आपो हिष्टा मयोभुवः

ANNUAL REPORT
2022-23

NATIONAL INSTITUTE OF HYDROLOGY

(Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti)
Jalvigyan Bhawan, Roorkee - 247667(Uttarakhand)

National Institute of Hydrology
राष्ट्रीय जल विज्ञान संस्थान
आपो हिष्टा मयोभुवः

आपो हिष्ठा मयोभुवः स्थान ऊर्जे दधातन ।
महे रणाय चक्षसे ।।

O water, because of your presence,
the atmospherer is so refreshing,
and
impart us with vigour and strength.
We revere you
who gladdens us by your pure essence.

ANNUAL REPORT 2022-23

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Director's Note

I feel immensely proud to present the Annual Report of the National Institute of Hydrology, Roorkee for the year 2022-23. The Annual Report provides glimpses of the activities and achievements of the Institute during the year 2022-23.

Its more than four decades since the NIH was established in the year 1978 and I feel greatly privileged to be associated with the Institute for more than three decades.It gives me immense satisfaction to witness how the Institute has grown up in recent years and established itself as a centre of excellence, contributing significantly to research in the area of hydrology and water resources, not only through organizational growth and infrastructure, but also in its activities and achievements. The Institute is carrying out its R&D activities under six scientific divisions at its HQ Roorkee and seven regional centres located across the country. The seventh regional centre at Jodhpur (North Western Regional Centre) was newly established during the year 2022-23 to carry out field-oriented hydrological studies related to arid and semi-arid region in the North-Western states of Rajasthan, Gujarat, Haryana and Punjab. The Institute is well equipped to carry out hydrologic modelling, laboratory & field oriented studies in the emerging areas of hydrology & water resources. Besides the basic and applied research undertaken through various in-house/sponsored/consultancy research projects and collaborative studies with relevant national/international organizations, the Institute vigorously pursues capacity development and technology transfer activities by organizing a number of training programs for field engineers, scientists, researchers and NGOs in the areas of hydrology and water resources. In addition, the Institute also performs various outreach activities viz., exhibitions, mass awareness in schools/villages/general public, etc.The Institute has now established itself not only as a premier research institute of the Government of India but also as an Institute of International repute. The achievements of the Institute have been possible due to the dedicated efforts of the scientists with due support from the scientific, technical and administrative staff and the project staff. My sincere gratitude to all of them for their sincerity, hard work and dedication. I also express my sincere gratitude towards N.I.H. Society, Governing Body, Standing Committee, Technical Advisory Committee, Working group and Regional Coordination Committees of the regional centres for their constant support and guidance. I also thank Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti, Government of India for their continuing support and encouragement, without which the achievements of the Institute would not have been possible. I also take this opportunity to express my appreciation towards all our national and international collaborators and sponsors for their support in our scientific and technical endeavours.

Considering the overall growth and progress being made by the Institute every year, I believe firmly that the Institute shall attain further higher levels of achievements in the years to come to fulfil the aspirations of the nation.

(Dr. Sudhir Kumar)

Achievements
at a glance

- ✓ The R&D work in the Institute has been carried out at the headquarters, Roorkee and six regional centres located at Bhopal, Belagavi, Guwahati, Jammu, Kakinada and Patna. At the headquarters, significant emphasis has been given on basic, applied and demand driven research while at the Regional Centres, more emphasis has been given to field oriented research problems related to the respective jurisdiction of the centre.
- ✓ During the year 2022-23, the Institute has worked on 51 R&D studies and 47 International/National sponsored projects to fulfil its objectives. With the changing scenario in water sector, the Institute has focused more on advanced and demand driven research.
- ✓ The Institute has also taken up 36 consultancy projects and successfully completed 11 consultancy projects funded by various Central/State Governments, PSUs and Private Organizations during the year.
- ✓ The studies and research carried out by the Institute have received national and international recognition and have resulted in the publication of 4 books, 43 chapters in books, and 217 research papers in reputed international and national journals and proceedings of various international and national conferences, seminars and symposia, during the year.
- ✓ As part of the Technology Transfer Programme of the Institute, a total 52 (1 International and 51 National) activities were organized during the year in different parts of the country. National Level activities include 2 symposia/seminar/conferences and 48 training courses/ workshops/ brainstorming sessions. The Institute also organized the World Water day 2023 jointly with IIT, Roorkee on 22 March, 2023.
- ✓ A total 62 Mass Awareness Programme were organized by the Institute during the year in different parts of the country. Of these, 28 activities were organised under Aazadi Ka Amrit Mahotsav, 17 activities under Swachh Bharat Mission, 1 activity under Poshan Pakhwada and 8 other activities. The Institute participated in 8 exhibitions at various places of the country.
- ✓ The Institute has been participating in a major project under National Hydrology Project (NHP) funded by MoJS (GoI) through World bank. NIH has been involved in various activities of NHP viz., Purpose Driven Studies, training and capacity building, development of hydrological model and Decision Support System (PM).
- ✓ A new regional centre (NIH-North Western Regional Centre, Jodhpur) has been established during the year 2022-23 at Jodhpur (Rajasthan) to carry out field-oriented hydrological studies related to arid and semi-arid region in the North-Western states of Rajasthan, Gujarat, Haryana and Punjab.
- ✓ A Centre for Cryosphere and Climate Change Studies has been established in the Institute at Roorkee during the year 2022-23 to facilitate the effective management of snow and glacier resources in the country to address the water availability, glacier change and glacial lake outburst flood studies.
- ✓ The Institute was awarded the ISO 9001:2008 Certificate on December 13, 2012. It was upgraded to ISO 9001:2015 on December 13, 2015. During the year 2022-23, on the basis of internal and external audits, the Institute continued as ISO 9001:2015 certified organization.
- ✓ Water Quality Laboratory was accredited by NABL in accordance with the standard ISO/IEC 17025: 2017– General Requirements for The Competence of Testing & Calibration Laboratories for 22 parameters for a period of two years w.e.f. 14.04.2021 (Certificate Number: TC-9421) (Lab ID: T-5679).
- ✓ Institute has received one patent on "Fluoride Removal Media Developed from Bagasse Fly Ash and a Method for Synthesis Thereof" during the year.The Institute has also received Rajbhasha Gaurav Puraskar-2022 (First Prize) for Hindi Paper published in Pravahinee Magazine of NIH entitled"Bharat mein barh prabandhan ke liye barhpoorv chetavani tantr" Prize awarded by Hon'ble Union Home Minister, M/o Home Affairs (GoI).

1 About the Institute

The National Institute of Hydrology is a premier research organization in India working in the areas of hydrology and water resources. It was founded on 16th December 1978 as an autonomous body registered under the Registration of Societies Act of 1860 under the then Ministry of Irrigation (Now under the Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti), Government of India, at Roorkee. The Institute is funded by the Ministry of Jal Shakti. The main objectives of the Institute are:

1. To undertake, aid, promote and coordinate systematic and scientific work in all aspects of hydrology
2. To cooperate and collaborate with other national, foreign and international organizations in the field of hydrology
3. To establish and maintain a research and reference library in pursuance of the objectives of the Society and equip the same with books, reviews, magazines and other relevant publications
4. To do all other such things as the Society may consider necessary, incidental or conducive to the attainment of the objectives for which the Institute has been established

Since 1978, the Institute has expanded with addition of six Regional Centres in different hydrological regions of India.

The organisational structure of the Institute consists of NIH Society, Governing Body, Standing Committee, Technical Advisory Committee, Working Group for Scientific Divisions at the Headquarters, and Regional Coordination Committees for the seven Regional Centres. Details of each component of the structure are presented in Chapter 2.

The Director of the Institute is the Principal Executive Officer of the Society and is appointed by the Government of India. As on 31.3.2023, the Institute has a team of 70 Group 'A' officers (including the Director, well qualified/trained Scientists, Senior Administrative Officer and a Finance Officer) and 93 other supporting scientific, technical and administrative staff.

The research activities of the Institute are being carried out under six Scientific Divisions at the Headquarters at Roorkee and six Regional Centres at Belgaum, Jammu, Kakinada, Guwahati and Bhopal. The Institute's research and other technical activities are monitored and guided by the Technical Advisory Committee, Working Group (for headquarters) and Regional Coordination Committees. As per the directions of the Technical Advisory Committee, significant efforts have been made to include basic and applied research as part of regular work program of the Scientific Divisions at Headquarters, while at the Regional Centres and the Centre for Flood Management Studies, more emphasis is being given to applied research and field-oriented research problems.

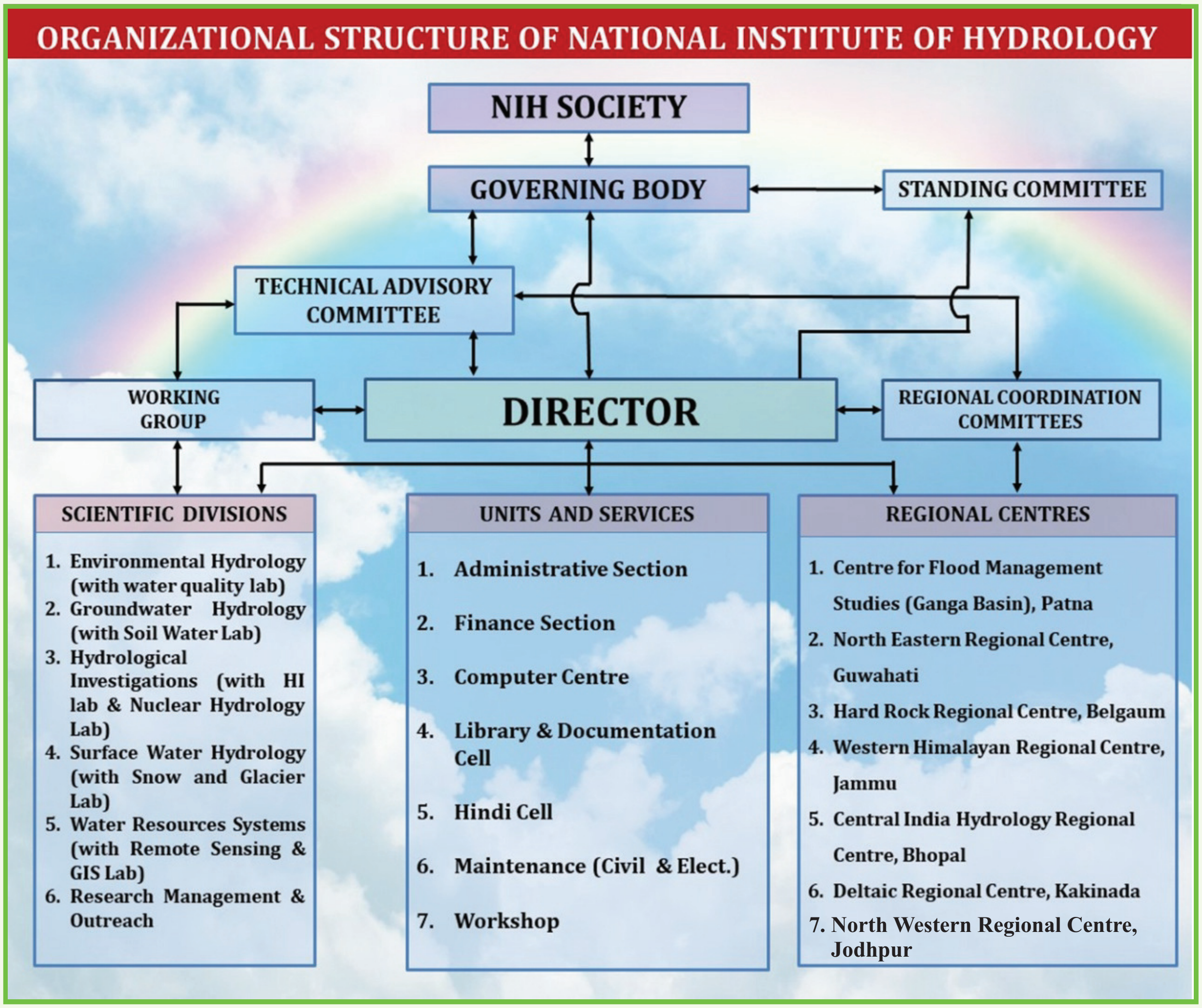
During the year 2022-23, the Institute has contributed significantly to the water sector in the country through basic and applied research in various frontier areas of hydrology. During the year, the Scientists of the Institute have published books, chapters in books, book reviews, research papers in peer-reviewed International/National Journals and proceedings of the various National and International Conferences/Symposia. A large number of R&D studies have also been undertaken under various thrust areas in hydrology. The Institute has also assisted several Central and State Government organizations, public sector undertakings and private institutions in the country in solving various hydrological problems through sponsored and consultancy projects. A number of technology transfer activities have also been organised. Brief details in respect of the above are given in 'Achievements at a Glance' and complete details are given in the ensuing chapters.

The progress made during the year 2022-23 on various scientific and technical activities along with the statement of accounts is presented in this report.

NIH Head Quarter Office Complex, Roorkee (Uttarakhand)

2 Organizational Structure

The organizational structure of the Institute is given below:



Organizational structure of NIH

2.1 Society

The National Institute of Hydrology Society is the apex body of the Institute. It reviews the progress and performance of the Institute and gives such directions as it may deem fit, to the Governing Body and the Institute towards attainment of the objectives enunciated in the Memorandum of Association of the Society. The Society has 48 members out of which 10 Ministers-in-Charge of Irrigation and Water Resources from the States and 10 eminent engineers and water resources experts are nominated by the President of the Society for a 3 years' term. The membership of the Society as on March 31, 2023, is given in Appendix-I.

2.2 Governing Body

The Governing Body (GB), under the Chairmanship of the Secretary, DoWR, RD & GR, Ministry of Jal Shakti, Government of India, is the executive body of the Institute and is responsible to pursue and carry out the activities as per objectives laid down by the Society. GB exercises all executive and financial powers of the Society. The constitution of the GB as on March 31, 2023, is given in Appendix-II.

2.3 Standing Committee

The GB has constituted a Standing Committee under the Chairmanship of the Additional Secretary, DoWR, RD & GR, Ministry of Jal Shakti, Government of India, to consider the financial and administrative matters pertaining to the Institute. The Standing Committee reviews the matters referred to it by the GB. Decisions of the Standing Committee are reported to the GB for its approval. The constitution of the Standing Committee as on March 31, 2023 is given in Appendix-III.

2.4 Technical Advisory Committee

The Technical Advisory Committee (TAC) under the Chairmanship of the Chairman, Central Water Commission (CWC), New Delhi, carries out technical scrutiny of the research program of the Institute and recommends priority areas for studies and research. It also scrutinizes the individual schemes submitted for external assistance and expansion of the Institute. The constitution of TAC as on March 31, 2023 is given in Appendix-IV.

2.5 Working Group

The GB has constituted a Working Group to consider and recommend to TAC the program of studies to be taken up by various Scientific Divisions of the Institute and review the progress of work. The Working Group, under the Chairmanship of Director NIH, has members from various Central and State Government organizations, Universities and individual experts working in the field of hydrology and water resources. The constitution of the Working Group as on March 31, 2023 is given in Appendix-V.

2.6 Regional Coordination Committees

Regional Coordination Committees (RCCs) have been constituted to ensure effective coordination between the respective Regional Centre and the various academic and field organizations engaged in water resources research and development in the Region. RCCs advise the Regional Centres in all technical and scientific matters and also examine the proposals for diversification of activities of the Centres. Experts from field organizations and academic institutes of the region covered by the Regional Centre are members of the RCCs with Director, NIH as the Chairman. Duly approved constitution of RCC for each Regional Centre is given in Appendix-VI.

2.7 Scientific Divisions

Studies and research activities at the headquarters are carried out under the following six scientific Divisions:

1. Environmental Hydrology Division
2. Ground Water Hydrology Division
3. Hydrological Investigations Division
4. Surface Water Hydrology Division
5. Water Resources Systems Division
6. Research Management and Outreach Division

The Divisions also undertake various consultancy and sponsored research projects and technology transfer activities.

2.8 Regional Centres

In order to deal with the specific hydrological problems in various regions of the country and for providing effective interaction with the States, the Institute has one Centre for Flood Management Studies (CFMS) and six Regional Centres (RCs) as given below:

1. Centre for Flood Management Studies (Ganga Basin), Patna
2. Hard Rock Regional Centre, Belgaum
3. Western Himalayan Regional Centre, Jammu
4. Deltaic Regional Centre, Kakinada
5. Central India Hydrology Regional Centre, Bhopal
6. North Eastern Regional Centre, Guwahati
7. North Western Regional Centre, Jodhpur (started w.e.f. 1.1.2023)

The detailed activities of the Scientific Divisions and Regional Centres are given in Chapter 3.

76th meeting of the Technical Advisory Committee of NIH, Roorkee (29th Aug., 2022)

53rd meeting of the Working Group, NIH, Roorkee (17-18 March, 2023)

31st RCC meeting of Deltaic Regional Centre on July 5, 2022

Scientific Divisions and Regional Centres

3

Scientific activities of the Institute are carried out under the scientific divisions and regional centres. The details are given below:

3.1 SCIENTIFIC DIVISIONS

3.1.1 Environmental Hydrology Division (EHD)

The Environmental Hydrology Division undertakes coordinates and conducts basic and applied research studies and organizes technology transfer activities in the area of environmental hydrology contributing to the sustainable water resources development and management. The thrust areas of research for the Division cover environmental monitoring including natural contaminants/pollutants, point and non-point source pollution, contaminant transport modelling, metal speciation/fractionation, wastewater and solid waste treatment/remediation technologies, river rejuvenation, water quality and human health, environmental impact assessment, environmental flow requirement for aquatic ecosystems and area drainage studies.

Research activities are conducted at varied scale from site specific, problem specific, and demand specific issues to understanding the basic relationships and dynamics between processes and their impacts in terms of quality and quantity of water resources. This includes investigations of the fate and transport of hazardous substances, investigations of chemical, biological and microbiological processes that affect quality of water and exploration of the complex hydrologic phenomena of water bodies. All research activities are aimed at improving the understanding of how the quality and quantity of water is affected by the natural environment and the anthropogenic activities.

The complex hydrological problems related to chemical-soil-water interactions are studied adopting multidisciplinary approach for drinking water, irrigation water, wastewater, hazardous wastes, and microbial pollution. To carry out basic and applied R & D studies, the Division has a well-equipped NABL Accredited Water Quality Laboratory with state-of-the-art monitoring and analytical instruments powered by a qualified team of scientists and supporting staff. Sophisticated and well-equipped Water Quality Laboratory is the major asset for research and development in the area of Environmental Hydrology. The laboratory has facilities and capabilities to determine various water quality constituents including major and minor ions, trace elements, pesticides, hydrocarbons and other organic compounds and bacteriological parameters.

