities were deferred. The study will be taken up only after getting funds and ownership confirmation from Ministry of Water Resources, River Development and Ganga Rejuvenation.

Since the above study could not be initiated so far due to non-availability of funds and ownership confirmation from MoWR, it would be appropriate that it may not be included in the Work Plan of 2016-17. The study can be included in the work plan later whenever confirmation from MoWR is received.

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

Dr. Anupma Sharma (PI) presented the progress of the study. She informed about the declining groundwater levels in Baghpat, Shamli and Muzaffarnagar districts of the study area. The decline in areas near the Eastern Yamuna Canal was less. Field observations carried out for water level and water quality monitoring as well as soil surveys for estimation of groundwater recharge along Saharanpur, Shamli and Muzaffarnagar district were highlighted. Results of soil texture and soil moisture retention analyses were shown. Suggestions were made about reanalyzing field capacity values for soil samples along the Hindon River Bank.

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

Mr. Sumant Kumar (PI) presented the objectives, progress and future plans of the study. PI seeks extension of 6 months for completion of study and permission was granted. Dr. Bartarya suggested that risk zone mapping can be done based on arsenic concentration in the study area. Director, NIH asked PI to do sampling for all the blocks of Ballia district to prepare Arsenic risk map. WG members enquired about the instrument and its principle for arsenic analysis and same was clarified by PI.

5. Project Ref. Code: NIH/GWD/NIH/15-16: **Web Enabled "Groundwater Recharge Estimation Model (WE-GREM)"**

Ms. Suman Gurjar (PI) demonstrated the completed study on Web Enabled "Groundwater Recharge Estimation Model (WE-GREM)" and explained about objectives, methodology and scope of the project. Working group members appreciated and approved to host it in public domain. They also suggested to publicize it as much as possible.

6. Project Ref. Code: NIH/GWD/NIH/16-17: **Groundwater fluctuations and conductivity monitoring in Punjab**

Dr. Gopal Krishan presented the progress made under the study and presented the future work plans. He also clarified the action taken on the comments of experts made during the 43rd WG meeting. Dr. S.S. Grewal suggested to take the meteorological data from RRSKA, Ballowal Saunkhri and KVK, Kapurthala.

7. Project Ref. Code: NIH/GWD/NIH/16-17: **Baseline data collection and analysis of Mewat district, Haryana**

Dr. Gopal Krishan (PI) presented the background, statement of the problem, objectives, methodology and future plans of the study. Dr. J.V. Tyagi, Sc. G suggested to modify the title. Dr. D.V. Reddy (NGRI) suggested to plot conductivity, water level and rainfall together. Dr. D.V. Reddy (NGRI) and Dr. S.K. Mittal, CSIO, Chandigarh asked about the role of Sehgal Foundation, Gurgaon. Dr. N.C. Ghosh (Head, GWHD) replied that the Sehgal Foundation has motivated NIH to take up the study and will provide the historical data as they are working on Mewat area since last 15 years.

8. Project Ref. Code: NIH/GWD/NMSHE/16-21: **Study of river - aquifer interactions and groundwater potential in the upper Ganga basin up to Dabrani**

Dr. Surjeet Singh (PI) presented the research needs, objectives, future plans and scope of the study. He described about the field visit made during the month of March, 2016 and also the topography, formations type and existing hand pumps in the higher altitudes of the Himalayan basin. No comments were received.

9. Project Ref. Code: NIH/GWD/NIH/16-16: **Web Enabled "Conjunctive Use Model for Management of Surface and Ground Water using concept of MAR and ASR"**

Ms. Suman Gurjar (PI) proposed new study on Web Enabled "Conjunctive Use Model for Management of Surface and Ground Water using concept of MAR and ASR" and explained about objective, methodology and scope of the project. Working group members suggested to merge this with the WEGREM but looking at its scope and after discussions they agreed to make it as the new study and extension of WEGREM. They suggested to host it as Version 2 in public domain.

10. Project Ref. Code: NIH/GWD/NIH/16-16: **Evaluation of Saryu Nahar Pariyojna (SNP) National Project in Uttar Pradesh**

Dr. N. C. Ghosh had informed that MoWR, RD & GR has sponsored the study with timeline of six months starting from March, 2016. Dr. Ghosh gave a brief objective of the study and expected deliverables. He elaborated the results of field visit undertaken during 11-13th April, 2016 along with a team.

11. Project Ref. Code: NIH/GWD/NIH/16-17: ***Country-wide Capacity Building Program on* "Bank Filtration for Sustainable Drinking Water Supply"**

The training course was sponsored by DST, Govt. of India to organize foure training courses with a cost of Rs.36.4 lakhs . Dr. Ghosh informed the objectives and methodologies of the training courses. He informed that first training course shall be organized during the month of September, 2016 and the second course shall be organized during February, 2017. The calendar for the 3rd and 4th training courses shall be decided later on.

The work program of the division for the year 2016-17, as recommended by the Working Group, is given below:

WORK PROGRAM FOR THE YEAR 2016-17

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 (Project Coord. & Leader) C.P. Kumar, B. Chakraborty, Y.R.S. Rao, Anupma Sharma, Surjeet Singh, Sumant Kumar, Suman Gurjar, S.P. Indwar, R.P. Singh, Anju	21/2 year (11/15 – 4/18) **Status: In progress**.	Sponsored by MoWR, RD & GR under Plan Fund.

		Choudhury, Sanjay Mittal, Ram Chandar, Staff SW Lab		
2. NIH/GWD /NIH/14-17	Management of Water Resources for Quantity and Quality in Yamuna-Hindon Inter-basin	Anupma Sharma (PI), N.C. Ghosh (Coordinator), Deepak Kashyap, IITR (Technical Consultant)	3 years (12/14 – 11/17) Status: **In progress**.	Internal Funding.
3. NIH/GWD /NIH/15-16	Alternate water supply management strategies in arsenic affected/ vulnerable areas: Mapping of Arsenic affected zones/regions in Eastern U.P	Sumant Kumar (PI) N.C. Ghosh, Rajesh Singh, R.P. Singh, Suman Gurjar, S.L. Srivastava, Anju Choudhary	1 year (04/15 – 3/16) **Status: In progress.**	Internal Funding.
4. NIH/GWD /NIH/15-16	Web Enabled “Groundwater Recharge Estimation Model (WE-GREM) ”.	Suman Gurjar (PI), N.C. Ghosh, Sumant Kumar, Surjeet Singh, Anupma Sharma	1 year (08/15 – 3/16) **Status: In progress.**	Internal Funding.
5. NIH/GWD /NIH/16-17	Groundwater fluctuations and conductivity monitoring in Punjab.	Gopal Krishan (PI), N.C. Ghosh, Surjeet Singh, Dan Lapworth (PI from UK) Alan MacDonald (Project Coordinator)	1 year (01/16 – 12/17) **Status: In progress.**	NIH in association with BGS, UK
Proposed New Study				
6. NIH/GWD /NIH/16-17	Baseline data collection and analysis of Mewat district, Haryana.	N.C. Ghosh (Project Coordinator), Gopal Krishan (PI), Surjeet Singh, C.P. Kumar, Brijesh Yadav (IITR), Lalit Mohan Sharma (Sehgal Foundation, Gurgaon)	1 year (03/16 – 03/17) **Status: New.**	Internal Funding.
7. NIH/GWD /NMSHE/ 16-21	Study of river - aquifer interactions and groundwater potential in the upper Ganga basin up to Dabrani.	Surjeet Singh (PI), N.C. Ghosh, R. J. Thayyen, S. P. Rai, Manohar Arora, Gopal Krishan,	1 year (03/16 – 02/21) **Status: New.**	Sponsored by DST under NMSHE.
8. NIH/GWD /NIH/16-16	Web Enabled “Conjunctive Use Model for Management of Surface and Ground Water using concept of MAR and ASR”.	Suman Gurjar (PI), N.C. Ghosh, Sumant Kumar, Surjeet Singh, Anupma Sharma	08 Months (04/16 – 11/16) **Status: New.**	Internal Funding.
9. NIH/GWD /NIH/16-16	Evaluation of Saryu Nahar Pariyojna (SNP) National Project in Uttar Pradesh.	N. C. Ghosh (PI), Gopal Krishan, R.P. Singh, J. K. Mishra	06 Months (03/16-08/16) **Status: New.**	Sponsored by MoWR, RD & GR.
10./NIH/GWD/16-17	*Country-wide Capacity Building Program on*	N. C. Ghosh, Lead Other Scientists of the	2 years (02/16 – 12/17)	Sponsored by DST