Current R & D Activities: The Division has undertaken five external sponsored and eleven consultancy projects in the area of hydrology and water resources, besides the five in-house research studies. During 2022-23, under technology transfer activities, the Division organized four training programmes in physical mode. The Division is also engaged in conducting field and laboratory-based R & D activities related to monitoring, assessment and modeling of surface and groundwater quality.

Interactions with other Organizations: In pursuits of the various R & D activities, the Division has made interactions with various organizations like Central Water Commission, Central Ground Water Board, Central and State Pollution Control Boards, State Water Resources Departments, NTPC, BIS, FRI and premier academic institutions like IITs, NITs & Central Universities, etc.

Teams conducting field investigations in respect of the ongoing studies of the Environmental Hydrology Division

3.1.2 Groundwater Hydrology Division (GWHD)

The vision of the Division is the development and application of efficient and effective methodologies and technologies for sustainable groundwater resources development and management. The thrust areas of research in the field of groundwater hydrology include groundwater storage and resource estimation; groundwater modelling and management; coastal aquifer management; surface water and groundwater interaction; hard-rock and karst hydrology; strategies to sustainably manage groundwater supply and demand; river bank filtration; contaminants mobilization in groundwater systems; threat of emerging contaminants in groundwater; groundwater protection measures against contaminants; and impact of environmental changes on groundwater resources. Keeping in view these thrust areas, the Ground Water Hydrology Division is pursuing basic and applied research pertaining to various aspects of groundwater hydrology such as aquifer parameter estimation; aquifer response to untoward stresses; groundwater assessment, modelling and management; coastal groundwater dynamics; contaminant transport modelling; managed aquifer recharge; bank filtration; impact of climate change on groundwater resources, etc. The division has two technical services facilities (i) *Soil Water Laboratory,* and (ii) *Centre of Excellence for Advanced Groundwater Research* which includes 'Numerical Groundwater Modelling Unit' and 'Indo-German Competence Centre for Riverbank Filtration'. All these facilities are well equipped with advanced tools and instrumentation required for estimation of soil physical and hydraulic parameters, groundwater monitoring and assessment, characterization of aquifer hydraulic parameters, groundwater quality detection, modelling and management of groundwater.

Current R & D Activities: During the year 2022-23, the Ground Water Hydrology division was engaged in conducting field, laboratory and computer based research studies and projects related to: Groundwater fluctuations and conductivity monitoring in Punjab; Assessment of impacts of groundwater salinity on regional groundwater resources - Current and future situation in Mewat, Haryana; Ganges aquifer management in the context of monsoon runoff conservation for sustainable river ecosystem services; Integrated management of water resources for quantity and quality in Upper Yamuna basin up to Delhi; Enhancing food and water security in arid region through improved understanding of quantity, quality and management of blue, green and grey water; Expansion of the Indo-German Competence Centre for Riverbank Filtration – CCRBF; Partitioning evapotranspiration into evaporation and transpiration fluxes using stable isotopes of oxygen and hydrogen; Capacity development program on site suitability mapping for managed aquifer recharge under varying climatic conditions using remote sensing and machine learning based hydrological modelling tools; Development of integrated GEE-MODFLOW based groundwater recharge assessment system for Hindon river system; Studying arsenic genesis and developing alternate water supply management strategies in Ganga basin; Conjunctive management of water resources in IGNP command; and Studying groundwater dynamics using machine learning and numerical modelling. Apart from conducting regular R&D studies, the Division has also undertaken various sponsored and consultancy projects. In addition, the division organized four training courses/workshops on groundwater modelling and management, and decision support system during 2022-23.

Interaction with other Organizations: From time to time, the Ground Water Hydrology division has been receiving demands for undertaking R & D and specific studies from different State Government departments and other national and international organizations in areas related to groundwater. The division interacted with a number of international organizations, such as British Geological Survey, University of Manchester, Salford University, University of Birmingham, Cranfield University, India-UK Water Centre, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia, University of Applied Sciences (HTWD), Germany etc.

Geophysical survey using Electrical Resistivity Tomography (ERT) in IGNP, Rajasthan

Demonstration of G-MCDA tool for site suitability mapping for Managed Aquifer Recharge (MAR) to state officials

3.1.3 Hydrological Investigations Division (HID)

The Hydrological Investigations Division works on field and laboratory based hydrological studies using advanced isotope techniques, geophysical and hydrological techniques. The Division's main areas of research include (i) Spring Hydrology & Spring Management, (ii) Lake, Wetland & Reservoir studies, (iii) Snow & Glacier Studies (iv) Water Management in Mines, (v) Dynamics of Deeper Aquifers, (vi) Groundwater Management, (vii) Rain Water Harvesting studies and (viii) Development/ implementation of modern technologies for measurement of various data. The Division has two laboratories attached to it, namely (i) Nuclear Hydrology laboratory, and (ii) Hydrological Instrumentation laboratory. The Nuclear Hydrology laboratory has facilities to measure different types of radioactive and stable isotopes while the Hydrological Instrumentation laboratory has state of art instruments for measurement of various hydro-meteorological parameters.

Current R & D Activities: During the year 2022-23, the Division has carried out 03 R & Studies and 09 Sponsored Projects. The important components studied under these studies include (i) assessment of dissolved radon concentration in groundwater (ii) spring mapping and sustainability of springs (iii) ground water dynamics in coastal aquifers (iv) conservation and management plans for lakes (v) inventorization of springs (vi) leachate transport modelling (vii) rain water harvesting studies (viii) assessment of impact of agriculture on water balance etc. Apart from R&D studies and sponsored projects, the Division was also engaged in consultancy projects related to hydro-geological aspects of thermal power plants, assessment of impacts of thermal power plants on water quality and rain water harvesting studies.

Interaction with other Organizations: Currently, the division is consistently working with International Atomic Energy Agency (IAEA), Austria; NWO, IHE Delft Netherlands. The division is also working closely with CGWB, IITs, SKUST (Kashmir), SRM University (Chennai), BHU (Varanasi), NTPC, NEHU (Shilong), Delhi University, NEERI, and Irrigation Department, Uttarakhand.

Scientists and staff of the Hydrological Investigations Division working in field

3.1.4 Surface Water Hydrology Division (SWHD)

The thrust areas of research of SWHD include: (i) water availability analysis, flow duration curve analysis and environmental flow requirement, (ii) flood estimation, (iii) flood routing, (iv) hydrological modeling, (v) structural and non-structural measures of flood management, (vi) snow and glacier melt monitoring and modeling, (vii) urban hydrology, (viii) watershed management studies, (ix) socio-economic aspects of flood disasters, (x) drought mitigation and management and (xi) impact of climate change on water resources.

Current R & D Activities: SWHD is actively pursuing research on hydrology of extremes, i.e., floods and droughts, hydrological modeling, prediction in ungauged basins, dam break analysis & preparation of emergency action plan, flood inundation modeling and flood hazard assessment, area drainage study, project hydrology, flood forecasting using deep learning techniques, development and applications of DSS(PM) for integrated water resources development and management, modeling of snow and glacier melt, Glacier Lake Outburst Flood (GLOF) modelling, water availability analysis, environmental flow requirement assessment, impact of climate change on water resources, applications of soft computing techniques in hydrology, etc. The division is maintaining a meteorological observatory at Roorkee. The division is also engaged in sponsored and consultancy projects and has organized seminars/symposia/training courses/ workshops in the area of Surface Water Hydrology.

Interactions with other Organizations: The Scientists of the division are in constant interactions with various organizations like Central Water Commission, State Water Resources Departments, NTPC, NPCIL, BIS, FRI and other R&D and academic institutions like IITs, NITs & Central Universities, etc.

Training program on "River Hydraulics with 1D and 2D HEC RAS" organised jointly with US Army Corps of Engineers, USA (26-29 Sep. 2022)

3.1.5 Water Resources Systems Division (WRSD)

With the diverse climatic and geographic setup, India has a variety of concerns in managing its water resources, such as (a) huge spatial and temporal variation in the water availability and disparity with water demands which results in intersectoral and interstate deficits and water-related natural disasters such as floods, droughts, soil erosion and reservoir sedimentation, etc.; (b) rising water stress in large parts of the country, triggered mainly by rapidly growing population, irrigation needs, industrialization, urbanization and climate change; and (c) lack of accessible databases on hydrology and related sectors. Water resources projects are frequently planned in an isolated manner without giving due consideration to optimum utilization and environmental sustainability. WRS division is working towards finding solutions to these issues. The division is determined to provide feasible solutions to water problems by developing and applying methodologies for integrated and optimum management of water resources at the basin scale.

Current R&D Activities: TheDivision is currently carrying out experimental hydrology studies in the Himalayan region (Gangotri glacier, Henval, Uttarakhand and Leh, Ladakh, Jammu & Kashmir) involving establishment of a state-of-art hydrological field observatory with advanced automated instrumentation such as automatic weather station, automatic water level recorder, Eddy covariance flux measurement unit and COSMOS soil moisture monitoring system etc. The Division has carried out extensive works in the field of water availability, water accounting plus (WA+), snow & glacier studies, glacial lake outburst flood and watershed management in the recent past.

Application of various models for river basin planning involving the use of remote sensing data and GIS tools is in progress. The Division is actively participating in National Hydrology Project (NHP), Science and Research Board (SERB), DST, ISRO-DoS, National Mission for Sustaining the Himalayan Eco-system (NMSHE) and National Mission on Himalayan Studies (NMHS) projects. The Division is also actively involved in developing a few software, such as NIH_ReSyP (NIH_Reservoir Systems Package) and web-based information software, which is under constant refinement and improvement.

Interaction with other Organizations: The scientists of the Division are coordinating with Water Resources Departments of various States for the database development for DSS applications. Research collaborations with Carleton University, Canada; UK Centre for Ecology and Hydrology (UKCEH), Cranfield University, U.K. and International Centre for Integrated Mountain Development (ICIMOD), Nepal, have been developed by the scientists of the division. The division is involved in one international project funded by MoS-ISRO. Some of the national research collaborations have been developed by the division with IIT Roorkee, NIT Raipur, IGKV, Raipur, Jawaharlal Nehru University (JNU), Delhi, GB Pant Institute of Himalayan Environment and Development (GBPNIHESD), Indian Institute of Remote Sensing (IIRS), Dehradun etc. Scientists are interacting with officials of public sector units, viz. THDC, UJVNL, SJVNL, NHPC, etc., for solving their specific project problems. Scientists of the division are also interacting with Central Govt. Organizations like MoES, CWC and CGWB for various studies being carried out in the Division.

Training Course on the "National Hydrology Model" sponsored by the National Hydrology Project, NHP (01-05 Aug., 2022)

3.1.6 Research Management and Outreach Division (RMOD)

The vision of the Division is effective dissemination of scientific output of the Institute to improve scientific delivery and outreach of the Institute for benefit of the various stakeholders.

Current R & D Activities: RMOD basically performs the activities related to research management and techno-administration. Major functions of the Division include: to coordinate research activities among Scientific Divisions & RCs, to coordinate and liaise with the Ministry of Jal Shakti (GoI) and other ministries and departments of the Central and State Governments, coordination of technical/scientific meetings (WG, TAC, etc.), monthly reporting the progress/physical achievements (viz. technical reports, publications, trainings, etc.), preparation of documents (e.g. Output-Outcome/Result Framework Document

(RFD), NIH Annual Report, Input for AR of MoJS, Input for Jal Charcha Magazine of MoJS, etc.), preparation of thematic videos of R&D activities under "Hydrology for People" for social media and exhibitions, coordination of IEC activities/Mass Awareness in Schools, Villages, Exhibitions, coordination of Capacity building programmes including to facilitate dissertations of UG/PG students of various Institutes, input in S&T dissemination (Library & Documentation, Media Cell Activities, AV unit, Exhibitions, Training Cell Activities, IPR Cell Activities, ISO activities, INC-IHP, LCU-New Delhi), coordinating review of NIH technical reports, etc. During the year 2022-23, the Division was engaged in R & D Studies and Sponsored Projects including the Innovation Centre for Eco-Prudent Wastewater Solutions (IC-EcoWS).

Interaction with other Organizations: RMOD carries out the tasks of networking and liaison with ministries and departments, academic and research organizations, industry, NGOs, UNESCO/INC-IHP, WMO, UK-CEH, etc.

Participation of the Institute in 7th India Water Week-2022 at India Expo Centre, Greater Noida (01-05 November, 2022)

Outreach Activity in GIC, Daulatpur, Dist. Haridwar (14th Feb., 2023)

3.2 CENTRE FOR FLOOD MANAGEMENT STUDIES AND REGIONAL CENTRES

In order to deal with the specific hydrological problems in various regions of the country and for providing effective interaction with the States, the Institute has established following one Centre for Flood Management Studies (CFMS) and five Regional Centres (RCs).

3.2.1 Centre for Flood Management Studies (CFMS), Patna

Centre for Flood Management Studies (CFMS), formerly known as the Ganga Plains North Regional Centre (GPNRC) was established in May, 1991. Important rivers in the region originate mainly from different mountain ranges of the Himalayas. These Himalayan rivers carry enormous amount of silts which get deposited in the river courses and over the plains. Shifting of river courses are reported to be a common phenomenon in most of the rivers of Himalayan origin. Apart from floods, formation of chaurs, waterlogging and drainage congestion in most of the river basins are also of grave concern. Based on the hydrological problems of the Gangetic plains covering eastern Uttar Pradesh, Bihar, Jharkhand and West Bengal, the Centre is currently focusing on the studies related to design flood estimation, flood routing, structural and non-structural measures of flood management, application of remote sensing and GIS, waterlogging and drainage congestion problems, evaluation of geomorphologic characteristics of rivers, river flow modelling, erosion and sedimentation modelling, preparation of flood plain zoning maps, rainwater harvesting potential assessment and design of rainwater harvesting structures/facilities/systems and urban hydrology. In addition to field and laboratory based studies, the Centre is also involved in technology transfer activities and collaboration with various local Govt. organizations and reputed institutes. The Centre is also involved in mass awareness campaigns by organizing activities for students and villagers/farmers/women's on the topics of water conservation and sanitation.

Office building of CFMS, Patna

Objectives of the Centre: (i) to undertake strategic and adaptive research activities related to flood management for the Ganga basin (ii) to advice different Government organizations dealing with hydrology and water resources about the technological advancement in flood management and (iii) to make aware different Government organizations through technology transfer activities about the advancement in flood management.

Current R & D Activities: The centre is actively involved in basic and applied research pertaining to various aspects of the hydrological problems of the

Gangetic plains. In the years 2022-23, the Centre has completed two Institute funded R & D Studies. Presently, the centre is engaged in three Institute funded R & D Studies and 01 Sponsored Projects funded by NHP-PDS. The studies related to integrated flood management, long term safety and solution measures to address flood problem, river sediment transport modelling, river shifting and morphodynamic modeling, non-stationarity flood frequency analysis and area drainage are also proposed and are being carried out at the Centre. Under ongoing PDS study the radar based automated water level recorders (AWLR) have been installed at two sites viz. Fatehabad and Baligaon on Gandak river.

Interaction with other Organizations: The Centre has established close interaction with various central and state government organizations of water resources sector of the region. In pursuance of various R & D activities, the Centre is interacting with NWDA; CWC; CGWB; GFCC; IMD; Water Resources Departments, Governments of Bihar and Jharkhand; Bihar Rajya Jal Parishad; PHED, Bihar State Pollution Control Board. The Centre is also in close contact with public sector undertakings like NTPC, NHPC, NPCIL and DVC etc. Interactions has also been established with technical institutes like IIT Roorkee, IIT Patna, NIT Patna and other training and research institute like WALMI, FMISC, ICAR regional centre. Interactions with NGOs of Bihar, Jharkhand and West Bengal dealing with disaster management and rehabilitation works have also been established.

Technology Transfer Activities:The centre is actively involved in technology transfer activities by organizing trainings on state-of-art hydrological modeling tools, study specific workshops andawareness programme for the user agencies as well as students. The Scientists of the Center deliver lectures in other organizations like ICAR, WALMI, NERIWALM, Engineering colleges and also provide guidance to Ph.D, M. Tech and B. Tech students.

Glimpse of technology transfer & mass awareness activities organized by CFMS Patna

3.2.2 Hard Rock Regional Centre (HRRC), Belgaum

About 67% area of India is occupied by hard rock terrain. This region frequently experiences drought and at times flood also. The groundwater is one of the most dependable water resources in the region. Over the last decade, the usage of groundwater has increased exponentially causing lowering of groundwater levels. On the other hand, increased anthropogenic activities in region have resulted in dramatic changes in the land use and land cover. This has strongly affected the water availability of the region. These problems are further complicated by the changes observed in the rainfall and meteorological parameters over the region. Keeping these problems of the peninsular India in view, the Hard Rock Regional Centre (HRRC) is carrying out studies related to water availability of the hard rock region, forest hydrology, groundwater, and water logging and salinity studies. However, looking at the present and future needs of the region, drought studies, urban hydrology and the impacts of climate change on water resources sector have also been added.

Current R & D Activities**:** The Regional Centre is actively involved in conducting field-based Studies for many years. Presently the centre is engaged in many research studies, such as, Monitoring and Evaluation of Ground Water Quality of Belagavi City, Karnataka, India, Groundwater Model development in Micro Basin of Hard Rock in Krishna and Godavari River basins of Telangana Impact of Sand Mining on Groundwater Regime in parts of Manjira River Basin, Telangana State, Comprehensive Assessment of Water Availability, Use and Issues for Goa State. Also doing consultancy study of Flood review in Kali and Sharavathy river basin, Dam Break analysis, inundation mapping and preparation of Emergency action Plan for Dams in Kali, Sharavathy and Varahi river basins sponsored by Karnataka Power Corporation Ltd.

Interaction with other organizations**:** The HRRC has taken up collaborative studies with Maharashtra Irrigation and Ground Water departments, Karnataka Water Resources Department and Ground Water Department of Telangana. The Regional centre is regularly interacting with Karnataka Irrigation Department; Water and Land Management Institute, Dharwad, Institute of Water studies, Taramani, Chennai; Central Ground Water Board; Dept. of Mines and Geology, Karnataka; Gogte Institute of Technology, Belgaum; KLESociety's College of Engineering and Technology, Belgaum; Karnataka Power Corporation Ltd; Rani Chennamma University, Belgaum; Visvesvaraya Technological University, Belgaum etc. Further, the centre is recognized under Visvesvaraya Technological University, Belgaum for guidance of students pursuing M. Tech and PhD in the field of Hydrology and Water Resources. Apart from this, the centre is actively involved in giving internship to undergraduate students from engineering colleges and diploma students from polytechnic from Karnataka.

Office Building of Hard Rock Regional Centre, Belagavi

Awareness program on Water Conservation under Azadika Amrit Mahotsav by HRRC Belagavi (15.02.2023)

3.2.3 Central India Hydrology Regional Centre (CIHRC), Bhopal

The Central India Hydrology Regional Centre (CIHRC), Bhopal, formerly known as Ganga Plains South Regional Centre, was established at Sagar on 1st December 1995. The Centre was relocated to MP-WALMI Campus, Bhopal on November 1, 2012 and renamed as the "Central India Hydrology Regional Centre" in the year 2015. This Centre has been set up to carry out research studies to solve hydrological problems of basins and sub-basins of north-flowing tributaries of the Ganges namely Banas, Chambal, Kalisindh, Betwa, Dhasan, Ken, Tons, Son and other rivers of Central India including Narmada, Mahanadi, Tapti etc. The jurisdiction of CIHRC, Bhopal covers Madhya Pradesh, Chhattisgarh, southern part of Uttar Pradesh, southeast Rajasthan and the southwest part of Bihar.

The area under the jurisdiction of the Centre is primarily dependent on rain-fed agriculture. Lack of appropriate water resource management, degraded watersheds, recurrent droughts, excessive soil erosion, groundwater depletion, deterioration of water quality and reduction of forest cover has given rise to water scarcity, reduced crop yields which has resulted in the exacerbated poverty in this region. Under these circumstances, sustainable management of water resources including its quality is one of the key challenges in the R & D activities. The major focus of the Centre towards sustainable management of water resources in Central India region based on scientific research including hydrological modelling, climate change impact assessments, drought management, DSS development, reservoir sedimentation, command area management, watershed management, artificial recharge of groundwater, and water quality.

Current R & D Activities: The Regional Centre is presently involved in conducting various sponsored as well as in-house research studies and projects. During 2022-23, the centre has carried out five Purpose Driven Studies (PDS) under National Hydrology Project (NHP) and four in-house projects. These PDS studies are being carried out in collaboration with Water Resources Department, Govt. of Madhya Pradesh and Water Resources Department, Govt. of Rajasthan. PDS studies are mainly focused on prominent hydrological issues such as impacts of upcoming irrigation projects and climate change on the droughts and desertification in Chambal basin, integrated assessment of the impacts of climate change on the hydrology in Narmada basin through hydrological modelling approaches, assessment of irrigation return flow in Sanjay Sagar command in MP, and efficient utilization of water resource in Parbati canal & Dholpur piped irrigation project in Rajasthan. The in-house projects include low-cost auger hole technique assessment for groundwater recharge, re-assessment of evapotranspiration for Madhya Pradesh, water availability assessments for sub-basins of Ganga river in Madhya Pradesh, reservoir operation plan development under climate change scenarios for Kolar reservoir in Madhya Pradesh.

Interaction with other Organizations: The Centre has been involved in many National and International sponsored R&D projects in collaboration with other states and central government departments in Madhya Pradesh, Gujarat, Rajasthan, and Chhattisgarh including CWC, CGWB, WALMI, WRD, PHED, CPCB. The Centre has organized one training course sponsored by National Water Mission and six mass awareness programs during the current year. The activities of the Centre also follow close interaction with technical institutions viz., MANIT Bhopal, BHU Varanasi, IIFM Bhopal, IGKVV Raipur, JNKV Jabalpur, and MPU Udaipur.

Field visit to the Kotra Sewage Treatment Plant (13-17 March 2023)

3.2.4 North Eastern Regional Centre (NERC), NIH, Guwahati

The North Eastern Regional Centre (NERC), NIH Guwahati, formerly known as Centre for Flood Management Studies, catering for the seven North-East states, Sikkim and parts of West Bengal (Teestha basin) was established in August 1988 at Guwahati and is working for solving various water resources problems of the region. The Centre is working in the following thrust areas: As per the action plan, thrust areas for research and studies of the Ventre are (i) Flood estimation and routing; (ii) Structural/non-structural measures for flood management; (iii) Integrated watershed management for flood control; (iv) Hydrological data base management system; (v) Drainage congestion and erosion problems; (vi) Water quality problems; (vii) Socio-economic aspect of flood disaster; (viii) Springshed management; and (ix) Technology transfer through trainings and awareness programs etc. The Centre has got long term ongoing program of representative basin studies and has procured advanced software for flood studies and packages for GIS.

Current R & D Activities: The centre is actively involved in conducting field based studies for many years. Presently, the centre is engaged in Institute funded 05 R & D Studies and 02 Sponsored Projects funded by NHP. The centre is also involved in one study Sponsored under DST-SERB (Power Grant) entitled "A Coupled Hydrodynamic and Bank Dynamic Modeling Approach for Forensic Analysis of Bankline Erosion Process Along Majuli Island- the Largest Inhabited River Island in the World".

Interaction with other Organizations: Since its inception, the Centre has been actively interacting with various state/central government agencies and academic institutions like Brahmaputra Board, CWC, CGWB, IMD, NESAC, NERIWALM, Water Resources Departments, State Pollution Control Boards, IIT Guwahati, Guwahati University, and Assam Engineering College for carrying out its studies and research within the framework of recommendations of the Regional Coordination Committee.

Office Building of NERC, Guwahati

Training Program on Hydrological modelling using SWAT at NERC, Guwahati (December 5-9, 2022)

3.2.5 Western Himalayan Regional Centre (WHRC), Jammu

The major objective of Western Himalayan Regional Centre (WHRC), located at Jammu, is to carry out hydrological research for the Western Himalayan Region of the country. Jammu & Kashmir, Ladakh, Himachal Pradesh and the hilly portion of Uttarakhand constitute the jurisdiction of WHRC. This region is marked by steep mountains that influence the climatic conditions of north-west India and is the main source of water supply for Indo-Gangetic plains.

The hydrological problems of the Himalayan region differ from those of the plains due to variable topography, geology, climate, land use, soil, land cover, etc. The Western Himalayan region faces a variety of hydrological problems aggravated by the increasing impact of climate change and LULC changes: depleting cryosphere resources, drying up springs, decreasing water availability, floods associated with high intensity rainfall events, cloudbursts and glacial lake outbursts, water quality problems, soil erosion & sedimentation, deficient scientific planning for optimum use of water at various scales constrained by inadequately trained manpower and insufficient monitoring network as well as low public awareness regarding water security resulting in poor water management and wastage. Keeping these in view, the thrust areas for research at WHRC are focussed on impact of climate change on weather patterns, dynamics of Western Himalayan cryosphere including snow, glacier and permafrost with special emphasis on climate feed backs and their impact on downstream water availability using field methods, remote sensing applications and hydrological modelling, inventorying springs for their rejuvenation, hydrology of floods, representative basins, water availability and quality, effects of afforestation/ deforestation on hydrological regime on lake hydrology, hydrological network improvement & instrumentation.

Training workshop on "Tools and Techniques for Springshed Management" at Udhampur (Sep 03, 2022)

Current R & D Activities: In view of the hydrological problems in the Western Himalayan Region, WHRC is striving hard to develop methodologies for providing solution to some of the problems. In future, WHRC envisions to contribute in the following areas: assessment of impact of climate change on hydrological variables and preparation of synthetic data sets suited for WHR using statistical methods; strengthening of hydrological network in the region by using modern equipment; monitoring of hydrological characteristics of cryosphere in the region with dual emphasis on monitoring and modelling; integrated water resources management studies for Tawi river basin with special focus on flood disaster risk reduction and water availability; soil erosion assessment as well as hot spot analysis of springs and their rejuvenation plan; integrated water resources management studies for Tawi river basin with special focus on flood disaster risk reduction and water availability. Moreover, scientists and technical personnel posted at WHRC are actively involved in sponsored and internal studies carried out by NIH-HQ including two studies on spring in Ravi and Tawi basins. Also, the Water Quality and RS/GIS laboratories have been equipped to cater to some of the immediate needs of the region.

Interaction with other Organizations: The Regional Centre has been involved in supporting the State Specific Action Plan under National Water Mission, as well as assisting Jal Jeevan Mission – Jammu & Kashmir, Jammu and Kashmir Wetland Authority, Irrigation & Flood Control Department, Jammu, Soil and Water Conservation Department, J&K, Jal Shakti Abhiyaan, etc. by providing technical inputs. It also has been interacting with academic institutions in the region such as University of Jammu, Central University of Jammu, SKUAST, Jammu, IIT Jammu, etc. in issues related to the water sector. The Regional Centre also has been at the forefront of spreading awareness regarding water conservation and water security among the budding youngsters especially in Jammu and nearby areas through various IEC activities under AKAM and SBM.

IEC Activity on "Water Conservation, Sanitation and Security'" under Azadi ka Amrit Mahotsav at Govt. Girls Higher Sec. School, Satwari, Jammu (21-28 Nov., 2022)

3.2.6 Deltaic Regional Centre (DRC), Kakinada

The east coast of India is rich in utilizable water resources as most of the central and peninsular rivers (i.e., Ganges, Mahanadi, Godavari, Krishna and Cauvery) drain towards the Bay of Bengal through important river deltas. Approximately 25 km width of the east coast of India is vulnerable to the cyclone hazard and the risk is particularly severe at the mouths of rivers and estuaries. Due to cyclones and floods, the coastal areas are frequently inundated. Groundwater problems are also significant in coastal areas apart from surface water problems. The backwater through the streams and rivers, aquaculture practices, excessive pumping of groundwater and increasing temperatures are the main sources of salinity contamination in the shallow aquifers. Other than the salinity, the groundwater and surface water are also deteriorating due to industrial effluents, poorly treated sewage, irrigation return flows, and unsatisfactory household and community sanitary conditions. Further, the east coast of India, with its high population density and significant economic activities, is one of the regions that are highly vulnerable to the adverse effects of climate change. This region has also faced droughts, heatwaves, and coastal floods frequent in recent decades. Therefore, the thrust areas have been identified after interacting with various water resources agencies in the region. The main thrust areas are Urban hydrology, real-time flood forecasting, climate change impacts on river flows, drought monitoring, flash floods in ungauged basins, reservoir sedimentation, point and non-point groundwater source contamination, submarine groundwater discharge (SGD) studies, saltwater intrusion modelling, time series analyses, and rainfall-runoff modeling. The Centre is also equipped with a water quality laboratory, RS & GIS, and advanced hydrological software.

Current R&D Activities: The Deltaic Regional Centre is presently working on demand driven R&D studies referred by various state Govt. departments. Further, sponsored projects on High Performance Advanced Septic System (HPAS) for villages and roadside restaurants, Unravelling Submarine Groundwater Discharge (SGD) Zones are under progress. Purpose Driven Studies (PDS) on Groundwater salinity source identification in Godavari Delta, sedimentation study in Hirakud reservoir, behaviour of Multi-Aquifer system & Aquifer mapping for an effective Groundwater Management in Gunderu Sub-Basin (West Godavari district, AP), and identification of recharge and discharge areas of Palar River Basin in Tamil Nadu are also being carried out. Dam break studies of Kandaleru and Pulichintala dams in Andhra Pradesh, and Urban hydrological studies in Hyderabad have been completed recently under NHP. Additionally, studies pertaining to climate change impacts on regional hydrology and natural hazard risk assessments are under progress.

Interaction with other Organizations: The Centre is actively participating in various review meetings of all State Water Resources Departments of Odisha, Tamilnadu and Andhra Pradesh and also contributing to the NGT cases. Further, the Centre is imparting training on various facets of Hydrology and extending guidance for M. Tech thesis work and conducting public awareness programs.

Office Building of Deltaic Regional Centre, Kakinada

Water Quality Laboratory at Deltaic Regional Centre (NIH), Kakinada

3.2.7 North Western Regional Centre (NWRC), Jodhpur

The 7th Regional Centre of NIH namely the 'North Western Regional Centre' (NWRC), was established in Jodhpur, Rajasthan, on 01.01.2023. The jurisdiction of the newly established Regional Centre covers the north western states of Rajasthan, Gujarat, Haryana and Punjab. Large parts of these north western states fall under arid and semi-arid zones and face several challenges like low and erratic rainfall, recurrent droughts, flash floods, water scarcity, contamination of water resources, etc. Moreover, the groundwater resources are often overexploited, leading to depletion of aquifers and reducing the availability of water for agriculture, industries, and domestic use. In addition, there are problems of inefficient water management and climate change vulnerability.

The vision of NWRC revolves around water resources aspects of arid and semi-arid regions such as efficient utilization of surface and groundwater resources, augmentation of groundwater recharge through water harvesting structures, water quality monitoring and assessment, combating desertification, climate change mitigation and adaptation, alternative water harvesting methods, disaster risk reduction, and integrated water resource management planning.

Current R & D Activities

The Centre will focus on studies and hydrological investigation to address the different challenges stated above for north western states, like rainwater management for enhanced water availability, modelling studies of surface and groundwater resources for efficient utilization, sustainable utilization of palaeochannels as a potential water source, climate change impact analysis on water resources and mitigation, research on region-specific technology solutions to combat desertification, groundwater recharge studies through water harvesting structures, investigations on dew and fog climatology for alternative water harvesting methods, water quality monitoring, measures to prevent water contamination, integrated water resource management planning, and studies on disaster risk reduction.

Interaction with other Organizations

NWRC, Jodhpur, has proactively taken the initiative to collaborate with various esteemed institutions, aiming to augment its research and development endeavours. Notable organizations such as Central

Arid Zone Research Institute (CAZRI), Central Ground Water Board (CGWB), Central Water Commission (CWC), State Surface Water and Ground Water Departments of Rajasthan, Gujarat, Punjab, and Haryana, Indian Institute of Technology (IIT), Jodhpur, Indian Meteorological Department (IMD), and several other institutions of national importance have been engaged in interactions and collaborative efforts.

Office Building of NWRC of NIH, Jodhpur

Water Resources of India 4

Water resources of a country constitute one of its vital assets. India receives annual precipitation of about 4000 km^3. The total average annual flow per year for the Indian rivers is estimated as 1953 km^3. The total annual replenish able groundwater resources are assessed as 432 km^3. The annual utilizable surface water and groundwater resources of India are estimated as 690 km^3 and 396 km^3 per year, respectively. With rapid growing population and improving living standards the pressure on our water resources is increasing and per capita availability of water resources is reducing day by day. Due to spatial and temporal variability in precipitation the country faces the problem of flood and drought syndrome. Over-exploitation of groundwater is leading to reduction of low flows in the rivers, declining of the groundwater resources, and salt water intrusion in aquifers of the coastal areas. Over canal-irrigation in some of the command areas has resulted in waterlogging and salinity. The quality of surface and groundwater resources is also deteriorating because of increasing pollutant loads from point and non-point sources.

Water requirement for various sectors has been assessed by the National Commission for Integrated Water Resources Development Plan (NCIWRD) as tabulated below:

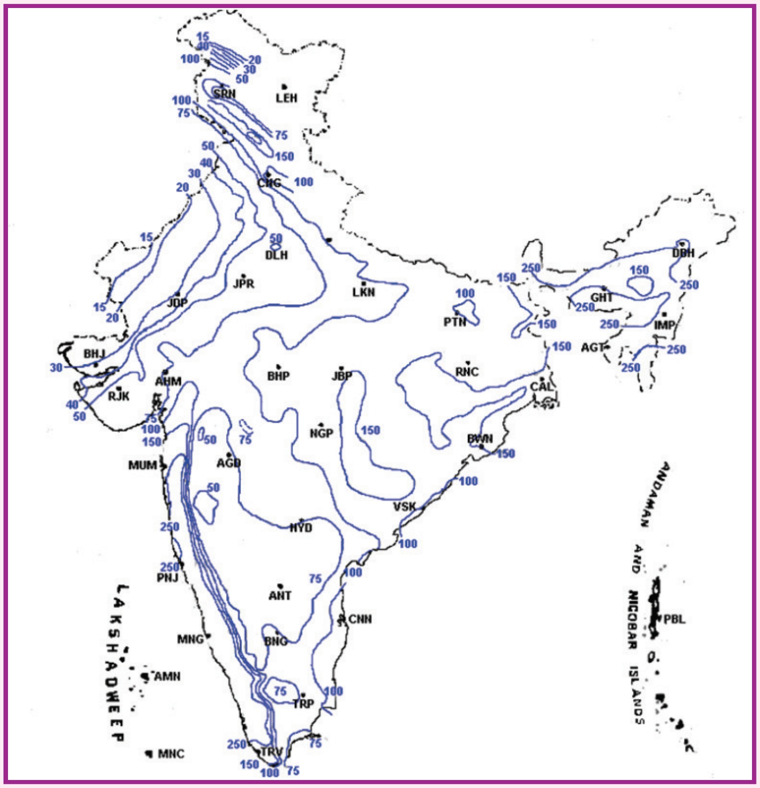
Projected Water requirements of India

Sector	Water Requirement (BCM)	
	Year 2025	Year 2050
Irrigation	611	807
Drinking Water	62	111
Industry	67	81
Energy	33	70
Others	70	111
Total	843	1180

Climate of India

Temperature and rainfall are two important variables that characterize climate.

Most of the rainfall takes place under the influence of South-West monsoon between June and September, except in Tamil Nadu where it occurs under the influence of North-East monsoon during October-November. Rainfall in India shows great variations, unequal seasonal distribution, unequal geographical distribution, and frequent departure from the normal. The long-term average annual rainfall for the country is 1160 mm, which is the highest anywhere in the world for a country of comparable size. The annual rainfall in India how ever fluctuates widely. The highest rainfall in India of about 11,690 mm is recorded at Mousinrarn near Cherra punji in Meghalaya in the north east. In this region rainfall as much as 1040 mm is recorded in a day. At the other extreme are places likeJaisalmer, in the west, which receives barely 150 mm of rain. Though the average rainfall is adequate, nearly three-quartersof therain poursdown inlessthan 120 days, from June to September. Asmuch as 21% of the area of the country receives less than 750 mm of rain annually while 15% receives rain fall in excess of 1500 mm. Precipitation generally exceeds 1000 mm in areas to the east of Longitude 78°E. It reaches nearly to 2500 mm along almost the entire west coast and over most of Assamand sub-Himalayan West Bengal. Large areas of peninsular India receive rain fall less than 600mm. Annual rainfall of less than 500 mm is experienced in western Rajasthan and adjoining parts of Gujarat, Haryana and Punjab. Rain fall is equally low in the interior of the Deccan plateau, east of the Sahyadris. A third area of low precipitation is around Lehin Kashmir. The average rainfall over India is shown in Figure below. Annual rainfall for major rivers basins is given in Table below.