	"Bank Filtration for Sustainable Drinking Water Supply"	division	4 training courses	

HYDROLOGICAL INVESTIGATIONS DIVISION

Dr. Sudhir Kumar, Scientist G and Head, presented an overview and progress of studies and activities carried out by the Hydrological Investigations Division during the year 2015-16. He informed that out of 7 internal R&D studies, 4 have been completed. Out of the 5 sponsored studies, one project has been completed, while 4 studies are being continued. He further informed that the scientists of the division have also completed 1 consultancy project, conducted 4 training programs / workshops / National Seminar and published more than 20 papers in Journals and conferences.

Dr. Sudhir Kumar informed that for the next year, i.e., 2016-17, 3 internal studies, 4 sponsored projects, and 8 consultancy project shall continue from the year 2015-16. Further, 2 new internal studies and one sponsored project has been proposed for the year 2016-17. Also, many consultancy projects have been submitted by the scientists of the division and expected to be started during 2016-17.

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

INTERNAL STUDIES:

S.N.	Project Reference No.	Title of Study	Comments/Remark
1.	NIH/HID/INT/2013-15/2	Isotopic Studies for the Identification of Different Aquifer Groups and their Dynamics in Upper Yamuna River Plains	Study completed No comments received
2.	NIH/HID/INT/2013-15/4	Estimation of Radon Concentration in Waters and Identification of Paleo-groundwater in Part of Punjab Located in Satluj River Basin using Isotopes	Study completed
3.	NIH/HID/INT/2014-16/1	Interaction between groundwater and seawater along the parts of East Coast of India	No comments received
4.	NIH/HID/INT/2014-16/2:	Isotopic investigation of benchmark Himalayan glaciers	Study to be completed by June, 2016. No comments received
5.	NIH/HID/INT/2014-16	Assessment of dissolved radon concentration for groundwater investigations in Haridwar district	Study completed
6.	NIH/HID/INT/2015-16/1	Hydrological Aspects of Rewalsar Lake, Himachal Pradesh (Status Report)	Study extended upto July 2016 due to proposed summer WQ sampling. No comments received
7.	NIH/HID/INT/2015-18/1	Lake-Groundwater Interaction Studies for Sukhna Lake, Chandigarh	No comments received.

SPONSORED PROJECTS:

	Project Reference No.	Title of Study	Comments/Remark
8.	NIH/HID/MOES/2012-15	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates	Study extended upto July 2016 No comments received
9.	NIH/HID/IAEA-1/2012-15:	The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems in North Eastern Parts of Punjab, India	Completed
10.	NIH/HID/IAEA-2/2012-15	Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques	Study extended upto December, 2016 No comments received
11.	NIH/HID/IAEA-3/2013-15	Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains	No comments received

Three new projects proposed for the year 2016-17 were also presented as given below:

NEW STUDIES

	Project Reference No.	Title of Study	Comments/Remark
12.	NIH/HID/INT/2016-18 (Internal study)	Radiocarbon dating of deeper groundwater of Indo-Gangetic Basin	No comments received
13.	NIH/HID/INT/2016-18 (Internal study)	Isotopic Investigations in parts of Upper Yamuna River Basin	No comments received
14.	NIH/HID/SPON/2016-21 (Sponsored Project)	Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques	No comments received

The approved program for the year 2016-17 is given below:

APPROVED WORK PROGRAMME FOR 2016-2017

S. No.	Study	Team	Duration/ Status
INTERNAL STUDIES			
1.	Interaction between groundwater and seawater along the northern part of east coast of India	M. S. Rao (PI), Sudhir Kumar Pankaj Garg	2 years (01/15 - 12/16) Continuing Study

S. No.	Study	Team	Duration/ Status
2.	Status Report on Rewalsar Lake, Himachal Pradesh	SD Khobragade (PI) Sudhir Kumar, C. K. Jain	1 year (04/15 – 03/16) Continuing Study (to be extended upto July, 2016
3.	Lake-Groundwater Interaction Studies for Sukhna Lake, Chandigarh	S.D Khobragade (PI); Sudhir Kumar; S. P. Rai, Senthil Kumar; Pankaj Garg	3 years (04/15 – 03/18) Continuing Study
4.	Radiocarbon dating of deeper groundwater of Indo-Gangetic Basin	M. S. Rao (PI) Sudhir Kumar	3 years (04/16 – 03/19 New Study
5.	Isotopic Investigations in parts of Upper Yamuna River Basin	S. K. Verma (PI), Sudhir Kumar, S P Rai, Mohar Singh, Vishal Gupta	2 years (04/16 – 03/18) New Study
SPONSORED PROJECTS			
6	The Structure and Dynamics of Groundwater Systems in Northwestern India under Past, Present and Future Climates	S. P. Rai (PI); M. S. Rao; Surjeet Singh; S. K. Verma; C. P. Kumar; Sudhir Kumar	3 years (06/12-03/16) Continuing Study To be extended upto July, 2016
7	Assessment of Baseflow and its Impact on Water Quality in the Part of Satluj River in India using Environmental Isotopes and Age Dating Techniques	S. P. Rai (PI) R. V. Kale M. S. Rao C. P. Kumar Sudhir Kumar	3 years (10/12-04/16) Continuing Study To be extended upto July, 2016
8	Integration of Isotope Hydrology in Aquifer Mapping Efforts in India: A Pilot Study of Upper Yamuna Plains	Sudhir Kumar (PI); S. P. Rai; S. D. Khobragade; C. K. Jain; P. K. Garg	2 years (05/13-03/16) Extended by IAEA till Jun 16
9.	Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques	S. P. Rai (PI); Sudhir Kumar; Rajesh Singh; S. D. Khobragade; M. Arora; Dr. R. J. Thayyen; Sh. P. K. Garg	*5 Years 04/16-03/21 New Study*
CONSULTANCY PROJECTS			
1.	Hydrogeological Study for Dewatering of Jhamarkotra Mines, Distt. Udaipur	Sudhir Kumar	05/13-04/16 Continuing Study
2	Hydro-geological study for Gadarwara super thermal power project, Madhya Pradesh	SD Khobragade	07/15-06/16 Continuing Study
3	Hydro-geological study for Katwa super thermal power project, West Bengal	Sudhir Kumar	07/15 – 4/16 Continuing Study
4	Hydro-geological study for Darlipali super thermal power project, Odisha	Sudhir Kumar	9/15 – 8/16 Continuing Study