Average annual rainfall over India

Annual rainfall for major river basins in India

River basin	Annual normal	
	Rainfall (cm)	No. of rainy days
Brahmaputra	268.7	112
Cauvery	119.8	65
Ganga	115.8	52
Godavari	116.1	59
Indus	88.7	46
Luni	40.6	20
Mahanadi	142.2	69
Mahi & Sabarmati	84.0	37
Narmada	123.1	50
Tapi	79.7	46

In the parlance of the India Meteorological Department (IMD), a day with a rainfall of 2.5mm or more is known as a rainy day. The mean annual number of rainy days over India varies from less than 20 over the northwestern parts (West Rajasthan and Kutchh region of Gujarat), to more than 180 in the north-east parts. In the southern parts of the West Coast also, the annual number of rainy days is quite high, about 140 days. The annual number of rainy days is around 40–60 over central parts of India. From the observed spatial pattern, the mean intensity of rainfall is found to vary between 10 and 40mm per rainy day. In the extreme northern parts, the lowest value is below 10 mm/day. The intensity is near about 10 mm/rainy days over north-western India. Along the West Coast as well as in some parts of north-eastern India, the highest value is about 40 mm/day.

With the onset of monsoons, the maximum temperature drops significantly, although the weather can be quite humid at times. Temperatures start falling from October onwards and are at the lowest during December-January. With the passage of vernal equinox in March, cool weather gives way to hot summer. Eastern parts of Andhra Pradesh, Tamil Nadu and some parts of Gujarat and Orissa are the warmest parts of the country. Jammu & Kashmir, Himachal Pradesh, Uttaranchal, and Arunachal Pradesh are the coolest states. Over the central parts of India, the maximum recorded temperatures often exceed 45^0cwhile along the west coast, the maximum temperatures fall in the range between $35-40^0$C. Smaller values of maximum temperatures of around 25^0C are recorded in parts of Himachal Pradesh and Jammu & Kashmir. Low temperature dropping to the vicinity of -40^0C have been recorded in the northern most parts of India at Kargil.

Based on the temperature and precipitation variations, there are four distinct seasons in India.

(i) The Cold Weather Season

The cold weather season starts in early December and is over by the end of February. January and February are the coldest months. In these months the temperature remains cool and dry. The temperature varies between 10^0C–15^0C in the northern India as well as about 25^0C in the southern India. Due to the western disturbances, heavy rainfall on the coast of Tamil Nadu occurs in this period. The north-west part of India also receives some rainfall or snowfall in this season. In other parts of the country, the months of January and February are cloudless and rainless and the weather remains pleasant.

(ii) The Hot Weather Season

The hot season starts in the month of March and lasts till mid-June. Weather is very hot during this season due to vertical sunshine over India. The highest day temperature reaches close to 50_ C in some places. Pre-monsoon showers are found to occur in Chottanagpur, Kerala, and Western Ghats due to low-pressure moist winds from Arabian Sea. The northern plains remain dry and hot winds called *loo* blow during the day. Sometimes dust storms occur in Punjab, Haryana and Uttar Pradesh followed by light rain and cool breeze, thereby lowering the temperature to a great extent.

(iii) The Advancing Monsoon Season

As already described above, this season runs from mid-June to September. Heavy rainfall in the whole of India occurs due to monsoon winds starting from Bay of Bengal and Arabian Sea.

(iv) The Retreating Monsoon Season

This season runs from October to November. In this season sky is usually clear and humidity is low. Monsoon starts retreating in late September to early October. The months of October and early November form a period of transition from hot rainy season to dry winter season.

Snow and Glaciers

Precipitation occurring in the Himalayas at heights of 2,450 m and above usually gets solidified as snow. The mountainous area covered by snow is about 80% of the total area of Himalayas. In Himalayas, the western part gets more snow than the eastern and gets it earlier. The snowline, the lowest line on a mountain at which snow exists throughout the year, is about 5,490 m at the equator and 610m in Greenland. In temperate zones, it is about 3,050 m. In winters, the snow line can descend to altitudes as low as 2,500 m. As successive snowfalls occur, pressure on the lower layers increases and the snow becomes a granular ice. When the weight of ice increases, the depth of ice being more than 76 m, it begins to move and is known as a glacier. The rate of movement varies from 0.3m to several meters a year.

Indian Himalayan Glaciers

Glaciers can be conceived as natural reservoirs which store precipitation in the winter season and gradually release it as melt water in summers, thereby augmenting

flows into the rivers. Himalayas are the home to a multitude of glaciers and are the largest reservoir of snow and ice outside the polar regions. In the rivers originating from Himalayas, significant snow and glacier melt runoff contribution begins in April when seasonal snow cover starts ablating. This contribution continues till October/ November depending upon the climate conditions.

The principal glaciers in Himalayas can be divided in four groups:

a) Punjab Himalaya Group,
b) Garhwal Himalaya Group,
c) Nepal Himalaya Group, and
d) Assam Himalaya Group.

Punjab Himalaya Group of Glaciers: Under the Punjab Himalaya Group, the major glaciers are: Rakhiot Glacier, Kolhai Glacier, Neh-Nar Glacier, Sarbal Glacier, Kangriz Glacier, Brahma Glacier, Drung Drung Glacier, Mulkila Group Glaciers, Barashigri Glacier, Dibi Bokri Glacier, Gara Glacier and Gorgarang Glacier.

Garhwal Himalaya Group of Glaciers:Garhwal Himalaya Group of Glacier includes Gangotri Glacier, Santopath Glacier, Kedarnath Glacier, Milam Glacier, Pindari Glacier, Shankulapa Glacier, and Poting Glacier.

Nepal Himalaya Group of Glaciers:Yaling Glacier, Chong Kumadan Glacier, Rundun Glacier, Glaciers adjoining to Dhaulagiri and Annapurna Peaks, Kang Shung Glacier, Rupal Glacier, Khumbu Glacier, Glaciers adjoining to Makalu Peak, and Zemu Glaciers fall under this group.

Assam Himalaya Group of Glaciers:Glaciers adjoining Kanchenjunga peak, Sanlung Glacier and Glaciers adjoining Gyara Pari peak falls under the Assam Himalaya Group of glaciers.

Major River Groups of India

Based on the topography, the river systems of India can be classified into four groups. These are: (i) Himalayan rivers, (ii) Deccan rivers, (iii) Coastal rivers, and (iv) Rivers of the inland drainage basin.

The Himalayan Rivers receive input from rain as well as snowmelt and glacier melt and, therefore, have continuous flow throughout the year. During the monsoon months of June to September, Himalayas receive very heavy rainfall and experience maximum snow melt and these are the periods when the rivers carry about 80% or more of the annual flows. This is also the time when these rivers are prone to flooding. The main river systems in Himalayas are those of the Indus and the Ganga-Brahmaputra-Meghna. The Indus rises near Mansarovar in Tibet. Flowing through Kashmir, it enters Pakistan and finally falls in the Arabian Sea near Karachi. A number of important tributaries of Indus flow through India, namely, the Sutlej, the Beas, the Ravi, the Chenab and the Jhelum.

The Deccan rivers are rainfed and therefore have very little flow during non-monsoon season; many of these are non-perennial. The rivers of Deccan can be further classified in two groups: west flowing rivers and east flowing rivers. The Narmada and the Tapi rivers flow westwards into Arabian Sea. The important east flowing rivers are the Brahmani, the Mahanadi, the Godavari, the Krishna, the Pennar, and the Cauvery. These rivers fall into the Bay of Bengal.

The coastal streams, especially on the west coast, have small catchment areas and are short in length. Most of them are non-perennial. There are numerous coastal rivers which are comparatively small. While only handful of such rivers drain into the sea near the deltas of east coast, there are as many as 600 such rivers on the west coast. The West Coast rivers are important as they contain as much as 14% of the country's water resources while draining only 3% of the land.

The rivers of the inland system, centered in western Rajasthan state, are few and frequently disappear in years of scant rainfall. They flow for some time during monsoon only. A few rivers in Rajasthan do not drain into the sea. They drain into salt lakes or get lost in sands with no outlet to sea.

Basins of India are shown in the figure given below which is taken from WRIS (Water Resources Information System).

River basins of India

Physical Characteristics of India

India occupies the south-central peninsula of the Asian continent. Besides the mainland, there are two groups of islands, namely Lakshadweep in the Arabian Sea and Andaman & Nicobar Islands in the Bay of Bengal. The mainland of India lies between $8^{0}4'$ N and $37^{0}6'$ N latitude and $68^{0}7'$ E and $97^{0}25'$ E longitude. The Andaman and Nicobar Islands lie to the south east of the mainland and Lakshadweepto the southwest.

India is endowed with almost all the important topographical features, such as high mountains, extensive plateaus, and wide plains traversed by mighty rivers. The country is bounded by Himalayas in the North and has a large peninsular region tapering towards the Indian Ocean. The Himalayas in the north are the major mountain ranges of the world. The other prominent mountains of India include the Aravallis, the Vindhyachals, the Satpuras, the Eastern Ghats, and the Western Ghats. The mountains are the primary source of rivers which derive their flow from rainfall and snow and glacier melt. The plateaus are another striking feature of topography in India and they range in elevation from 300 to 900 m.

With a geographical area of 3,287,263 sq. km, India is the seventh largest country in the world. India occupies about nearly 2.42% of the land area of the earth. The latitudinal and longitudinal extent of India is almost of the same magnitude in degrees, about 30_. The distance between the extreme north to south tip is about 3,200 km while the east-west extent is 3,000 km.

In India, about 51.09% of the land is under cultivation, 21.81% under forest and 3.92% under pasture. Built up areas and uncultivated land occupy about 12.34%. About 5.17% of the total land is uncultivated waste, which can be converted into agricultural land. The other types of land comprise upto 4.67%.

Indian soils are generally classified into four major types: (i) the Indo-Gangetic alluvium soils; (ii) the black cotton or regur soils; (iii) the red soils lying on metamorphic rocks; and (iv) the laterite soils.

India is rich in bio-diversity – the country is one of the 12 mega-diversity nations. The country has 7% of the world's biodiversity and supports 16 major vegetation types. About 200 million people in India depend on forests for their livelihoods –directly or indirectly. Forests are important in environmental and economic sustainability, provide numerous goods and services, and maintain life-support systems.

The Indian forests ranges from evergreen tropical rain forests in the Andaman and Nicobar Islands, the Western Ghats, and the north-eastern states, to dry alpine scrub that are found in the Himalayas. Interspersed between these two extremes are semi-evergreen rain forests, deciduous monsoon forest, thorn forests, subtropical pine forests, and montane zone forests.

The Forest Survey of India (FSI) assesses the forest cover of the country using satellite imageries and ground verification. India has 51,285 sq. km of very dense forest, 339,279 sq. km of moderately dense forest, 287,769 sq. km of open forest, and 99,896 sq. km of tree cover. This implies that forest cover occupied 20.64 % of country's geographic area, tree cover occupied 3.04% area, yielding total 23.68 % of the covered area. Madhya Pradesh accounts for the largest forest cover of the country at 76,429 sq. km followed by Arunachal Pradesh (68,019 sq. km), and Orissa (48,366 sq. km).

Plants of a particular region, which have several species, are referred to as flora. About 49,000 species of plants have already been found in India, which represents the widest range for any country of the world. Out of 49,000 species of flora, about 5,000 species are found exclusively in India including flowering and non-flowering.

Agriculture Seasons in India

India has mainly two agricultural seasons, namely, the Kharif and the Rabi. In Kharif season crops are sown in June-July and harvested in September-October. The Kharif crops include rice, millets, maize, groundnuts, jute and cotton. Pulses are also grown during this season.Rabi SeasonCrops are sown in November and are harvested in April-May. The Rabi season production largely depends upon subsoil moisture. The major crops are wheat, gram, oil seeds like mustard and rapeseed.

Besides these two main seasons, farmers in irrigated areas are able to reap a third harvest during May to July. This season is known as hot weather or Zaid. Moong and Urad are popular crops of this season. Watermelon and Cucumber are also grown in this season. In addition to food crops, India also produces a large number of non-food or cash crops like, Sugarcane, Tea, Coffee, Cotton, Tobacco, Rubber, and Spices, etc. Sugarcane is a perennial crop that occupies land year around. India is famous all over the world for high quality tea, such as the Darjeeling tea. Tea plants thrive in hot and humid climate. Tea is mainly grown in West Bengal, Assam, Tamil Nadu, and Kerala. Coffee is a related crop that also requires similar climatic conditions albeit lesser rainfall. It is grown mainly in Karnataka, Kerala, and Tamil Nadu and large production of the crop has made India a leading coffee exporter.

Water Resources Requirement

Water use efficiency in India is presently estimated to be around 40% for canal irrigation and about 60% for ground water irrigation schemes. India's per capita water availability per year (1991 census) was estimated at 2,209 m^3 against the global average of 9,231 m^3.

Surface water is either used in-stream for hydropower, recreation, navigation etc. or is diverted for off-stream use. Ground water is mostly used for irrigation or for domestic requirements. The consumptive uses of water are: (a) Irrigation for agriculture, (b) rural and municipal water supply, and (c) industrial water supply. The Indian economy has traditionally been agriculture based and the principal consumptive use of water is for irrigation. On the total water use in 1990, the share of agriculture was 83%, followed by domestic use (4.5%), energy (3.5%) and industrial use (2.7%). The remaining 6% were for other uses including environmental requirements. At the time of independence, it was of crucial importance to develop irrigation to increase agricultural production for making the country self-sustained and for poverty alleviation. Accordingly, irrigation sector was assigned a very high priority in the 5-year plans. Giant schemes like the Bhakra Nangal, Hirakud, Damodar Valley, Nagajunasagar, Rajasthan Canal project etc. were taken up to increase irrigation potential and maximize agricultural production.

The annual potential natural groundwater recharge from rainfall inIndia is about 342.43 km^3, whichis 8.56%of total annual rainfall of the country. The annual potential groundwater recharge augmentation from canal irrigation system is about 89.46km^3. Thus, total replenishable ground water resource of the country is assessed as 431.89%. After allotting 15% of this quantity for drinking, and 6 km^3 for industrial purposes, the remaining can be utilized for irrigation purposes. Thus, the available groundwater resource forirrigation is361km^3,of which utilizable quantity (90%) is 325 km^3.

Dams and Lakes in India

Dams in India are constructed mainly for irrigation, hydroelectric generation, flood control, and water supply; a few are constructed for other purposes. At the turn of twentieth century (1900), there were 42 dams in India. During 1901 to 1950, about 250 dams were added. That is, at the time of the beginning of first five-year plan period (1950-51), there were a total of about 300 dams. During the next twenty years, there was a spurt in dam construction activity in which 695 dams were added, bringing the total number of dams to nearly 1,000 up to the year 1970. The dam building activity intensified during the next two decades and at the end of 1990, the total number of Indian dams stood at 3,244 (not accounting for 236 dams for which the year of construction is not available). Due to slow down in economy, opposition on socio-economic grounds, and other reasons, only 116 dams could be added between 1990 and 2000. India had 4,291 large dams and about 250 large barrages by 2003, including 695 dams under construction. Distribution of large dams in India according to their age is presented below.

Distribution of large dams according to age

Year of completion	Number of dams
Up to 1900	42
1901-1950	251
1951-1960	234
1961-1970	461
1971-1980	1,190
1981-1990	1,066
1991 – 2000	116
Year of construction not available	236
Under construction	695
Total	4,291

Depending upon the depth of water and uses, the lakes are known by different names in different parts of the country like, Jheels, Bheels, Marshes, Talab and Tank. In India, the lakes have been extensively utilized, often resulting in overexploitation. A national inventory of lakes entitled "The All-India Wetland Survey" was completed in the mid-1980s.

Some lakes in India have significance from religious point-of-view. The city of Amritsar in Punjab which is famous for the Golden Temple got this name (Amritsar means the lake of nectar, the drink of Gods. He who drinks nectar becomes immortal) because of the holy lake. A bath in the lake water is considered to be a privilege. The main important lakes in India are Dal lake, Nagin lake, Surinsar Lake, Mansar Lake, Khajjiar Lake, Nainital lake, Harike lake, Loktak lake, Chilka lake, Pushkar Lake etc.

Concluding Remarks

Water is one of the most essential natural resources for sustaining life and it is likely to become critically scarce in the coming decades, due to continuous increase in its demands, rapid increase in population and expanding economy of the country. Variations in climatic characteristics both in space and time are responsible for uneven distribution of precipitation in India. This unevendistribution of the precipitation results in highly unevendistribution of available water resources both in space and time, which leads to floods and drought affecting the vast areas of the country. Better and scientific structural and non-structural measures are required for mitigating the floods and droughts. Mathematical models are needed for forecasting the monsoon rainfall accurately,which maybe utilized by the decision makers and farmers for adopting appropriate strategies for management of droughts and floods. There is a need for increasing the availability of water and reducing its demand. For increasing the availability of water resources, there is a need for better management of existing storages and creation of additional storages by constructing small, medium and large sized dams considering the economical, environmental and social aspects. The availability of water resources may be further enhanced by rejuvenation of dying lakes, ponds and tanks and increasing the artificial means of ground water recharge.

Impact of Climate Change in India

5

Introduction

India's water resources are already under pressure due to population growth, economic development, industrialization, urbanization, over exploitation of groundwater and most importantly the inefficient usages of water. It has been further exacerbated by adverse impacts of climate change due to number of reasons. Climate change is causing, rising temperatures, and spatio-temporal shifts of precipitation more severe, unpredictable weather are likely to affect rainfall and its distribution, as well as river flows and groundwater, and impaired water quality. The climate change has also resulted in an increase in frequency and intensity of extreme precipitation, droughts and tropical cyclones. Floods account for almost 47% of natural disasters in India in the last 100 years and nearly 20% of the total flood-prone area is affected every year. Climate change is also expected to increase the frequency of droughts in future. India has to ensure water, food, and energy security to its growing population and also need to protect its people from water-related disasters which are likely to become more frequent, intense, and widespread with time. Recently published Sixth Assessment Report (AR6): Working Group (WG) 1 (The Physical Science Basis) in August, 2021 by the Intergovernmental Panel on Climate Change (IPCC) is quite similar but larger than its predecessor AR5 and differs from it on one main account i.e. the scientists are now more confident that major cause of climate change are human activities. Therefore, it would be necessary to initiate actions in time so that the adverse impacts are mitigated and the damage to infrastructure and population is minimized.