S. No.	Study	Team	Duration/ Status
5	Hydro-geological study for Khargone super thermal power project, Madhya Pradesh	SD Khobragade	07/15 – 4/16 Continuing Study
6	Hydro-geological and isotopic study for 1x660 MW Harduaganj thermal power project, UP	Sudhir Kumar	11/15 – 10/16 Continuing Study
7.	Hydro-geological and isotopic study for 1x660 MW Panki thermal power project, UP	Sudhir Kumar	12/15 – 11/16 Continuing Study
8.	Hydro-geological study for Kudgi super thermal power project, Karnataka	Sudhir Kumar	11/15 – 10/16 Continuing Study
9.	Hydro-geological study for Jawaharpur thermal power project, Etah, UP	Sudhir Kumar	12/15 – 11/16 Continuing Study

SURFACE WATER HYDROLOGY DIVISION

Dr. Rakesh Kumar, Head, Surface Water Hydrology Division gave a brief overview of the various scientific and other technical activities carried out by the Division after the previous meeting of the Working Group. Thereafter, the Scientists of the Surface Water Hydrology Division presented the progress achieved in carrying out the various studies as mentioned below.

Work Program for the Year 2015-16

S.No. & Ref. Code	Title	Study Team	Duration
1. NIH/SWHD/ NIH/13-16	Application of DSS (P) for Integrated Water Resources Development & Management	A.K. Lohani Surjeet Singh Rahul Jaiswal D K Sonkusale Akilesh Verma	3 years (April 2013 to March, 2016)
2. NIH/SWHD/ NIH/13-16	Quantitative assessment of uncertainties in river discharge estimation	Sanjay Kumar Sharad Jain	3.5 Years (April 2013 to Sept. 2016)
3. NIH/SWHD/ NIH/13-16	Evaluation and modeling of hydrological support system for watersheds of Garhwal, Uttarakhand hills.	Avinash Agarwal Manohar Arora RK Nema	3 Years (November 2013 to October 2016)
4. NIH/SWHD/ NIH/14-16	Estimation of Water Balance for Integrated Water Resources Management in Yerrakalva Pilot Basin, A.P.	J.V. Tyagi YRS Rao	2.5 years (April 2014 to Sept. 2016)
5. NIH/SWHD/ NIH/14-17	Hydrological modelling of Brahmani Baitarani river basin using eWater Source platform	J.P. Patra Rakesh Kumar Pankaj Mani	3years (April 2014 to March 2017)
6.	Study of Rainfall Patterns and	Archana Sarkar	3 years

NIH/SWHD/ NIH/14-17	Comparison of Rainfall Data from different Sources for Uttarakhand State	Vaibhav Garg, Sc C, IIRS, Dehradun Rakesh Kumar N.K. Bhatnagar	(April 2014 to Sept. 2017)
7. NIH/SWHD/ NIH/14-17	Monitoring and modelling of streamflow for the Gangotri Glacier	Manohar Arora Rakesh Kumar	3years (May 2014 to March 2017)
8. NIH/SWHD/ NIH/14-17	Effect of climate change on evaporation at point scale	Digambar Singh A. R. Senthil kumar Manohar Arora	3years (June 2014 to March 2017)
9. NIH/SWHD/ NIH/15-16	Analytical Solution for meeting of two surges or bores	Dr. S.K. Singh	1 year (April 2015 to March 2016)
10. NIH/SWHD/ NIH/15-16	Generalization and parameter estimation of GEV distribution for flood analysis	Dr. S.K. Singh	1 year (April 2015 to April 2016)
11. NIH/SWHD/ NIH/15-18	Flood and Sediment studies in Himalayan basin using MIKE-11 Model	A.K. Lohani	3 years (April 2015 to March 2018)
12. NIH/SWHD/ NIH/15-18	Snowmelt Runoff Modelling and Study of the Impact of Climate Change in Sharda River Basin	Achana Sarkar T. Thomas Vaibhav Garg	3 years (April 2015 to March 2018)
13. NIH/SWHD/ NIH/15-18	Study on effect of climate change on sediment yield to Pong reservoir	A. R. Senthil Kumar J. V. Tyagi Avinash Agarwal Suhas Khobragade Manohar Arora	3 years (April 2015 to March 2018)
14. NIH/SWHD/ NIH/15-17	Study of regional drought characteristics and long term changes in supplemental irrigation water requirement in Seonath Basin in Chhattisgarh	R.P. Pandey Rakesh Kumar	2 years (April 2015 to March 2017)
15. NIH/SWD/N IH/14-17	Effect of Changing Global Tropospheric Temperature on Asia-Pacific Monsoon Circulation and Rainfall Fields across India	Ashwini Ranade	3 years (Oct. 2014 to March 2017)
New Studies			
16. NIH/SWD/N IH/16-18	Snow cover variability in the Upper Yamnotri Basin	Naresh Kumar Manohar Arora Rakesh Kumar	2 years (April 2016 to June 2018)
17. NIH/SWHD/ NIH/16-17	Generalization and parameter estimation of GEV distribution for flood analysis: Specific application on Indian data	Sushil K. Singh	1 year (April 2016 to March 2017)
18. NIH/SWHD/ NIH/16-19	Application and development of analytical models on data collected at NIH under Saph-Pani Project	Sushil K. Singh	3 years (April 2016 to March 2019)