Likely Impacts of Climate Change

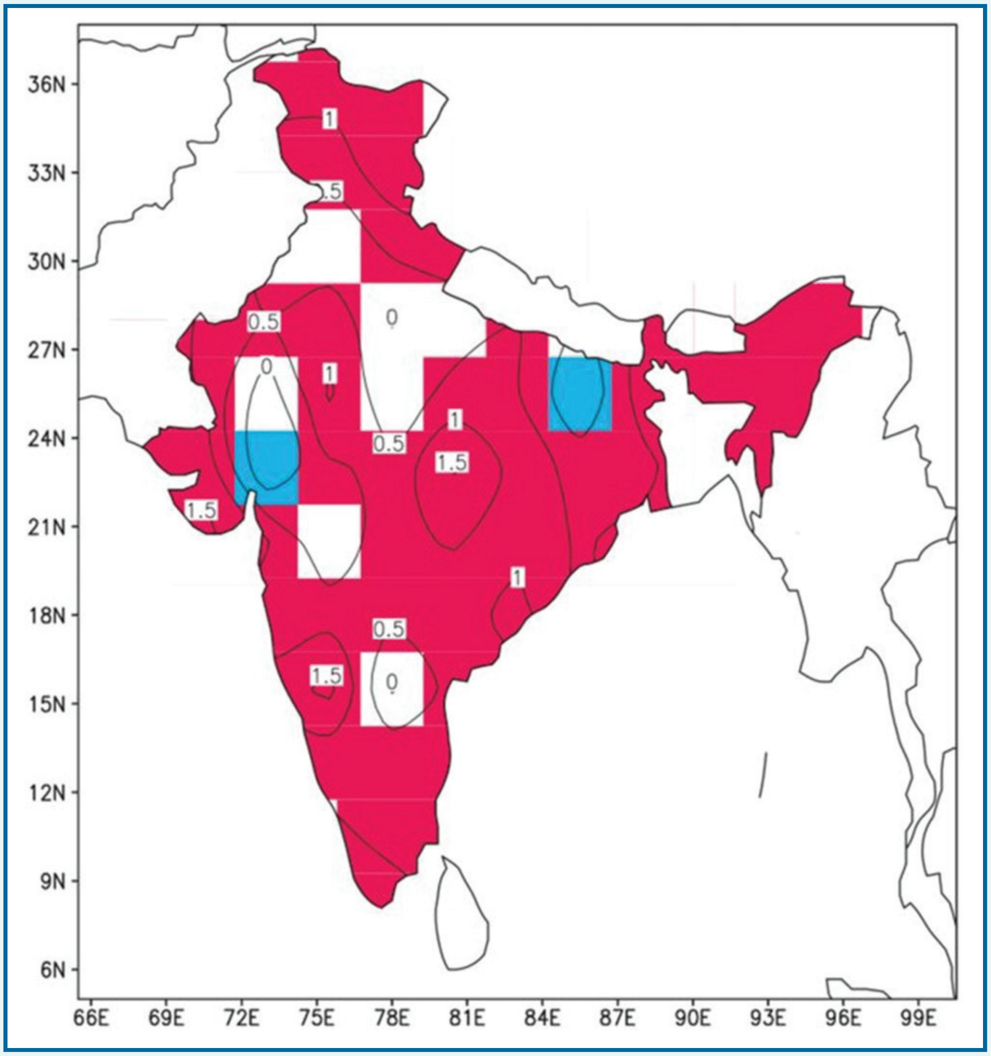
The regional climate over the Indian subcontinent involves complex interactions of the atmosphere–ocean– land–cryosphere system on different space and time scales. In addition, there is evidence that anthropogenic activities have influenced the regional climate in recent decades.

(i) Rainfall

The summer monsoon precipitation (June to September) over India has declined by around 6% from 1951 to 2015, with notable decreases over the Indo-Gangetic Plains and the Western Ghats. There is an emerging consensus, based on multiple datasets and climate model simulations, that the radiative effects of anthropogenic aerosol forcing over the Northern Hemisphere have considerably offset the expected precipitation increase from GHG warming and contributed to the observed decline in summer monsoon precipitation. In order to study the impact of Climate Change on rainfall quantity and pattern, a detailed analysis was carried out to determine the trends in rainfall amount and number of rainy days in Indian River basins by using daily gridded rainfall data at $1^{o}\times1^{o}$ resolution. Trend analysis of rainfall data of 135 years (1871-2005) indicated no significant trend for annual, seasonal and for any monthly rainfall on all-India basis.

(ii) Temperature

Temperature is another critical variable showing changes over the years. There is a rapid rise in surface temperatures over India, particularly since 1980 and may increase 2.5^{0}C to 5.5 ^{0}C at the end of 21st centuryunder GHG scenarios. The maximum susceptibility over Himalayas, north, central and western parts of India with a lower influence on the southern part of India and will have more warm days and nights as compared to the cold days and night. The temperature anomalies based on the data for the period 1901-2019 suggest significant positive



Trends in annual mean temperature significant at the 95% level over India during 1901–2016 (after Ross et al., 2018) (red colour indicates increasing trends while blue colour indicates decreasing trend)

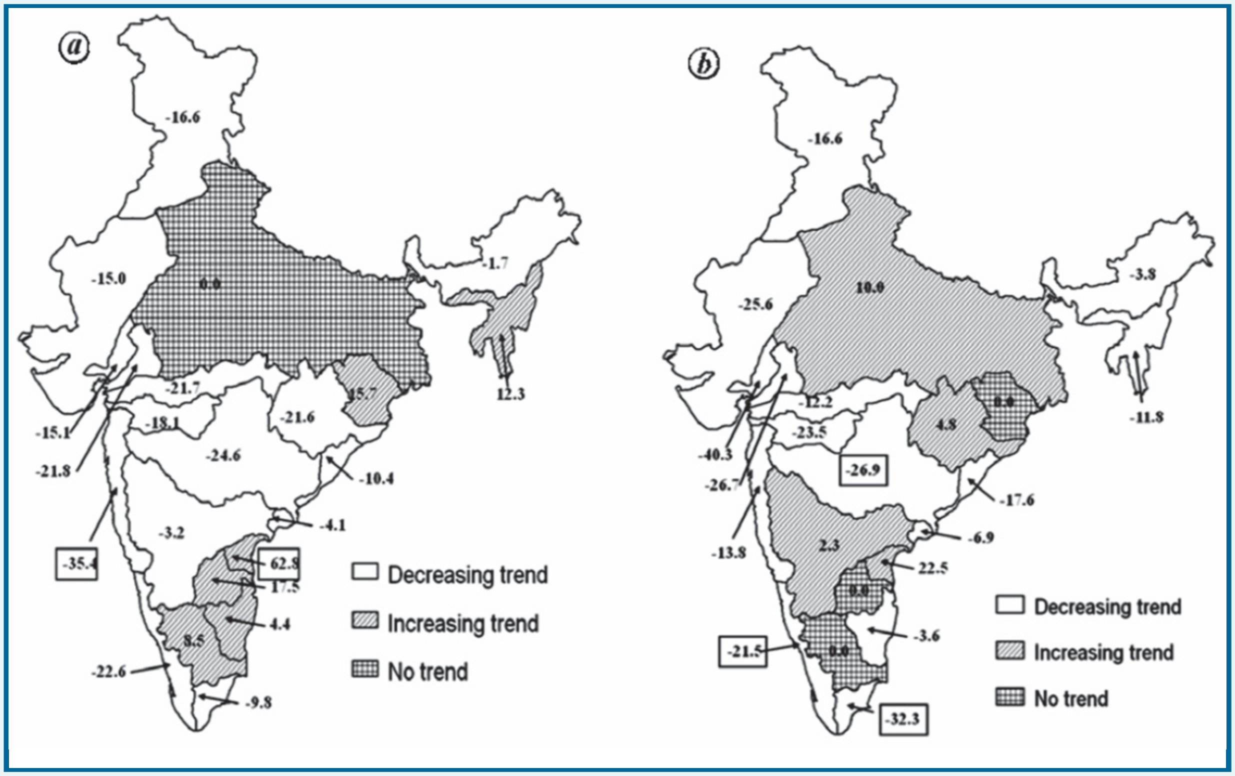
(increasing) trend over most parts of the country except in parts of some States that include Rajasthan, Gujarat, Uttar Pradesh and Bihar, where significant decreasing trend was observed

(iii) Water availability

Water availability is a major factor for human society's ability to meet the future food and energy needs of a growing population. Climate change is likely to cause significant changes in the availability of surface and groundwater in river basin. It is projected to affect the water balance, and particularly the amount of runoff and recharge, which in turn determines the water resources available for human and ecosystem. Due to likely reduction in stream flow and ground water recharge along with increase in irrigation demands, the water stress in the region would aggravate.

Climate change is also expected to affect groundwater due to changes in temperature, precipitation and evapo-transpiration which in turn affect soil water balance and ground water recharge. The direct effect of climate change on groundwater resources depends upon the change in the volume and distribution of groundwater recharge.

Increase of temperature and changes in precipitation patterns over the Himalayan region is a major



Trends and magnitude pertaining to rainfall changes for different river basins in India. Significant trends are displayed in boxes. (a) annual rainfall (% of mean/100 years); (b) annual rainy days (% of mean/100 years)

concern for the health of the Himalayan snow cover and glaciers. This region has experienced significant melting of snow and retreat of glaciers during the past five decades. Long-term trends in the maximum, minimum and mean temperatures over the north western Himalaya during the 20th century suggest a significant rise in air temperature in the north western Himalaya, with winter warming occurring at a faster rate. The continuous glacier loss and corresponding development and progressive growth of glacial lakes has been attributed to warming temperatures particularly minimum temperature.

(iv) Water Demands

Rising temperatures and altered meteorological variables will also alter demand for most water uses leading to imbalance between user demand and supply and may be worsened under climate change.

Water use in Agriculture

The Indian agriculture is heavily climate dependent with notable regional and climatic variabilities. The agriculture sector is already facing multi-dimensional pressure from many stressors such as climate change, socio-economic, i.e., population growth, unbounded urbanization and industrialization. The changes in climate (mainly) in the form of precipitation, temperature, and radiation will affect the water availability and water demands for both irrigated and rainfed crops, crop growth and productivity. The crop water demands differ among cropping systems and could be significantly impacted by climate change.

Domestic and Industrial Water use

India's urban population as per the 2011 census was 377 million, accounting for nearly 31% of the country's total population. Currently, around four billion people live under conditions of severe freshwater scarcity for at least one month of the year, with half a billion people in the world facing severe water scarcity all year round. India is in the midst of a severe and chronic water shortage due to climate change, supply/demand imbalance, and poor water resource management. By 2050, India is expected to have significant water shortages due to population growth and other factors.

Water use in Energy Production

India is the 7th largest hydroelectric power producer in the world and has a high potential for hydropower generation. Climate change is likely to have an impact on hydropower generation by altering the timing and amount of streamflow, increasing inter-annual variability of flows, changing the type and variation of demands, and altering evaporation from reservoirs and sediment fluxes. Changes in seasonal snow, as well as glacier mass, will also have the potential to change the magnitude and seasonality of streamflow. All of these changes can directly affect hydropower operations.

Water for Environment

Climate change induced changes will also likely freshwater environments and ecosystem services (e.g. fisheries, water purification, tourism). It has many possible impacts on the biogeochemical processes that occur in different types of water environments. The major impacts may be (i) enhanced eutrophication, salinization, and nutrients release, (ii) reduced pH and dissolved oxygen in the water bodies, (iii) increase in the influx of pollutants into the water bodies due to more frequent extreme storm events, (iv) increase in waterborne diseases due to upsurge of pathogens, and (iv) alteration in the aquatic biodiversity composition. Rising water temperature will also lead to the deterioration of the drinking water quality due to impact of climate change.

Challenges in Assessment and Mitigation/ Reducing the impacts of Climate Change

(i) Uncertainties in Projections

The questions in hydrological studies is how to develop more reliable and regional scale projections so that they can be applied in hydrological modelling effectively. Uncertainty in future climate change presents a key challenge for adaptation planning. Customization of climate models for Indian conditions is also a challenge.

(ii) Human Migration due to climate change

The Intergovernmental Panel on Climate Change (IPCC) noted that the greatest single impact of climate change could be on human migration with millions of people displaced by shoreline erosion, coastal flooding and agricultural disruption.

The climate change is likely to be the primary driver of biodiversity loss in the future. Climate change imposes additional stress on ecosystems that are already stressed due to overuse, degradation, fragmentation, and loss of total area. When these factors interact, they reduce not only ecosystem resilience but also human options for dealing with a changing environment.

In India, a very large populations live in the areas that are likely to get more floods and water stress. It may also lead to lower agriculture productivity therefore migration of people from these places is expected. In coastal areas also, the dependence on agriculture for daily subsistence and livelihoods, more floods, landslides, droughts, and cyclones will increase vulnerability leading to migration related challenges.

(iii) Understanding Hydrological Extremes

Hydro climatic extremes such as droughts and floods are inherent aspects of the monsoonal landscape. The quantification of extreme events (floods or droughts) due to Climate Change poses a major challenge because of accuracy related issues in downscaling of global climate models at smaller catchment scales. Increased frequency of localized heavy rainfall on sub-daily and daily timescales has enhanced flood risk over India. Increased frequency and impacts of floods are also on the rise in urban areas. The overall decrease of seasonal summer monsoon rainfall during the last 6–7 decades has led to an increased propensity for droughts over India. Both the frequency and spatial extent of droughts have increased significantly during 1951–2016. In particular, areas over central India southwest coast, southern peninsula and north-eastern India have experienced more than 2 droughts per decade, on average, during this period.

(iv) Crop growth and food production

Climate change may have a number of negative consequences on crops in various locations, and detrimental consequences are already being felt. The majority of model predictions indicate that without adaptation major agricultural yields (wheat, rice, and maize) will suffer in tropical areas. There is a need for intensive, innovative, and location-specific adaptations to ensure food security in the future.

(v) Ensuring Water, Food and Energy Security

India is one of the countries most affected by climate change and occupies sixth place in the Global Climate Risk Index 2018. According to India's Composite Water Management Index (2018), 600 million people in the country are suffering from an acute shortage of water.

Energy is the primary cause of climate change since it produces the majority of greenhouse gases. The world's reliance on fossil fuels, as well as their increasing usage, has contributed to the current situation. The climate change problem will not be solved unless the energy issue, in all of its aspects, is addressed.

Climate change, on the other hand, is limiting the amount and quality of water available for drinking and agriculture. Country's food security may be placed under progressively greater pressure due to rising temperatures, heat extremes, floods, droughts and increasing year-to-year rainfall variability that can disrupt rain-fed agricultural food production and adversely impact crop yield. In Himalayan region, receding of glaciers and reduction of snowmelt coupled with rising population and altered land use/land cover have serious implications for water security.

Energy security and climate change are interrelated issues, and India will need to adopt strategies that would meet its energy needs and cause minimal disruption to the economic growth, at the same time, reducing carbon emissions. The challenge is managing the integration and trade-offs of energy security and climate change.

(vi) Infrastructure and Governance Needs

Effective climate change adaptation requires an understanding of the various ways in which social processes and development pathways shape reduction in disaster risk. India must adopt mainstream climate action, accelerate adaptation efforts across sectors, and build resilience capacity, while also maintaining efforts toward sustainable development and embracing innovative solutions to reduce GHG emissions. This will necessitate the use of governance frameworks that include key components as well as feedback between the various components. Appropriate institutional arrangements to achieve the goals to coordinate between different institution/departments having expertise in the related interdisciplinary field as we know that the climate change impact studies are multi-disciplinary.

Opportunities and Way forward

(i) Mitigation and Adaptation

A detailed scientific understanding of the causes behind climate change, trends in data and possible impacts is essentially required. For this, impact of climate must be assessed at regional and national level. Hydrologists need to generate what-if scenarios based on the probability of occurrence of extreme events in order to develop adaptation measures. Such scenarios can reveal the performance and resilience of hydro-infrastructure, as well as any critical design and operation gaps.

Probabilistic flood inundation maps for each basin should be created and updated on a regular basis to account for changes in land use, construction, climate, demography, and so on.

The adaptation measures such as rainwater harvesting, afforestation in soil erosion-prone areas, water recycling and reuse, desalination, efficient crop water management, and pond and wetland restoration need to be promoted.

(ii) Management of Hydrological Extremes

As the extreme events are going to be more frequent and intense, it will be necessary to develop and strengthen infrastructure (structural as well as non-structural for both, surface water and groundwater resources) to deal with increasing variability. We need to develop ways and means to store water made available during high flows to minimise adverse impacts and use stored water beneficially in dry periods. In this regard, there is strong need to conserve water at suitable places in natural/artificial surface water storages (through dams/ponds/ wetlands or interlinking schemes) as well as in aquifers (through water harvesting and artificial GW recharge) The creation of adequately sized surface water storage provides resilience against temporal variability of inflows whereas the interlinking of rivers (ILR) takes care of the spatial variability of water resources availability across river basins. The ILR alone, if implemented as per the National Perspective Plan, can increase the utilisable water resources to the tune of about 200-250 BCM.

There should be active collaboration within the institutes and departments engaged in the applications of new methodologies and techniques such as hydrological modelling, soft computing, GIS and remote sensing, downscaling of GCM and RCM data and assessment of impact of climate change etc. for estimation of design floods for various types of hydraulic structures and flood inundation for the present situation and future considering impact of climate change.

Regulation of urban development in flood-prone areas and flood plains needs to be brought along with Preparation of Emergency Evacuation Plans (EAP) for the flood prone areas and design of appropriate drainage systems in urban centres, to quickly drain off the accumulated flood waters in the city.

(iii) Aspects of Research & Development

More research is needed towards understanding the behaviour of climate system, especially in four areas: a) regional climate prediction, b) precipitation forecasts, c) aerosols, and d) paleoclimate data.

Improved Understanding of Climatic phenomena

The climate research and development programs strive to advance the understanding of the physical, chemical, and biological components of the Earth system, the causes and consequences of climate and land use change, and the vulnerability and resilience of the earth system to such changes. A thorough scientific understanding of the causes and historical trends underlying climate change and its consequences is a must for dealing with the problem. This will aid in initiating the necessary actions to mitigate the negative consequences. Future climate projections at the local and regional levels are full of uncertainty. These projections serve as the foundation for corrective actions such as adaptation projects. As a number of modelling groups around the world work to improve their models, it is hoped that the regional projections made by the next generation of models will be less uncertain and useful to planners and policymakers. These efforts will be aided by the availability of better data and more powerful computers.

Improved Hydrological and Allied Data Collection

Climate data are essential in an array of climate research and applications that include analyses of climate variability and trends and modelling the impact of climate variability and change on different socioeconomic activities. But, there is considerable uncertainty in the country's future climate projections due to a lack of data on hydrologic, economic, and other sectors. Uncertainty may arise as a result of the use of GCMs for climate projections, downscaling techniques, and hydrologic models. There are numerous critical data gaps in India's water sector. To predict the changes, reliable baseline data are required. It would be beneficial to establish a network of reference climate data stations capable of providing high-quality long-term data for a better understanding of changes in meteorological and hydrological variables across the country and we need to develop future projections of maximum temperature, minimum temperature, mean temperature, and precipitation at fine spatial and temporal resolutions for various greenhouse gas concentrations.

Alongside this, a society which is knowledgeable and aware is more resilient and can better be prepared to manage the risks. Hence, the society should be made aware and their understanding about climate change risks need to be enhanced. Water quality data in India are scanty; limited variables are measured and at sub-optimal frequency. Hydrogeological maps are needed for improved assessment of ground water resources, impact of climate change on them, and groundwater contamination. Utilization of water in its various uses is rarely measured. Hence, there is considerable uncertainty in the estimates of water utilization which needs to be resolved.

Improved Water Management Practices

With the changing water demands and water availability distributions, the design and operation protocols of water resources projects (say, rule curves for deficit water management and flood operation policies for excess water management) need to be revised at regular time intervals. IWRM (integrated water resources management) is increasingly seen as the holistic way to manage water resources in a changing environment while managing competing or conflicting demands. IWRM consists primarily of three major components: explicit consideration of all potential supply-side and demand-side actions, inclusion of all stakeholders in the decision-making process, and ongoing monitoring and review of the water resources situation. In the absence of climate change, IWRM is an effective approach with numerous justifications for implementation. Adopting integrated water resource management will go a long way toward improving water managers' ability to adapt to climate change.

Concluding Remarks

India is among the countries that are highly vulnerable to climate change, due to geographical location as well as topography and economy and population. Reports of IPCC and discussions on international forums have been urging the nations to initiate actions tackle challenges arising due to climate change. In response, the Indian government developed a National Action Plan on Climate Change (NAPCC) in 2008 as well as asked all states to prepare State Action Plans on Climate Change (SAPCC). The NAPCC has eight missions that deal with different facets of climate change adaptation and mitigation. Among these, the missions relevant to water sector are: National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for Sustainable Agriculture, and National Mission for Strategic Knowledge on Climate Change.

6 Research and Development

National Institute of Hydrology is engaged in hydrological research for more than forty years. At present, research and development activities at the Institute are carried out under six scientific divisions at headquarters and five regional centres at Belgaum (Karnataka), Jammu (J&K), Kakinada (Andhra Pradesh), Bhopal (Madhya Pradesh) and Guwahati (Assam) and one Centre for Flood Management Studies (CFMS) at Patna (Bihar). The program of studies and research for the year 2022-23 of the Institute is given in Appendix-VII. Brief description of some of the important studies completed and ongoing during the year 2022-23 is given below.

6.1 R & D STUDIES COMPLETED DURING 2022-23

Uncertainty in rating curves and discharge estimation

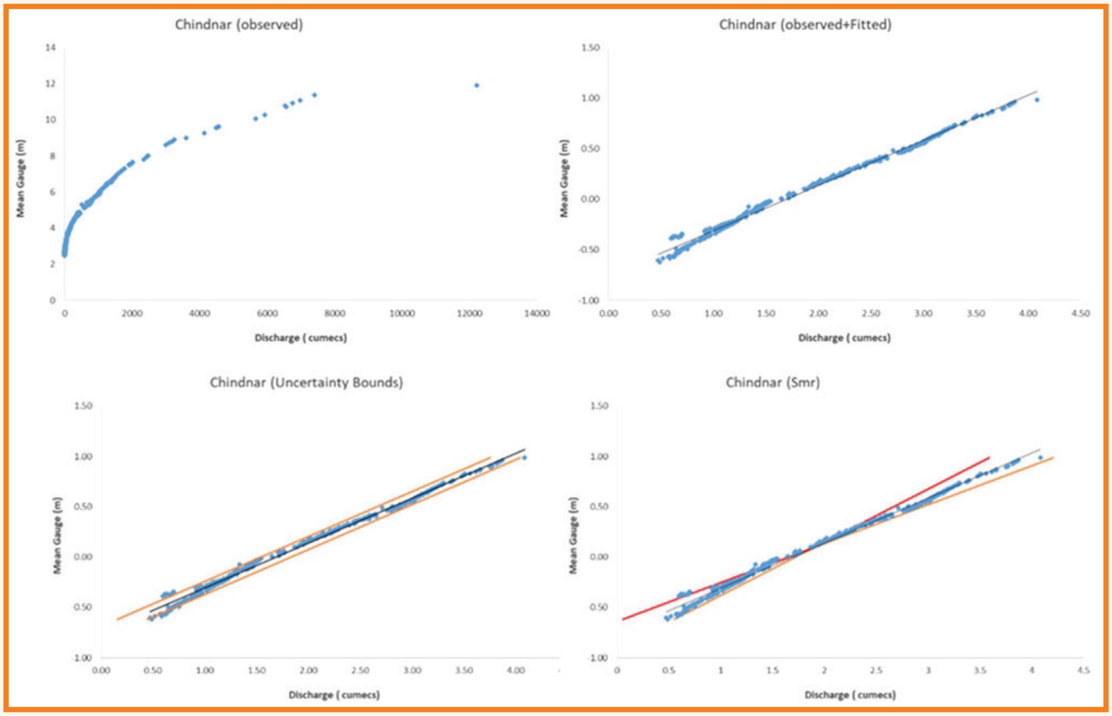
The uncertainty in the river discharge measurement and estimation is caused by different sources of errors. These mainly includes uncertainty in (a) observations of river stage and discharge used to parameterize the rating curve, (b) presence of unsteady flow conditions, and (c) interpolation and extrapolation errors of the rating curves. The study provided a framework for analyzing and quantifying the uncertainty in the (i) stage-discharge relationship and (ii) river flow data. The study also examined various hydraulic factors controlling the flow at a cross section in the river and provided an understanding of independent variables that describes relations among stage, discharge and other parameters, specifically discharge measurement under steady flow conditions.

The uncertainty in discharge measurement (assuming velocity area method) was quantified as per the ISO 748 which provided the magnitude of these errors at 95% confidence level. The Guide to the expression of uncertainty in measurement (GUM) defines the law of propagation of errors for combining uncertainties from several sources and Hydrometric Uncertainty Guidance (HUG) described it for different types of mathematical expressions generally used in hydrometry.The uncertainty of a discharge measurement determined from a stage-discharge rating function was evaluated using statistical equations based on law of propagation of errors. Observed and estimated discharge data of several gauging sites in the lower Godavari basin (subzone 1f) was collected from CWC. The observed stage and discharge data of these sites was used to determine the stage-discharge(SD) relationships and their standard error of estimate (SE). The quantification of the deviation of observed discharge from SD curve (fitted) provided a measure of uncertainty of the SD relationship (SMR). The stage-discharge relationships for various sites has been shown graphically and uncertainty in the SD relationship is quantified.

The total uncertainty in the discharge estimation has been quantified by combing uncertainty as described in HUG. Four different sites were considered for analysis. The results show that uncertainty at these gauging sites depend on flow conditions at these sites. Unsteady flow conditions are associated with large uncertainties in the measurement and estimations of the discharge. The results also shown that uncertainty in computed discharge at low and higher stages is more as compared to discharge computed in the medium range of stages. The uncertainties bound at a particular site (Chindnar) has been shown below (Table and Figures).

The uncertainties bound at a particular site (Chindnar)

Chindnar	Min	Max	Median
Stage	-0.620	0.985	0.045
Discharge	0.304	3.901	1.795
SMR	0.124	0.154	0.009
SE	0.073		



The uncertainties bound at a particular site (Chindnar)

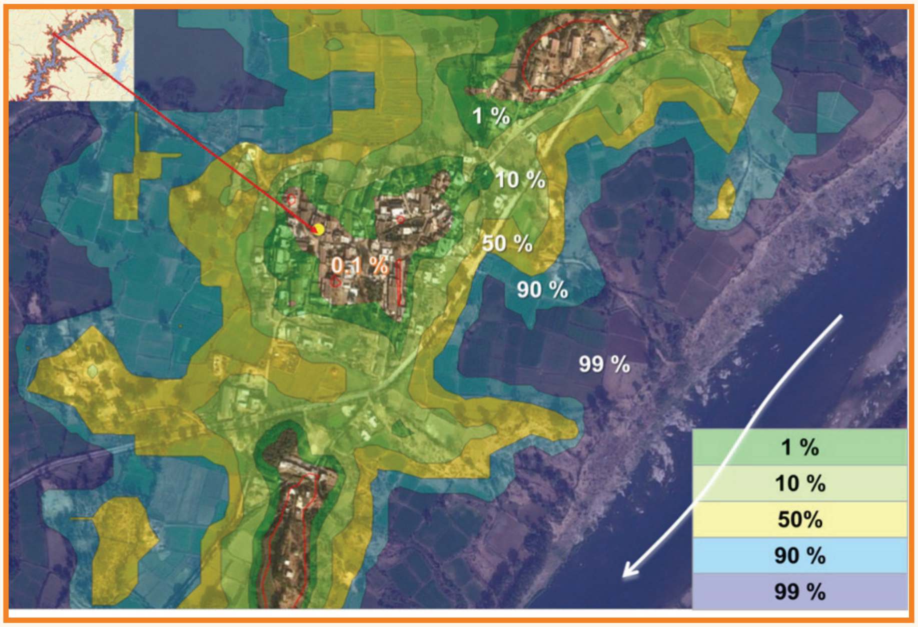
Evaluation of the influence of low-frequency atmosphere-ocean oscillations on annual floods in the Godavari and Narmada River basins

Indian summer monsoon rainfall is strongly influenced by large-scale atmosphere-ocean oscillations including Pacific Decadal Oscillation (PDO), El Niño-Southern Oscillation (ENSO), and Indian Ocean Dipole (IOD). Researchers have shown that the negative phase of PDO or La Niña episodes of ENSO produce higher magnitude rainfall and hence relatively wetter years. So, it is imperative to have better knowledge of flood characteristics in the Indian watersheds for optimal planning and design of various infrastructure, and for optimal planning and management of reservoir operations. Traditionally, such information is estimated using flood frequency analysis (FFA), however the adequacy of traditionally accepted assumption that the annual peak flows are independent and identically distributed (*i.i.d.*) is questioned globally. This study evaluates the adequacy of this assumption in Godavari and Narmada River basins and assesses the influence of PDO, ENSO and IOD on flood characteristics. The results indicate that the flood characteristics at majority of the gauges are significantly influenced by these oscillations, higher magnitude floods are associated with negative episodes. A very few gauges are inversely related to these teleconnections, although statistically not significant. Overall, the signal of all the three teleconnections is found in the annual and seasonal floods in majority of the gauging stations and the results clearly indicate that higher magnitude floods are associated with negative episodes of these teleconnections.

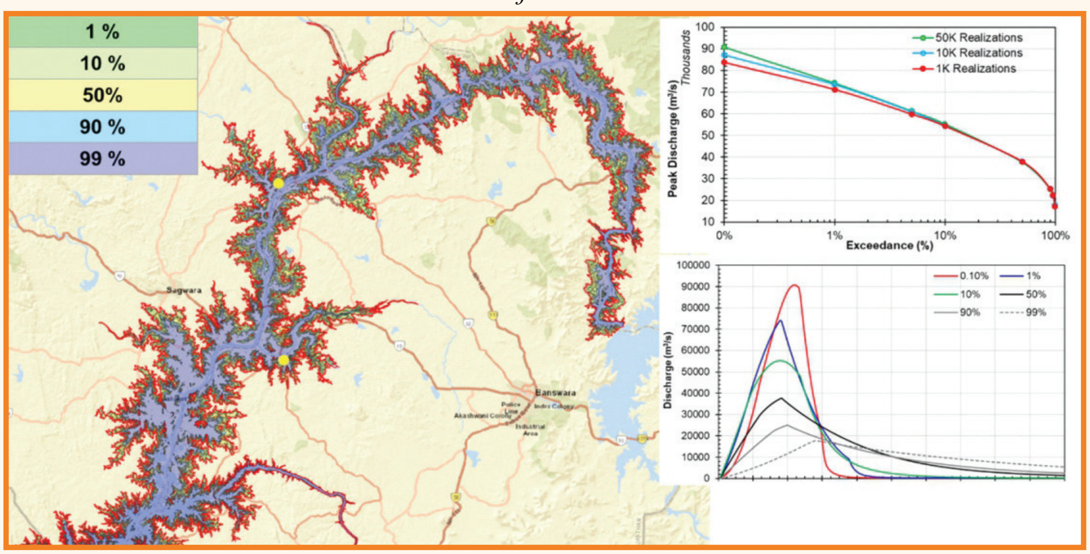
Probabilistic dam break flood wave simulation and flood risk assessment for preparation of EAP for Mahi Bajaj Sagar dam in Rajasthan

Dam breach modelling is a key component to a well-rounded and robust dam safety program. Various researcher and guidelines recommended combination of breach parameters. However, instead of mapping a large zone with equal probability of occurrence (either “in” or “out” of the flooding zone), modelling a full range of breach scenarios – from partial to complete, correlating the downstream impacts with a likelihood or probability of an area actually flooding would be of practical importance for dam owners. This risk-based approach arms decision makers with a probability based analysis map, would help them to visualize and prioritize actions in areas that are more likely to flood first. With this background the study was undertaken with objectives (a) Estimation of probabilistic dam breach outflow hydrograph, (b) Preparation of Exceedance Probability Inundation (EPI) Maps, (c) Comparison outflow hydrographs due to level pool and dynamic routing of flows through the reservoir and (d) Flood hazard and flood risk assessment due to Mahi Bajaj Sagar dam breach.

This study uses Froehlich's (2016) dam breach parameter equations and a dam breach modelling framework using HEC-RAS to improve the reliability of breach hydrograph prediction of Mahi Bajaj Sagar Dam. The MBS dam being earth rock fill dam, a trapezoidal breach section is considered. Initially the outflow hydrograph with breach parameters at different statistical level in a deterministic approach is estimated. It is evident that there is large variation in the estimated values of peak discharge at different statistical level of breach parameters. In probabilistic approach each breach parameter is randomly sampled about pre-defined probability distribution up to 100000 realization and breach flood hydrograph for each realization is generated using a truncated model of MBS dam in HEC-RAS. The skewness and kurtosis of % deviation in peak breach outflow has not converged up to 10000 realizations and convergence of statistical moments are found to be adequate for 50000 realizations. The estimated peak discharge at 1%, 5%, 10% and 50% EP are estimated as 74100 m^3/s, 61183 m^3/s, 55221 m^3/s and 37612 m^3/s respectively. No significant difference in the peak discharge is observed among 1000, 10000 and 50000 realizations up to 10% EP. Further, even at 1% EP there is no significant difference in the peak discharge between 10000 and 50000 realizations. Large variation in peak breach outflow is observed at different EP. However, the time of peak discharge is identical for most of the EP. The EPI maps are prepared using HEC-RAS results. The inundation area at 1%, 10% and 50% EP are estimated to be 967 km^2, 874 km^2, and 706 km^2 respectively (Fig.). Though the peak of dam breach flood at 1% EP is about two times to that of 50% EP, the corresponding increase in flood inundation area is about 37%. The EPI maps will be more useful in risk informed decision making process by further analysis of flood hazard and population at risk. The results of this study aid our understating of dam breach flood simulation uncertainties and increased understanding of probabilistic dam breach modelling. Utilizing such approach, areas with the highest risk of flooding could be prioritized for evacuation and better emergency action plan can be prepared to increase public safety and minimize losses during critical situations.



Exceedance probability Inundation Map (EPI) for Mahi Bajaj Sagar dam in Rajasthan



Probabilistic dam breach flood inundation. (a) Exceedance probability inundation maps, (b) Exceedance probability of peak breach outflow, (c) dam breach flood hydrograph at different Exceedance probability

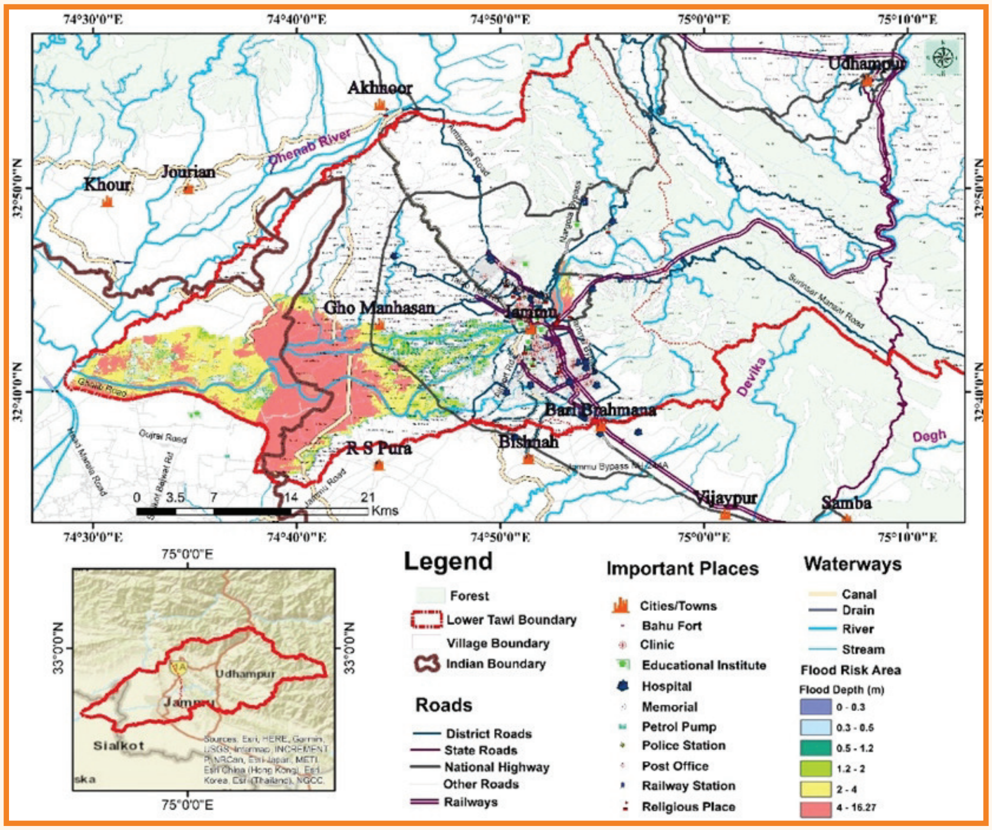
Hydrologic and hydraulic modeling for floodplain inundation mapping under future climate change scenarios: A case study of Tawi River, India

The Tawi River basin is continuously subjected to water-related disasters such as heavy torrential rainstorms, and frequent cloud bursts along with its high precipitous relief. The historic record of floods that occurred over Jammu and Kashmir region clearly brought out the role of changing climate patterns and its impact on the occurrence of severe flood events in this region with increased frequency. In order to assess the flood risk due to uncertain climatic conditions, there is a need to study the climate change impacts on future floods by using improved modelling capabilities and climate change scenarios. Particularly in the Tawi River basin, September 2014 precipitation event proved to be a triggering event that triggered government and civil organizations to plan better flood assessment and management as well as reduction strategies to fight water-related disasters under glooming future climate change scenarios. To address these issues, this study has been taken up with the following objectives: (i) To set-up HEC-HMS model for the Tawi River basin for the rainfall-runoff simulation (ii) To set-up HEC-RAS model for the Tawi River basin for flood inundation mapping (iii) Flood frequency analysis for the Tawi River basin under current climatic conditions (iv) Assessment of flood inundation under current and changing climatic conditions.