S.N.	Title of Project/Study, Study Group, Start/ Completion Dates	Status and Recommendations/Suggestions
1	Application of DSS (P) for Integrated Water Resources Development & Management **<u>Study Group:</u>** A.K. Lohani Surjeet Singh Rahul Jaiswal D.K. Sonkusale Akilesh Verma DOS: April 2013 DOC: March 2016	Dr. A.K. Lohani mentioned that the DSS (P) software, which was developed under HP-II has been applied in Arpa basin of Seonath river basin to demonstrate the capabilities of the DSS (P) model. Dr. Lohani mentioned that the hydrological time series data and spatial data have been collected from Water Resources Department, Chhattisgarh for the application of DSS (P) software. Dr Lohani further mentioned that the NAM rainfall-runoff model has been setup in Mike-11 RR. ANN Rainfall-runoff model was also developed on the same set of data. Using the DSS (P) software crop planning has been carried out for (i) normal rain years, (ii) 10% above normal rain and (iii) 10% below normal rain. He further mentioned that the report writing is in progress. Dr. S.S. Grewal mentioned that the planning may be carried out for the situations beyond 10% blow or above normal rainfall criteria. Dr. Lohani agreed that the crop water planning will be attempted for suggested cases also and incorporated in the final report. Dr D.V. Reddy, NGRI suggested that the micro level DSS being developed under other projects should be merged with this DSS to extend the capabilities of the DSS. Director, NIH mentioned that the DSS (P) is a basin level DSS and it cannot be merged with the micro scale level DSS. Dr. Rakesh Kumar, Scientist G and Head Surface Water Hydrology Division also mentioned that the DSS (P) was developed under Hydrology Project-II and it is a best planning DSS in basin Scale. It has five components for (i) Surface water planning; (ii) Integrated operation of reservoirs; (iii) Conjunctive surface water and ground water planning; (iv) Drought monitoring, assessment and management; and (v) Management of both surface and ground water quality. As the spatial scale of a micro level and a Basin level DSS are very much different and both have their own specific purpose therefore it is not advisable to have a common DSS for both the purpose.
2	Quantitative assessment of uncertainties in river discharge estimation **<u>Study Group:</u>** Sanjay Kumar Sharad Jain DOS: April 2013 DOC: March 2016	Dr. Sanjay Kumar presented the study on “Quantitative assessment of uncertainties in river discharge estimation”. He explained the background and objectives of the study and informed that study is a part of the systemic review of uncertainty clause of the ISO 9123 document. He explained the methodology based on ISO documents GUM (Guide to the expression of uncertainty in measurement), HUG (Hydrometric uncertainty guidance) and presented the progress of the study. He mentioned that, based on the discussions in the Tokyo meeting (held on 15th May 2015), all the comments and suggestions from member countries were incorporated in the Draft international standard (DIS). This DIS document was sent to BIS on 15th January 2016 for uploading on ISO site for further comments of member countries. As BIS is in the process of uploading the document, further comments on the documents are awaited. Considering above, P.I. of the

		study requested for the extension of six months to incorporate possible changes in the DIS documents based on the further suggestions/comments from member countries. Taking into account the progress of the study, Chairman and members agreed to extend the study for next six months.
3	Evaluation and modeling of hydrological support system for watersheds of Garhwal, Uttarakhand hills. **<u>Study Group:</u>** Avinash Agarwal, Manohar Arora R.K. Nema DOS: November 2013 DOC: October 2016	Dr. Avinash Agarwal, Scientist 'G' has presented the study, entitled "Evaluation and modeling of hydrological support system for watersheds of Garhwal, Uttarakhand hills". He informed that analysis has been completed and writing of the report is in progress. Some of the Working Group members stated that a long term and very useful data base has been created for monitoring, modeling and rejuvenation of the springs in this study. The springs are a very important source of fresh water in the hilly regions. The members expressed that not many studies are available on this important aspect of drinking water in the hilly regions. The Working Group members suggested that the research work on monitoring, modeling and rejuvenation of the springs should be continued by the Institute.
4	Estimation of Water Balance for Integrated Water Resources Management in Yerrakalva Pilot Basin, A.P. **<u>Study Group:</u>** J.V.Tyagi YRS Rao DOS: April 2014 DOC: March 2016	Dr. J.V. Tyagi presented the study and informed the house that the water balance study is taken up in Yerrakalva river basin in coastal Andhra Pradesh which is selected as pilot basin by NIH for integrated water resources management. SWAT model has been employed to quantify the water balance of the basin in the present study. The model was calibrated and validated on monthly data and water balance components were computed for the basin. It was, however, informed that all files stored in the computer (including word files, excel files, pdf files, data files etc) were infected and crypted by some unknown virus. The files could not be recovered despite all efforts by experts. Therefore, entire exercise including data file preparation, SWAT model set up and calibration and validation processes have to be redone. In view of the reasons beyond control, the P.I. requested for six months extension of the study period. The working Group considered the problem and granted the extension up to September 2016.
5	Hydrological modelling of Brahmani Baitarani river basin using eWater Source platform **<u>Study Group:</u>** J.P. Patra Rakesh Kumar Pankaj Mani DOS: April 2014 DOC: March 2017	Sri J.P. Patra explained the objectives of the study and stated that the eWater source is Australia's first national river basin scale water modelling system. The source modelling platform has been developed to take a holistic approach to water management including human and ecological impacts. This includes integrating policy, addressing water savings and sharing for a whole river and connected groundwater systems including cities, agricultural and environmental demands. In the India-Australia Water Science and Technology Partnership programme, Australia is collaborating with the Ministry of Water Resources to pilot the source river basin modelling platform in India. The MoWR, RD & GR is planning to develop an Integrated Water Resources Management (IWRM) plan for Brahmani Baitarani basin using the source river basin

		modelling platform. Hence, the present study has been taken up to develop a rainfall runoff model for Brahmani Baitarani river basin in source platform and test its applicability by generating hydrological time series. It was informed that collection of hydro meteorological data, satellite images, thematic maps etc., compilation, statistical and trend analysis of rainfall and river discharge and rainfall-runoff model set up in eWater Source platform have been completed and implications of different rainfall inputs and sub catchment size and calibration and parameter estimation are under progress. Thereafter, model performance evaluation with in various time periods would be taken up. It was explained that catchment modelling of Brahmani Baitarani river basin in eWater source platform is being carried out. The rainfall runoff model was setup with daily rainfall data of .25°×.25° obtained from IMD and ET data from Terrestrial Hydrology Group, Princeton University. The model calibration is being carried out with gauged sub catchments represented by a small proportion of the basin. Various objective functions viz. NSE Daily, NSE Monthly, NSE Monthly & Bias Penalty, NSE Daily & Flow Duration, NSE Daily & log Flow Duration, Minimise Absolute Bias, NSE Daily & Bias Penalty etc. are used for calibration of the model. Further optimization algorithm like Shuffled Complex Evolution (SCE), Uniform Random Sampling (URS), Rosenbrock, SCE then Rosenbrock etc is evaluated for their performance. In case of SCE then Rosenbrock, the variability among different simulation runs are found to be minimum. Comparison of simulated discharge obtained from various models viz. GR4J, Sacramento and SimHyd with observed discharge have been compared. It is found that the GR4J model has performed better in comparison to other model for this basin. Further it has only four parameters to calibrate, which also reduces uncertainty. Further, the exercise with available daily point rainfall data is being carried out.
6	Study of Rainfall Patterns and Comparison of Rainfall Data from different Sources for Uttarakhand State **Study Group:** Archana Sarkar Vaibhav Garg, Sc C, IIRS, Dehradun Rakesh Kumar N.K. Bhatnagar DOS: April 2014 DOC: March 2017	Mrs Archana Sarkar, PI of the study presented the background, objectives, methodology and expected deliverables of the new study. Mrs Sarkar informed that the study area is the Uttarakhand State, often referred to as the "Land of the Gods" due to the many holy Hindu temples and pilgrimage centres found throughout the state which observed a massive flood disaster in June 2013. Mrs Sarkar informed the house that a good knowledge of local rainfall-regime is crucial for planning and management of domestic, urban as well as industrial water use, irrigation and crop practices besides forecasting and management of extreme events like floods and droughts. She further informed that in view of the recent flood disaster in the Uttarakhand state, it becomes all the more important to carry out a scientific analysis of the rainfall regime of the region. Mrs Sarkar also informed that a comparative accuracy assessment of various data sources of

		rainfall viz, Rain gauges, satellite sensors (TRMM), and high resolution gridded re-analysis rainfall (APHRODITE) is of prime importance as the rainfall data from these data sources are further provided to hydrological models to produce forecasts. Mrs Sarkar presented the progress of the study with results of trend analysis of historical rainfall series of number of rainfall events of various intensity (annual and monsoon) by parametric and non-parametric methods for ten rainfall stations (grid centres) five each in Kumoan and Garhwal regions using IMD gridded rainfall data of 113 years (1901 to 2013). She also informed about the processing of TRMM rainfall data being processed. Mrs Sarkar informed about the further work that will be carried out for rainfall comparison for different sources if rainfall. Working group members noted the progress of the study as well as appreciated the work.
7	Monitoring and modelling of streamflow for the Gangotri Glacier **Study Group:** Manohar Arora Rakesh Kumar DOS: May 2014 DOC: March 2017	Dr Arora presented the progress of the study. He informed the house that the data collected for the ablation period of 2015 was analyzed and the results were presented in the last working group. He informed the house that the future scenarios have been developed in collaboration with IIT Delhi. It is observed that the statistical downscaling has limitation in this area because of non availability of historical observed data. The Cordex experiment data can be used for the future water availability analysis. In addition the mathematical model to be used for simulation has to be tuned with the observed physical phenomena in the region. The aspect consideration with the extent of debris cover will be incorporated in the model to improve efficiency. The aspect map developed for the Gangotri glacier was presented.
8	Effect of climate change on evaporation at point scale **Study Group:** Digambar Singh A. R. Senthil kumar Manohar Arora DOS: June 2014 DOC: March 2017	Shri Digambar Singh, PI of the study, presented the objectives, methodology and progress of the study from Jan 2016 to March 2016. The PI explained about the Turc and Thornthwaite method to calculate the evapotranspiration. The PI also explained about the yearly variability of sun shine and wind speed, temperature and humidity. Sensibility analysis was also carried out during this period. Wind speed shows sinusoidal behavior on the yearly basis. Sunshine duration decreases in the later part of the year. Sunshine analysis shows that the temperature has major control in evaporation.
9	Analytical Solution for meeting of two surges or bores **Study Group:** S.K. Singh DOS: April 2015 DOS: March 2016	Dr. S. K. Singh informed that the study is complete and the report will be submitted by this month.

10	Generalization and parameter estimation of GEV distribution for flood analysis **Study Group:** S.K. Singh DOS: April 2015 DOC: April 2016	Dr. S. K. Singh informed that the study is complete and the report will be submitted by this month.
11	Flood and Sediment studies in Himalayan basin using MIKE-11 Model **Study Group:** A.K. Lohani Sanjay K. Jain DOS: April 2015 DOC: March 2018	Dr. A. K. Lohani, Scientist G presented the progress of the study. He mentioned that the cloudburst data of District Uttarkashi of Uttarakhand have been collected. Using the DEM slope maps, river cross section and drainage network of Assiganga river basin have been prepared. Further a cloudburst event of 2012 has been considered and it has been converted to flood event considering triangular hydrograph. This hydrograph is routed to downstream using MIKER-11 model. Further flood inundated area has been plotted. Dr. Lohani mentioned that the study of other cloud burst events is in progress. He also mentioned that the sediment modelling is also planned in the study and efforts are being made to procure sediment modelling module of MIKE-11 or MIKE HYDRO RIVER from DHI. Dr S.S. Grewal appreciated the study. Shri N.K. Sharma, IRI also appreciated the study and mentioned that the results will be useful for water resources planning purpose.
12	Snowmelt Runoff Modelling and Study of the Impact of Climate Change in Sharda River Basin **Study Group:** Achana Sarkar T. Thomas Vaibhav Garg DOS: April 2015 DOC: March 2018	Mrs Archana Sarkar, PI of the study presented the background, objectives, methodology and expected deliverables of the new study. Mrs Sarkar informed that the study area is the Uttarakhand State, often referred to as the "Land of the Gods" due to the many holy Hindu temples and pilgrimage centres found throughout the state which observed a massive flood disaster in June 2013. Mrs Sarkar informed the house that a good knowledge of local rainfall-regime is crucial for planning and management of domestic, urban as well as industrial water use, irrigation and crop practices besides forecasting and management of extreme events like floods and droughts. She further informed that in view of the recent flood disaster in the Uttarakhand state, it becomes all the more important to carry out a scientific analysis of the rainfall regime of the region. Mrs Sarkar also informed that a comparative accuracy assessment of various data sources of rainfall viz, Rain gauges, satellite sensors (TRMM), and high resolution gridded re-analysis rainfall (APHRODITE) is of prime importance as the rainfall data from these data sources are further provided to hydrological models to produce forecasts. Mrs Sarkar presented the progress of the study with results of trend analysis of historical rainfall series of number of rainfall events of various intensity (annual and monsoon) by parametric and non-parametric methods for ten rainfall

		stations (grid centres) five each in Kumoan and Garhwal regions using IMD gridded rainfall data of 113 years (1901 to 2013). She also informed about the processing of TRMM rainfall data being processed. Mrs Sarkar informed about the further work that will be carried out for rainfall comparison for different sources if rainfall. Working group members noted the progress of the study as well as appreciated the work.
13	Study on effect of climate change on sediment yield to Pong reservoir **Study Group:** A. R. Senthil Kumar J. V. Tyagi Avinash Agarwal Suhas Khobragade Manohar Arora DOS: April 2015 DOC: March 2018	Dr. Suhas D Khobragade, Co- PI of the project presented the objectives, methodology and the progress made during January 2016 to March 2016. The sediment inflow to Pandoh reservoir located in the upstream of the Pong reservoir is not observed and it is an important input to the SWAT model. The Co-PI presented the sediment yield to Pandoh reservoir computed from the sediment observed at Mandi downstream of Pandoh reservoir using the average trap efficiency of Bhakra and Pong reservoir. The sediment volume computed to Pandoh reservoir is 3924.485 Mm^3 which is much higher than the reservoir volume of 41 Mm^3. The Co-PI informed that information of sediment yield to a reservoir similar to Pandoh would be collected and used. The Co-PI also informed that the study would be merged with the NMSHE (National Mission for Sustaining the Himalayan Eco-system) project in case the required information was not available.
14	Study of regional drought characteristics and long term changes in supplemental irrigation water requirement in Seonath Basin in Chhattisgarh **Study Group:** R.P. Pandey Rakesh Kumar DOS: April 2015 DOC: March 2017	The Head Surface Water Hydrology Division reported an over view about the progress of studies and subsequently invited Dr R.P. Pandey, PI of the project to make presentation and explain the details of the work done and the progress of study after the previous Working Group meeting held during 08-09 December 2015. Dr Pandey presented the complete progress on preparations of base-maps, methodology used in the analysis and results of the work done under this study. He informed that the occurrence of droughts in various parts of Seonath basin have been major concern of crop failure and acute water shortages from time to time. He informed that the Seonath river basin is the longest tributary of the Mahanadi basin draining three districts of Chhattisgarh namely Durg, Rajandgaon and Bilaspur. The drainage area of the Seonath river basin is 30,860 Sq km. which comprises nearly 25% of the upper catchment of the Mahanadi basin.In the presentation, the working group was informed that the analysis of meteorological data has progressed well. The analysis of variability and long-term trends of meteorological variables (i.e. rainfall, maximum & minimum temperature, humidity, wind speed and the evapotranspiration have been carried out for annual and seasonal time scales. Dr Pandey informed that the study will be continue for the next years to achieve the objectives of the study and to determine Long Term Trend in net irrigation requirement and changes in total Irrigation Water Demand (IWD). It is expected that this study will yield objective quantification of changes in irrigation water demand over past 50 years and projections for the next 50 years. He informed that the progress of the study is