The HEC-HMS modelling schematic was prepared to simulate the runoff at three G&D stations namely Udhampur (Salmay Bridge), Sidhara (Jammu) and Jammu (Bikram Chowk) as well as other subbasins up to the Jammu (Bikram Chowk bridge) G&D station. During calibration, the simulated hourly flood hydrographs (e.g. High flood event of September 2014) by the developed event-based HEC-HMS model were very well comparable with the observed discharge and stage hydrographs. The performance of the event-based HEC-HMS model in the simulation of discharge and stage hydrographs using various performance criteria like NSE, R2, RMSE, PBIAS, Error in peak discharge estimation (%) and Error in time to peak (hr) was found to be very good. As during calibration, the observed and computed peak discharges were 12569 m3/s & 12201 m3/s (Ep= 3.9% &Ept= -0.16%, NSE = 0.79, R2 = 0.86, RMSE = 0.47 and PBIAS = 36.48%), and 13552.4 m3/s and 12232 m3/s (Ep= 10.8%, Ept= -0.83 hr, NSE = 0.82, R2 = 0.87, RMSE = 0.42 and PBIAS = 28.55%), respectively at Sidhara (Jammu) and Jammu (Bikram Chowk) gauging stations. During validation, the performance of calibrated event-based HEC-HMS model for the Tawi River basin was verified by comparing the simulated discharge and stage hydrographs with observed discharge and stage hydrographs at Sidhara (Jammu) gauging station for the 1-10 August 2016 flood event and the model performance was found very good for simulation of discharge hydrograph and good for simulation of stage hydrograph. Although, the event-based HEC-HMS model was calibrated with 2.76-time higher flood peak (6th September, 2014), it performed very well in the production of hydrograph shape as well as all other required parameters of performance evaluation criteria during the validation phase.

Further, the steady-state HEC-RAS model was set-up to obtain flood inundation mapping in the lower Tawi basin downstream of the Sidhara G&D station up to its confluence with Chenab just upstream of Marla Barrage using Energy Equations. It was found that for September 2014 high flood event, the total flood inundated area was 12096 Ha (120.96 km2) in India. Further, in the lower Tawi River basin, the total inundated flood depth was varying between 0 to 12.64 m including depth in the river. The flood inundation depth over the floodplain area varies between 0 to 8.3 m with maximum flood height observed at Indo-Pak border region.

Flood Frequency Analysis (FFA) was conducted at Bikram Chowk, Sidhara and Salmay Bridge G&D stations using nine types of frequency distribution recommended in the CWC guidelines. Based on the results of the FFA, the flood inundation map for different return year period were obtained using the developed HEC-RAS model for the Tawi River basin. Further, NEX-GDDP and COREDEX RCM datasets were used to generate future scenarios using Climate Perturbation Tool. Based on this analysis, it was found that winter precipitation will increase by 25 to 50% as predicted by all the RCMs considered. To analyze future floods under climate change impact, four scenarios with 5% (CC5), 15% (CC15), 25% (CC25) and 35% (CC35) increase in the extreme rainfall event assuming baseline period event of September 2014 were considered for simulation of flood hydrographs using event-based HEC-HMS model. The obtained future extreme floods for climate change scenarios CC5, CC15, CC25 and CC35 were used as input in the HEC-RAS model to generate future flood inundation depth maps and flood hazard maps for the lower Tawi basin downstream of the Sidhara gauging station. Based on climate change scenarios of CC35 (35% increase in baseline rainfall event of September 2014), the flood-affected area, agricultural and residential areas in the Indian territory in lower Tawi basin will increase by around 1700 ha, 1101 ha and 61 ha as compared to those during baseline period (September 2014), if the proper flood management activities will not be undertaken by respective flood control and management authority.



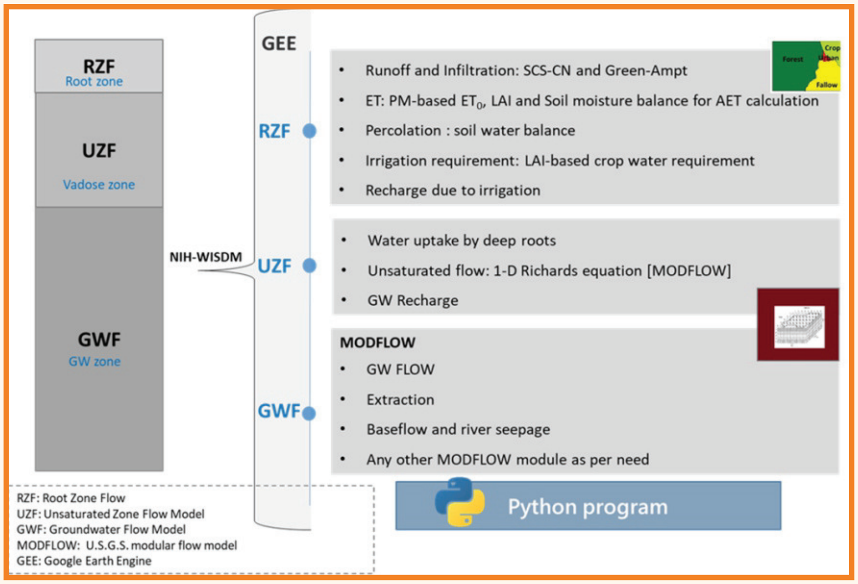
Flood hazard maps of the lower Tawi basin for climate change scenarios CC35

Integrated GEE-MODFLOW based Groundwater Recharge Assessment System for Hindon River System

The excessive groundwater withdrawal led by growing water demands has resulted in rapid and widespread groundwater declines in many parts of India. To manage water resources in a sustainable manner, comprehensive understanding of groundwater system is essential. Of particular importance are the understanding of recharge processes, quantification of recharge from various sources, such as rainfall and surface water bodies, assessment of the impacts of groundwater withdrawal, and understanding the exchange of fluxes between surface and subsurface hydrological systems. The developed model is named as GEE-MODFLOW which is a part of a larger system, named as "Web-based Catchment Modelling System for Decision Making (WISDOM)". The current version of WISDOM has only one model – the GEE-MODFLOW, however it is envisaged that a few other models, such as system model for canal commands, VIC and machine learning may also be incorporated in the next versions. The model is tested in Hindon river basin. Hindon river originates from Saharanpur district of Uttar Pradesh and joins Yamuna river near Delhi. The basin lies between the latitudes 28°30′15″ to 30°15′12″ N and longitudes 77°20′18″ to 77°50′10″ E and has an area of ~7000 km^2. It is largely composed of Pleistocene and

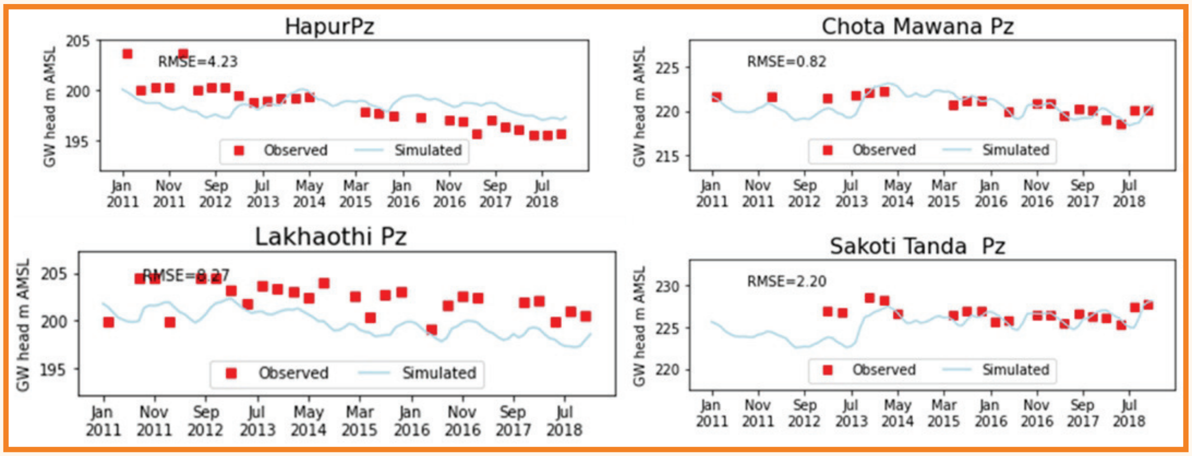
Quaternary alluvium represented by sand, clay and kankar. The brief objective of the study are: (i) GEE-MODFLOW model to estimate groundwater recharge and to disseminate model outputs, (ii) Evaluation of the estimated recharge using in-situ observations, (iii) Assessment of the impacts of various recharge/abstraction scenarios on groundwater system of Hindon river basin.

The integrated model developed in this study consists of various modules which simulate surface and sub-surface processes in unsaturated and saturated zones. The model has three simulation modules, namely Root Zone Flow (RZF), Unsaturated Zone Flow (UZF), and Groundwater Flow (GWF). The processes simulated by these modules and methods used are elaborated.



Methods used in simulating surface and sub-surface hydrological variables

The integrated GEE-MODFLOW model has been applied in Hindon river basin. Hindon basin is a part of gangetic plain and the basin boundary doesn't coincide with the groundwater divide, therefore it is difficult to assign boundary conditions in Hindon for MODFLOW. To address this, the model was applied to Ganga-Yamuna Doab region (up to Delhi) so that the boundary conditions can be assigned appropriately. The model is setup for a period of 2011 to 2018 at daily time-step. Various data sets from GEE, IMD and CGWB were used. All thematic layers, including DEM, land cover, soil, impervious surface fraction, etc., and some time series layers, such as Leaf Area Index (LAI) and vegetation fraction are retrieved from GEE using WISDOM's automated data retrieval module. Precipitation and temperature were taken from IMD. The aquifer geometry and parameters were taken from CGWB's district brochure and assessment report. To estimate the groundwater pumping from the irrigation demand (estimated by GEE-MODFLOW) proportion of irrigation demand being met from groundwater is taken from CGWB's assessment reports. Calibration of the model was performed by comparing simulated and observed groundwater heads at different locations. The comparison of the simulated and observed heads indicates that the RMSE varies from 0.27 to 4.23 m (AMSL). The performance of model is found satisfactory in the basin for simulating groundwater levels. However, it is seen that at some locations the simulated heads deviate considerably from the observed heads, especially during the later time-steps which can be improved if more detailed aquifer data is available. The GEE-MODFLOW model is also tested in upper Mahanadi Basin (upstream of Hirakund dam) for streamflow simulation. The model simulates streamflow satisfactorily with Nash–Sutcliffe Efficiency (NSE) of 0.6.



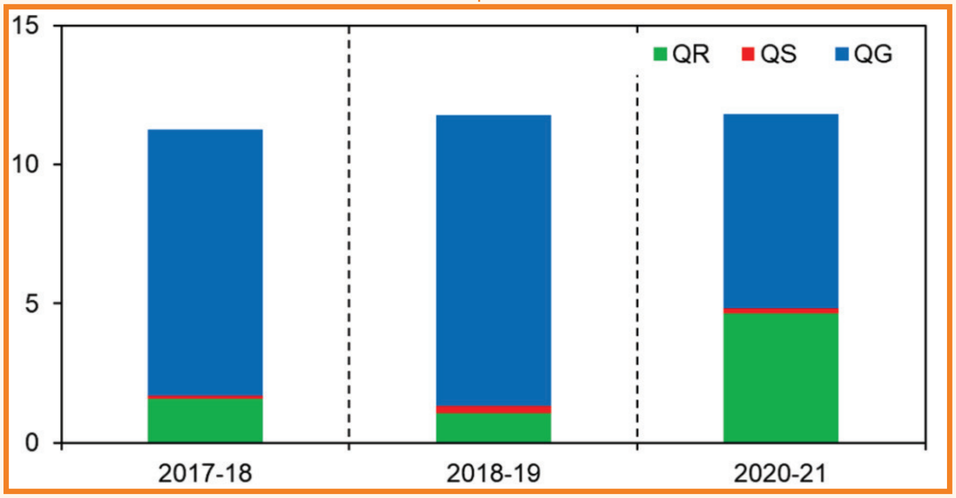
Comparison of simulated & observed GW heads at four locations in study area

The groundwater recharge was estimated for the period 2011 to 2018 using the calibrated model. The estimated annual recharge varies from 294 mm to 425 mm (spatially averaged). The recharge is mainly governed by precipitation and irrigation in the area. The estimated recharge is compared with the district-wise assessments of CGWB. A good agreement between the estimated recharge and CGWB's assessment is observed with R^2 value of 0.6. The GEE-MODFLOW model is developed to simulate surface-groundwater flow in root zone, unsaturated zone and saturated zone utilizing surface and subsurface (MODFLOW) models. Utilizing the web-enabled interface, GEE's cloud computing, python programming and models, it reduces efforts of modelers by automating data downloading, pre-processing, post-processing and visualization which would otherwise take considerable time to accomplish using traditional tools. With its freely available easy-to-use web-interface and automated data processing, GEE-MODFLOW allows groundwater modelling without the use of any commercial GIS and MODFLOW interfaces. GEE-MODFLOW is a part of a broader system, named as WISDOM, which would also incorporate other models for canal system modelling, irrigation demand estimation, and macro-scale hydrologic modelling using VIC, in upcoming versions.

Seasonal characterization of Gangotri Glacier melt runoff and simulation of streamflow variation under different climatic scenarios

Gangotri Glacier is located in Uttarkashi District, Uttarakhand, India in a region bordering China. The glacier is about 30 km long (19 miles) and 2 to 4 km (1 to 2 miles) wide. The Ganga originates as Bhagirathi from the Gangotri Glaciers. The Bhagirathi is joined by the Alaknanda at Deoprayag and the combined stream is there after named as Ganga. It is joined by a large number of tributaries on both the banks in the course of its total path of 2,525 km before its outfall into the Bay of Bengal.In this study the data collected for three years from 2018, 2019 and 2022 have been analysed and presented. The discharge showed increasing trend from May onward, reached to its highest value in July and then started reducing. The maximum and minimum daily mean discharge observed during study period was 18.4 to158.7 m3/s. The mean monthly discharge observed for May, June, July, August and September was 26.1, 58.0, 99.7, 99.5 and 51.9 m3/s, respectively. Almost similar trend of distribution of runoff is observed for all the years. The strong storage characteristics of the Gangotri Glacier are reflected by the comparable magnitude of runoff observed during daytime and night time.

Suspended sediment concentration in the observed discharge was very high. Moreover, it was very much variable over the melt season. Daily mean concentration varied between 57 to 18750 ppm. Mean monthly suspended sediment concentration for May, June, July, August and September during the study period was 536.7, 1289.6, 2464.3, 1318.8 and 592.4ppm, respectively. Mean monthly total suspended sediment loads for May, June, July, August and September during the study period was found to be 36, 209, 668, 344 and 89×102 tons respectively. HBV model has been used for the simulation of the streamflow. HBV model can be useful at any location on the glacier where input data (i.e. meteorological measurements) are available. Average Gangotri Glacier streamflow (mn d^{-1}) and average contribution (%) of rainfall, snowmelt and glacier melt to total streamflow (mm d-1) during the ablation seasons (May-September) of 2017-18, 2018-19 and 2021-22 is given in the figure above. Qsim represents total discharge, QR represents the rainfall, QS represents snowmelt and QG represents glacier melt.



Average contribution (%) of rainfall, snowmelt and glacier melt to total streamflow at Gomukh during the ablation seasons

Assessment of Dissolved Radon Concentration in Groundwater of Haridwar and Dehradun Districts of Uttarakhand

Radon (222Rn86) is a naturally occurring odorless, colorless, tasteless inert gas. It is a daughter product of the radium (226Ra88) that forms in the decay chain of naturally occurring U-238 (approximately 55%) and Th-232. The immediate parent element of the radon 'radium' is a luminescent, brilliant white metal, and has a half-life of 1.6 years. Concentration of radium in groundwater is controlled by geochemical conditions and adsorption property of the host aquifer particles. Radium co-exist with other heavy metals like Fe, Mn, Al, Mg, Ba, Sr and sometimes with K, SO4, HCO3, NO3, type water. It occurs in low pH (acidic) and in anoxic (low dissolved O2) water. Radon has three isotopes 222Rn (t½=3.82 days), 220Rn (t½=55.6s), and 219Rn (t½=3.6s). Radon is sparingly soluble in (0.01 mol kg−1 bar−1 at 293 K), and the solubility decreases with increasing water temperature and salinity. Higher dose of radon inhalation or ingestion causes lung cancer. Therefore, monitoring of radon in groundwater help to identify risk of exposure to radon through drinking water.

Considering the importance of measuring radon concentrations in groundwater, a baseline data of the radon concentration measurement survey is conducted jointly with CGWB, Dehradun in the districts of Haridwar and Dehradun of Uttarakhand. Water quality analysis of the collected groundwater samples were also done along with measurement of radon concentration in groundwater. For the study, 33 groundwater samples were collected in the pre-monsoon season and post-monsoon seasons of the year 2022. Out of these 33, 7 samples were collected from southern-side Shiwalik foot-hills in Haridwar district, 10 samples from northern-side Shiwalik foot-hills in Dehradun district, 9 samples were collected from western bank flood-plain of river Ganga (6 from Haridwar district and 3 from Dehradun district), 2 samples in the eastern-bank flood plain of river Ganga (from Hardwar district) and 3 samples in the eastern-bank flood-plain of river Yamuna flood-plain (from Dehradun district). Radon concentrations in the collected water samples were done using RAD7 meter, heavy metal analysis on ICP-OES, and major ion analysis using ion-chromatograph.