		satisfactory.
15	Effect of Changing Global Tropospheric Temperature on Asia-Pacific Monsoon Circulation and Rainfall Fields across India **Study Group:** Ashwini Ranade DOS: Oct 2014 DOC: March 2017	Dr. Ashwini Ranade, PI of the project presented the overview of the project with objectives and progress done in last six months. She has also presented some important results of the study. The working group has well appreciated the work on onset and withdrawal of monsoon and extreme rain events.
New Studies		
16	Snow cover variability in the Upper Yamnotri Basin **Study Group:** Naresh Kumar Manohar Arora Rakesh Kumar DOS: Oct 2016 DOC: March 2018	Shri Naresh Kumar proposed a new study entitled, "Snow cover variability in the Upper Yamnotri Basin". In this study, snow cover variability in the Upper Yamnotri Basin will be studied and snow depletion curves for Upper Yamnotri Basin will be developed. For this study MODIS Mod 10 A2 data will be down loaded from National Snow and Ice Data Center (NSIDC) and will be used for Snow cover analysis of the study area and preparation of snow depletion curves for the study area for different years. The study will be completed by June 2018. The beneficiaries of this study will be the stakeholders in the downstream. It will be a valuable input for the modelling studies to be undertaken for the Yamnotri Basin.
17	Generalization and parameter estimation of GEV distribution for flood analysis: Specific application on Indian data **Study Group:** S.K. Singh DOS: April 2016 DOC: March 2017	Dr S. K. Singh proposed this new study of one year duration covering the application of developed generalization of GEV-2 and GEV-3 distribution to extensive Indian data-set (flood data at various GD sites) available/collected at NIH and CWC. In an earlier report, the practical unification of both type 2 and type 3 GEV distributions in a single GEV was taken up and a simple and an optimization methods for estimation of its parameters were considered with limited testing/application for flood frequency analysis At this stage there was no comment from the members.
18	Application and development of analytical models on data collected at NIH under Saph-Pani Project **Study Group:** S.K. Singh DOS: April 2016 DOC: March 2019	Dr. S. K. Singh presented the intended objectives of the study specifically utilizing/on the data collected during the Saph-Pani project completed at NIH, as (1) To apply and illustrate on the above surface-water groundwater interaction data, the developed and published analytical models by the author, a complied detail of which has earlier been submitted to our Ministry and Institute both directly and indirectly; (2) To possibly develop new analytical models if application on the data as at item 1 suggests so; (3) The items 1 and 2 are also with the aim to suggest general application of these and other methodology concerning the area of surface-water groundwater interaction in general with respective

		merits/demerits. It is an application study in which the developed methodologies and analyses by the author are intended to be applied on the concerning data collected at NIH as stated above. The intended development of new analytical model and methodology would be along those adopted in the development of earlier such models by the author. At this stage, there was no comment from members.

WATER RESOURCES SYSTEM DIVISION

Suggestion/comments received from members during 44th working group meeting (18-19 April, 2016)

Dr. Sharad K Jain, Scientist "G" and Head (WRS Div.), presented an overview of the division – scientific strength, the ongoing studies, sponsored & consultancy studies, technical publications and training courses organized. He also informed about the upcoming National Hydrology project (NHP), the project on National Mission for Sustainable Himalayan Ecosystem (NMSHE), and involvement of scientists of the division in other activities. Subsequently, Dr. M. K. Goel (MKG) gave an overview of NMSHE. Following are the comments received from working group on the presentations of the various studies.

NIH_Basin – A WINDOWS based model for water resources assessment in a river basin
PI: Dr. M. K. Goel, Scientist "G"

MKG made a brief presentation of the study and informed about the various modifications that have been introduced in the modeling methodology till date. He informed that after the last working group, considerable efforts have been made in developing an excel-based procedure for preparing interactive data files, to run an executable program with the data files, and evaluate the results in MS-Excel. This procedure has been developed for an ongoing project related to Krishna basin study and the same is planned to be followed in the present case also. A brief demonstration of the procedure was demonstrated in the meeting.

MKG clarified that the procedure will help in avoiding the development of a separate code in Visual Basic for the linkage of various data files and programs. He said that because of extensive efforts in this development, the finalization of the main program for the river basin model is still in progress. He requested to extend the time frame for the present study by one year which was agreed by the members. No specific queries were raised during the presentation.

Glacier change and glacier runoff variation in the upper Satluj river basin
PI: Dr. Sanjay K. Jain (SJ), Scientist "G"

SJ informed the house that glacier change study for the upper Satluj basin have been completed and presented in the previous meeting. He informed that the data base for modeling snow/glacier melt runoff has been completed. The future projections for rainfall and temperature from IIT Bombay have been received recently. Now snow/glacier melt runoff vis a vis climate change will be studied. SJ asked for extension of six months for completion of the study. House granted the permission of extension.

Modelling of Narmada Basin using GWAVA Model (Ongoing)
PI: Dr. Sanjay K. Jain (SJ), Scientist "G"

Mr. P. K. Mishra (PKM) presented the status as well as the progress of the study. He informed that all the mandatory input files, viz., Physical Parameter files, Water Demand Files and Climate Files in the required format have been completed. The crop data file has also been done. A pre-calibrated run of the model has already been done, but with an over estimation of flows. Few bugs in the Pre-processor have been removed at CEH and a new version of PREPROCESSOR.EXE has been sent by CEH recently. There is some error in flow direction of grids based on the automated extraction in ArcGIS. Single site calibration of the model with minimum data requirements is expected to be completed by May 15, 2016. Dr. Reddy recommended to revise the Objective 1. The suggestion has been noted and will be addressed.

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

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

Work progress for the study was presented by Mr D.S. Rathore. During the period, work was carried out pertaining to drought index and water quality modelling. Standardised Precipitation Index (SPI) of 1 to 4 month scale was used to estimate probabilities of occurrence of drought and mild dry conditions for monsoon months (June- September). In case, SPI is lower than 1 in any period, the drought condition was assumed. In case of negative values, mild dry condition was assumed. SPI values estimated from cumulative rainfall values for 1 to 4 months June onwards. Drought and mild dry probabilities were 20 and 10% respectively. Probabilities for percent deficit rainfall (June-September) classes <20, 20-40, 40-60 and >60 were also estimated. Excel based procedure was developed for computed catchment wise non point and point source pollutant loading and distribution of the load based on runoff values. Maximum generated pollutant load was simulated for conservative transport and low values of decay coefficients. The values simulated were higher than observed pollutant concentration and thus it will be possible to calibrate the model using suitable coefficients. Dr D.V. Reddy pointed out that in view of ongoing large scale drought conditions in India, drought prediction aspect may be looked into. Director suggested to analyze the current data for the purpose.

Development of Ganga Information Portal

PI: D. Chalisgaonkar (DC), Scientist "F"

In absence of the PI (DC), it was informed that the study is progressing well.

Catchment scale evaluation of cold-arid cryospheric system hydrology, Ganglass catchment, Ladakh

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

This project is aimed to evaluate the catchment scale hydrologic processes of the cold-arid regime. RJT informed about the progress made after the last working group. Winter and summer mass of Phuche glacier is calculated during this period and found to be positive. Discharge at 4700m asl is derived from the AWLR data and found to be highest since the monitoring began in this catchment. RJT informed about the delay in procuring the soil thermometers for the permafrost study. No specific suggestions received for this study.

Runoff modelling of Shyok River, Karakorum Range

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

This project is being executed in coordination with Border Roads Organisation (BRO) at km 150 of Durbuk—DBO axis. Since the last working group snow cover depletion curves for the basin have been developed. It is found that the most of the basin become snow free by June itself but the discharge starts increasing significantly since July, suggesting large contributions from glacier dominant areas. RJT informed that runoff modelling is hampered due to delay in procurement of AWS for the basin and no other temperature and precipitation information is available from the basin. No specific suggestions received for this project.

RJT also informed about two newly sanctioned sponsored projects by SERB titled "Mass and Energy balance of Phuche and Khardung glaciers Ladakh range" and NMHS project , where NIH is co-lead entitled "Dynamics of Himalayan Ecosystem and its impact under changing climate scenario"

Study of hydrological changes in selected watersheds in view of climate change in India
PI: Dr. L. N. Thakural (LNT), Scientist "C"

LNT presented the objectives, methodology and the status of the ongoing study. Hydro-meteorological data namely rainfall, temperature and discharge data processed for Ramganga and Bina river basins and its preliminary analysis carried out was presented. The status of the GIS database prepared using remote sensing data (Land sat 8 imagery) and NBSS & ULIP data for Land use/Land cover and soil maps respectively in ERDAS 9.3 and ARCGIS 9.3 environment for these basins were also deliberated. The preliminary analysis rainfall data at 3 month scale prepared for the drought characterization using SPI method for these river basins was also presented in the meeting. Ground water data processing and in turn generation of fluctuation map for the Bina river basin for year 2014 was also presented. No specific suggestions were received for this project.

Hydrological Processes and Characterization of Lesser Himalayan Catchments (Ongoing)
PI: Shri M. K. Nema (MKN), Scientist "C"

While presenting the progress of the study, MKN informed that the study is experimental in nature and requires setting up variety of instruments in the proposed catchments, which is a time-taking and challenging job particularly in Himalayan conditions. He informed that the stream gauging structures at both the stream have been completed and manual monitoring is also being done since Feb, 2016. One AWS has also been installed and data is being received at NIH, Roorkee Servers. He further updated that work order for AWLR has been placed and installation is yet to be done. No major comments were made by the WG members.

Studies on Temporal Variation of Sediment Yield in a Hilly Watershed of Upper Ganga Basin, Uttarakhand
PI: Dr. P. K. Singh (PKS), Scientist "C"

PKS presented the progress report of the project. Shri C.P. Kumar asked about the initial soil moisture (V_0) proposed to be incorporated in the time distributed sediment yield model development. The PI informd that the V_0 will be incorporated in the basic proprtionality concept ($Q/P-I_a = F/S$) in volumetric terms to account for the moisture before the storm. Dr. S.K. Bartarya, WIHG, Dehradun suggested to explore the possibility of incorporating the dissolved solids loads along with suspended sediment load. A suggestion regarding sampling of bed load was also emerged during discussion. However, it was decided that the possible inclusion of both the aspects will be explored in the next monsoon season.

Assessing Climate Change Impact across KBK (Kalahandi-Bolangir-Koraput) region of Odisha (Completed)
PI: Shri P. K. Mishra (PKM), Scientist "B"

Being a completed study, PKM presented objective-wise final results of the study. Shri Mishra presented the trend for rainfall (110 years), temperature (102 years), and potential evapotranspiration (102 years) for the eight districts coming under KBK region. The year having considerable shift in rainfall and temperature pattern in the region has also been presented. PKM presented the downscaled future rainfall and temperature for the region using HadCM3 Global Climate Model (GCM) for A2 and B2 scenarios. He also presented the water availability and utilization for the Tel basin, and discussed the outputs from the Soil and Water Assessment Tool (SWAT) modeling carried out for the Tel basin.

Hydrological modeling of a part of Satluj basin using SWAT model
PI: Shri P. K. Agarwal (PKA), Scientist "B"

The progress of the study was presented by PKA before the members of the Working Group. It was informed that data processing and preparation is in progress. Spatial data have been prepared in the format required by SWAT. PI informed that the required discharge data at Harike will be collected shortly. No specific comments were received from the members of the Working Group.

WORK PROGRAMME FOR THE YEAR 2016-2017

SN	Title	Study Team	Duration	Funding (Rs. in Lakhs)
CompletedSponsored/ Internal Studies				
1.	Assessing climate change impact across KBK region of Odisha	P. K. Mishra Sharad K. Jain Sanjay K. Jain	3 Years (04/13-03/16)	NIH (28)
Ongoing Internal Studies				
1.	NIH_Basin – A WINDOWS based model for water resources assessment in a river basin	M. K. Goel Sharad K. Jain DeepaChalisgaonkar Prabhash K. Mishra	3 Years (04/13-03/16)	NIH (16)
2.	Glacier change and glacier runoff variation in the upper Satluj river basin	Sanjay K. Jain Sharad K. Jain Renoj J. Thayyen	2.5 Years (10/13-03/16)	NIH (12)
3.	Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh	Renoj J. Thayyen S. P. Rai Sanjay K Jain Sudhir Kumar	3 years (04/14-03/17)	NIH (48)
4.	Hydrologic Modelling of a part of Satluj Basin using SWAT Model	P. K. Agarwal Sharad K. Jain Tanvear Ahmad M. K. Goel Sanjay K. Jain M. K. Nema	2 -3/4 Years (06/14-03/17)	NIH (23)
5.	Decision Support System for Water Resources Planning in Upper Bhima basin, Maharashtra	D. S. Rathore M. K. Goel, R.P. Pandey Sanjay Kumar Surjeet Singh	2 years (07/14-06/16)	NIH (34)
6.	Modeling of Narmada basin by using the GWAVA model	Sanjay K. Jain Sharad K. Jain T. Thomas (RC-Bhopal) P. K. Mishra P. K. Agarwal M. K. Nema	2.25 years Dec. 2014 – Mar 2017	NIH
7.	Runoff modeling of Shyok River, Karakorum Range	Renoj J.Thayyen Sanjay K.Jain	3 years Dec-2014 to Nov.2017	NIH (38)
8.	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	NIH+

		P. K. Agarwal		
9.	Development of Ganga Information Portal	DeepaChalisgaonkar Sharad K. Jain D. S. Rathore Sanjay K. Jain Sudhir Kumar P. K. Mishra P. K. Agarwal M. K. Nema	3 years (04/15-03/18)	MoWR (65.55)
10.	Study of hydrological changes in selected watersheds in view of climate change in India.	L. N. Thakural D. S. Rathore Surjeet Singh Tanvear Ahmad Sanjay K. Jain Sharad K. Jain	3 years (04/15-03/18)	MoWR (44.30)
11.	Studies on Temporal Variation of Sediment Yield in Hilly Watershed of Upper Ganga Basin, Uttarakhand	P.K. Singh Sharad K. Jain Sanjay K. Jain M. K. Nema	2 Years 01/16-12/17	NIH (8.20)
New Sponsored Study for the year 2016-2017				
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.	NMSHE SUB-PROJECTS	-	-	-

RESEARCH MANAGEMENT AND OUTREACH DIVISION (RMOD)

Progress Under Work Programme For Year 2015-2016

SN	Title of Project/Study, Study Team	Status and Recommendations/Suggestions
1.	Water conservation and management in Ibrahimpur Masahi village of Haridwar district (Uttarakhand) **Team:** Omkar Singh, V.C. Goyal, Dinesh Kumar DOS: April 2013, DOC: March 2016 (extended upto Sept., 2016)	The study was presented by Shri Omkar Singh (PI). The PI requested for 6 months extension to carry out the task of preparing a water conservation plan in this study, which was agreed by the WG.
2.	WEAP Model set up for four sub-basins under Pilot Basin Studies (PBS) Programme, jointly with the RCs/CFMSs **NIH HQs:** Jyoti Patil and V C Goyal (PBS Leader) **Co-investigators from NIH RCs/CFMSs:** Chandramohan T (RC-Belgaum), Y R S Rao (RC-Kakinada), T R Nayak (RC-Bhopal), B Chakravorty (CFMS-Patna), R V Kale (RC-Jammu) DOS: Apr 2015, DOC: Mar 2017	The study was presented by Dr. Jyoti P Patil. Database development and draft WEAP model setup is under progress. Shortcomings of the study are inaccessible classified data of Mahi river and demo/ training needed by RCs. There was no specific comment from the WG members.
3.	Customization of WEAP model for application	The study was presented by Dr. Jyoti P

	in Ur river watershed in Tikamgarh district of Bundelkhand region. **(Under TIFAC Project)** **Team:** R V Kale (PI Till Feb,2016), T Thomas-RC Bhopal, Jyoti Patil, Rajesh Agarwal, DOS: Apr 2014, DOC: March 2016 (completed).	Patil. This was completed study and efforts made by team were well appreciated by the WG members. There was no specific comment except to understand the optimization process of WEAP model.

WORK PROGRAMME FOR YEAR 2016-2017

S N	**Title of Project/Study**	**Study Team**	**Duration**	**Funding**
	Internal Studies			
1.	**Study- 1 (RMOD/2015-16/TS-1)** Water Conservation and Management in Ibrahimpur Masahi Village of Hardwar District (Uttarakhand)	Omkar Singh (PI), V C Goyal, Dinesh Kumar	DOS: Apr 2013 DOC: March 2016 (requires 6 month extenstion)	NIH
2.	**Study-2 (RMOD/2015-16/TS-3)** WEAP Model set up for four sub-basins under Pilot Basin Studies (PBS) Programme, jointly with the RCs/CFMSs	**NIH HQs:** Jyoti Patil (PI), V C Goyal **NIH RCs/CFMSs:** Chandramohan T (Belgaum), Y R S Rao (Kakinada), T R Nayak (Bhopal), B Chakravorty (Patna), R V Kale (Jammu)	DOS: Apr 2015 DOC: Mar 2017 (Ongoing study)	NIH
	Sponsored Projects			
3.	Integrating hydrology, climate change and IWRM with livelihood issues: Development of methodology and a DSS for water-scarce Bundelkhand region in India- preparation of final report	V C Goyal (PI), T Thomas, Jyoti Patil, Rajesh Agrawal	DOS: Aug 2013 DOC: Jul 2016	TIFAC (Rs 56.64 lakh)
4.	IWRM Based Development Plan for Water Security in Four Districts of Bundelkhand Region in India	V C Goyal (PI), Omkar Singh, Jyoti Patil, T R Nayak, Ravi Galkate, T Thomas, R K Jaiswal, Shashi P Indwar, Subhash Kichlu, Rajesh Agrawal, Dinesh Kumar	DOS: Apr 2016 DOC: Dec 2016	MoWR, RD & GR (Rs 299.4 lakh)
5.	Development of a DSS for Hydrology and Watershed Management in Neeranchal Project	V C Goyal (PI)	DOS: May 2016* DOC: Mar 2021	DoLR (GoI)

*Final approval from the DoLR (GoI) is awaited.

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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ANNEXURE-I

List of Working Group Members who attended the 44th WG meeting

21.	Er. R.D. Singh, Director, NIH	Chairman
22.	Dr. S.K. Bartarya, WIHG, Dehradun	Member
23.	Dr. D V Reddy, CSIR-NGRI, Hyderabad	Member
24.	Dr. G P Juyal, CSWCRTI, Dehradun	Member
25.	Dr. S K Mittal, CSIR-CSIO, Chandigarh	Member
26.	Er. Kireet Kumar, GBPIHED, Almora	Member
27.	Dr. S S Grewal, Chandigarh	Member
28.	Er. R K Khanna, New Delhi	Member
29.	Dr. S.K. Jain, Sc. G & Head WRS Division, NIH	Member
30.	Dr. N C Ghosh, Sc.G & Head GWH Division, NIH	Member
31.	Dr. Rakesh Kumar, Sc. G & Head SWH Division, NIH	Member
32.	Dr. Sudhir Kumar, Sc. G & Head HI Division, NIH	Member
33.	Dr. C K Jain, Sc.G & Head EH Division, NIH	Member
34.	Dr. V C Goyal, Sc. G & Head, RMO Division, NIH	Member-Secretary

Scientists from National Institute of Hydrology, Roorkee

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