This study revealed that the values of natural radioactivity of ^{222}Rn in groundwater of Haridwar and Dehradun districts of Uttarakhand were found higher than the suggested MCL of the USEPA in 21% of sampling sites in the study area in pre-monsoon and post monsoon seasons of year 2022. The water of 79% area of the sampled in Haridwar and Dehradun districts of Uttarakhand was found safe for drinking and utilization for other purposes and pose no significant risk of ^{222}Rn related hazards. However, it is advisable that the groundwater collected from the 21% of the sites mainly Ashutoshnagar and Sudhonwala area and surroundings should be boiled prior to use because it will be helpful for reducing the health risk due to ^{222}Rn in drinking water. The study contains the baseline data of the study area and it is suggested to carry out a detailed investigation.

Integrated flood management plan for a stretch of Burhi Gandak river from Sikanderpur to Rosera

Construction of embankments are the widely adopted flood protection measures. However, these embankments are vulnerable to breach during the high flood. The recurrent breaching affects the population and agricultural activity in the adjoining areas. The present study analyzes the exiting flood protection measure along both the banks of Burhi Gangak river from Sikanderpur to Rosera in a stretch of 105.5 km. The objectives of the study were:(i) to estimate the design flood at Sikanderpur and Rosera, (ii) to carry out flood simulation, compute water surface profile to evaluate the adequacy of embankment heights and to identify critical locations of spilling for the peak flood and design flood, (iii) to study the landuse in the flood plain to ascertain flooding due to spilling of embankment and study of the landuse for suitable landuse to maximize the floodplain benefits. The catchment area of Burhi Gandak river is 12,984 km^2 located both in Nepal and India out of which 10,297 km^2 (79%) lies in India (Bihar) and the rest 2,687 km^2 (21%) lies in Nepal. The study area is 903 km^2.

Design flood estimation was carried out using flood frequency analysis (FFA) using historical maximum discharges. Hydrodynamic model, MIKE FLOOD is used to compute the water surface and profile and other flood characteristics.The annual peak discharges of Burhi Gandak river at Sikanderpur for the period from 1956 to 2022 and at Rosera site for the period from 1956 to 2005 were used for FFA. The river network of Burhi Gandak and the cross-sectional data for 35 locations starting from 0.0 km at Sikanderpur to 105.5 km at Rosera surveyed during 2016 were used for model setup. The daily G & D data of Sikanderpur, and Rosera for the period 15 June to 15 October from 2000 to 2005 have been used as inflow and boundary data in the model. The water level data of Samastipur have been used for model calibration. The flow simulation for the inflow at Sikanderpur between the period from 05 July to 09 Aug 2004 (when single peak hydrograph is distinct) with peak inflow of 3,041 cumec occurred on 14 July, 2004 does not show any overtopping of the embankment. The model also computes the level of the embankment for the design flood of 50 and 100 years. Simulation of river flow model for 50 years' design discharge of 4,658 cumec at Sikanderpur, computes water surface profile which indicates that the flood water overtops at six locations namely at chainage 0 km, 75.878 km, 81.878 km, 82.878 km, 83.878 km and 86.878 km downstream of Sikanderpur. No overtopping could be noticed in other 29 cross-sections. Even, the magnitude of overtopping at these six locations were minimum, the maximum being 0.333 m at chainage 82.878 km on its left embankment. Similarly, simulation for 100 years' design discharge of 5,388 cumec at Sikanderpur indicated overtopping on the left bank between 0.070m at 88.878 km to 0.959 m at 82.878 km while overtopping on the right bank between 0.239 m at 45.378 km to 0.716 m at 86.878 km. This magnitude of the overtopping was added with the existing bank level at the overtopping locations (left, right or both) and the river flow model was simulated with the design discharge for no spilling. Adding a free board of 1.5 m to this embankment level, the level and height of embankment to be raised from at different locations in a stretch of 105 km from Sikanderpur to Rosera to contain 50 years design discharge of 4,658 cumec of Burhi Gandak at Sikanderpur was computed. The maximum raising of the embankment needed after adding a free board of 1.5 m is 1.833 m at 82.878 km and minimum of 0.229 m at 50.378 km with an average raising of 1.29 m on the left embankment. On the right embankment the raising of the embankment needed is 1.584 m at 86.878 km and minimum of 0.229 m at 25.168 km with an average raising of 1.335m. Similarly, for overtopping with 100-year design flood adding additional 10 cm in the bank level is required for preventing spilling. Simulation with this level showed no spilling. Adding a free board of 1.5 m, the quantum of raising for the left embankment is between 0.689 m to 2.559 and for the right embankment is between 0.810 m to 2.316 m. This bank level is for 100 year flood without spilling including the free board.

Landuse classifications were also done for the pre and post monsoon for the years 2000, 2005, 2010, 2015 and 2020 to see the changes in the vegetation/agricultural activity and other land uses. Although the effect of flooding due to river discharge and spilling of the embankments could not be seen, the area suffers from flooding and waterlogging due to accumulation of monsoon rain in the depressions, flat topography and absence of drainage outlets. The LULC classification indicates scope to increase in agricultural area so as to improve the livelihood of the people in the area. The agricultural activity in the area also suffers due to lack of irrigation during Rabi and Garma season. In order to reduce waterlogging, it is suggested to increase the crop area coverage in the area and use the groundwater potential so as to utilize the maximum surface and groundwater (available at shallow depth) during Rabi and Garma seasons for increasing agricultural activity which would in turn reduce the waterlogging (both surface and sub-surface) caused due to accumulation rainfall and lack of drainage.The study evaluated the adequacy of embankment height to mitigate the design flood. The locations of overtopping the embankment were identified. It will help to the implementing agency (WRD Bihar) to strengthen the embankments in the study reach.

CWC GD site at Railway Bridge, Rosera

Hydraulic and Mathematical Model Studies for Long Term Safety and Solution Measures for Flood Problem in Mahav

The Mahav nala is a left bank tributary of Bhagel nala which in turn meets the Rohini river originating from low mountains in Nepal. Mostly flash flood is reported in this stream and the duration of flooding ranges from 4 hours to 48 hours depending upon the rainfall spell in the catchment. The entire catchment of the nala is located in Nepal. In the hills, the slope of the nala is very steep and which reduces drastically when enters into foothills (tarai region). The nala is highly meandering in nature. The heavy siltation in upper reaches has significantly reduced the flow depth. During flash flood, the bank overtopping and bank erosion is the recurrent problem in the region. A very dense population is located along Mahav nala in its upper reach while wildlife sanctuary is located in the lower reach. During April 2022, a request was received from DFO Sohagibarwa wild life Division, Maharajganj, and also from Executive Engineer Irrigation Section-II, Maharajganj UP to propose suitable measures for flood mitigation in Mahav nala. In this background, the mathematical model study of Mahav nala was carried out with the objectives: (i) Extraction of catchment characteristics based on online Digital Elevation Model (DEM) and satellite data, (ii) Design flood estimation, (iii) Development of river flow model with existing river cross section and computation of safe carrying capacity of nala, (iv) Evaluating the river flow model for the nala section proposed by UPID and (v) Design of Mahav nala section for the estimated design flood.

In this study, design flood has been estimated using T= 2.66 year (recurrent flood) return period rainfall and unit hydrograph. Rainfall of specified exceedance probability is estimated using PMP atlas for Ganga basin developed by CWC and IMD. The various parameters of the synthetic unit hydrograph are derived from the Flood Estimation Report (CWC, 1985). The river flow model for Mahav Nala from Indo-Nepal border to its confluence with Baghel nala (23 km stretch) is developed in MIKE 11. The MIKE 11 is a versatile and modular engineering tool for modelling hydrodynamic conditions in rivers, lakes/reservoirs, irrigation canals and other inland water systems developed by DHI (DHI, 2004). The modelling is carried out to evaluate the adequacy of the river section at different chainage. The maximum flood level at different chainage is computed and plotted against the bank top level to identify the critical locations where the water spills from the nala. Several setups of flow model are developed using existing river cross sections, proposed and design river cross sections.

The study is completed and final report submitted to UP Irrigation Department and DFO Maharajganj during January 2023. Based on the study, the conclusions drawn are: (i) Using the SRTM DEM data the drainage line and watershed boundary for Mahav Nala has been extracted. The computed catchment area of Mahav nala is 218.5 km^2 while the length of longest flow path is computed as 66.34 km. The length of Mahav nala from watershed centroidal to outfall location is computed as 42 km. The equivalent slope of Mahav nala from its origin to outfall location is computed as 0.524 m/ km. (ii) The peak floods for the Mahav Nala are estimated as 186.5 m^3/s, 244.9 m^3/s, 293.2 m^3/s and 353.8 m^3/s for return period of 2.33 Year, 5 Year, 10 Year and 25 Year return period, respectively. (iii) The carrying capacity of Mahav nala with existing cross sections are computed of the order of 10m^3/s, although the maximum flood level at several chainage spills due to irregular bank profile. The flow congestion in Mahav nala starts at Chainage 15200 m. (iv) The proposed section by UPID has been evaluated through flow model and it was found that the safe carrying capacity of section is about 50 m^3/s provided that the bank profiles are maintained smoothly. (v) The design section of Mahav nala is computed for 187 m^3/s which is the estimated design flood for T=2.33 year (which are the estimates of the most recurrent flood) as Flow depth = 4m, Side slope = 1:1, and Bottom width = 22 m.The outcomes of this study is used by UPID Maharajganj for improvement of nala section leading to flood mitigation in the area.

A view of Mahav Nala at Indo Nepal Border

Hydrological behavior of two mid-sized mountainous catchments under the influence of climate change

The study was envisaged on the hydrological behavior of two mid-sized mountainous catchments in the eastern Himalayan region of India. The morphometric analysis of theDudhnai and Pare Rivers, the hydrological modelling of the two watersheds using the Soiland Water Assessment Tool (SWAT), and the analysis of the effects of climate change ondischarge are the objectives of this study. Morphometric analysis was performed using morphometric tools in GIS while SWAT model was used to calibrate, validate, and future simulation of discharge. The analysis of the meteorological data suggested that in the last two decades in Pare and Dudhnai watersheds, days and nights were getting warmerassociated with increasing rainfall intensity and consecutive dry daysand decreasing consecutive wet days.The most vulnerablesub-watersheds to soil erosion, according to morphometric study, Chil sub-watershed in Dudhnai watershed and SW25 in Pare watershed, which required interventions to soil and water conservationmeasures on a priority basis. SWAT model fared somewhat better in Pare watershed whencompared to the Dudhnai watershed. It slightly overestimated the discharge in the Dudhnai watershed while slight underestimation in the Parewatershed. Only NorESM1-M in the Pare watershed predicted decreasing streamflow conditions under RCP 8.5 projection scenarios, with a fall of about10.7 percent. While only CNRM-CM5 and NorESM1-M models in the Dudhnai watershedhave revealed decreases in discharge with magnitudes of -2.3 percent and -1.1 percent respectively, in the near future period under RCP 4.5 and RCP 8.5 scenarios. In bothwatersheds, during the monsoon season, considerable favourable increase in discharge were seen in the future estimates. While the majority of the negative development shappened between November and March. This meant that high flow would grow evenhigher and low flow would become leaner in the future. The percentage increase in surface runoff was predicted to occur at a faster rate than the lateral and baseflow components. This could result insignificant soil loss from the upstream of the watershed and major flooding in the low-lying areas downstream. The return floods in the Dudhnai watershed are not expected to varymuch in the future, according to comparisons of the maximum series of observed, RCP 4.5,and RCP 8.5 maximum series. Both watersheds wereanticipated to experience extended dry periods with significant flooding potential within ashort period of wet days, despite rising precipitation and streamflow. The study suggested that the state of both the watersheds is extremely sensitive to extreme events. Reports from various news outlet of losing springs in both the watersheds aided by theresults obtained in this study, we concluded that the state of the watersheds is quitevulnerable to extreme events in the future. Therefore, we recommend stakeholders suchas Water Resource Departments, Agriculture Departments and Irrigation Departmentsto collectively approach watershed management in scientific manner, creation of waterharvesting structures in suitable sites and also promote afforestation.

Changes in average annual discharge (%) w.r.t. baseline period 1976–2005 in Pare watershed

RCP	Time slabs	CCSM4	CNRM-CM5	MPI-ESM-LR	NorESM1-M	Ensemble
RCP 4.5	2030s	4.1	15.7	11.0	6.6	9.6
	2050s	27.2	14.8	27.3	14.2	20.8
	2080s	18.1	38.2	13.7	2.4	17.8
RCP 8.5	2030s	6.3	27.0	16.3	-10.7	10.1
	2050s	25.3	41.2	23.8	10.7	25.3
	2080s	45.0	52.1	41.5	54.4	47.6

All units in %

Changes in average annual discharge (%) w.r.t. baseline period 1976–2005 in Dudhnai watershed

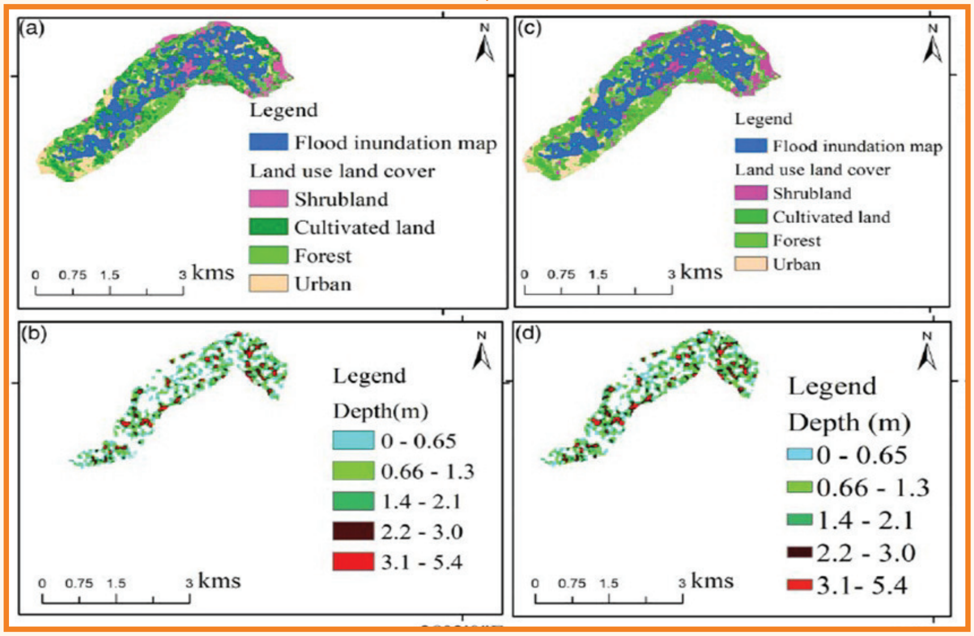
RCP	Time slabs	CCSM4	CNRM-CM5	MPI-ESM-LR	NorESM1-M	Ensemble
RCP 4.5	2030s (near)	6.5	-2.3	8.7	10.5	5.4
	2050s (mid)	18.6	8.0	3.8	16.4	11.4
	2080s (far	19.1	36)8	0.3	14.0	16.6
RCP 8.5	2030s (near)	10.8	3.7	16.0	-1.1	7.1
	2050s (mid)	16.3	21.6	1.2	11.5	12.2
	2080s (far)	37.6	17.8	18.4	42.4	27.5

All units in %

Impact of Climate Change on Flood Inundation in Beki River Basin

Flood is one of the most destructive events. Accurate and current floodplain maps are most valuable tools for avoiding severe social and economic losses.Early identification of flood-prone properties during emergencies allows public safety organizations to establish warning and evacuation priorities. This study has been undertaken for the Beki river basin based on the recommendation by the Chief Engineer, WRD Assam. The Beki (Manas) river originates in Tibet, runs through Bhutan and has wide floodplains in Assam's Barpeta district in India. The river has two channels; one named Beki is dead while the other termed as Manasis alive. Due to improper development of banks, the river flows over both the channels during peak flow/flood season. Area of the total basin is 32,725.92 Km^2. Soil Erosion, landslides and flash floods are the major problems faced in this region. Precipitation is a key climate variable in the global climate system and has an important impact on the hydrological cycle and the ecological system. Scientific evidence has shown that precipitation patterns change in a warmer climate, and the likelihood of extreme precipitation is expected to increase due to global warming. Thus, understanding the effect of climate change on precipitation has a great significance, as such information can be important for devising strategies to cope with such change.One of the major requirements for water resources development and management is analysis of rainfall runoff relationship and availability of water in the area, which vary with time and space. Flood Inundation modeling shows the effect of inundation due to floods in a given Basin. The impact of climate change on flood inundation was studied in this study. The objectives of this study are a) to estimate the impact of climate change on flood inundation in Beki River Basin and b)to quantify the change in flood inundation modelling due to climate change.

Simulations were carried out for the present and future scenarios of rainfall events. The extent of flood inundation area under the current condition was analyzed using the historical records of streamflow in the Beki watershed. The peak discharge was estimated using log Pearson type-III distribution after a thorough comparison with the other distributions (Samantaray & Sahoo 2020). Model analysis showed that the extent of variation between 50- and 100-year return period flood depths differs significantly. For the historical period, the 50-year return period flood inundated nearly 564 km2 in the area, whereas flood with a return period of 100 years could be 678 km2. The average flood depth in the baseline period was 4.0 m for a 50-year return period. According to the RRI model, the maximum flood depth reaching approximately 5.2 m has been estimated for 100-year return floods. Residential areas near to the bank of Beki were severely affected by flood in the study area. The 50 and 100-year inundation map indicated that 31.2 and 42.8% of the cultivated land will be affected by flood events, respectively.



Map of inundated area and depth for the baseline period: (a) flood inundation map for the 50-year return period, (b) depth map for the 50-year return period, (c) flood inundation map for the 100-year return period and (d) depth map for the 100-year return period

An experimental assessment of low cost Auger Hole Technique for accelerating ground water recharge

A number of widespread methods are used for artificial recharge of groundwater in the country like, check dams, farm ponds, contour bunds, gully plugging, nala bunding, percolation tank, gabions, trenches, etc. Most of these prevalent techniques of recharge are complex, costly and consume more time in their execution. To overcome these issues, an economical and scalable technology has been proposed to recharge point locations like wells, rural watersheds as well as urban areas through the construction of low-cost Auger Holes using locally available facilities and filter media. The study aims to test and evaluate the effectiveness of the Auger Hole technique for the artificial recharge of groundwater through experimental studies as well as pilot field studies.

The experimental study was carried out with construction of 10 Auger Holes in gardens, open areas, natural depressions and flow paths in WALMI campus, Bhopal. The dimensions of the auger hole were, 1 feet diameter and 6 to 10 feet depth. Infiltration tests were conducted at the various auger hole sites. Encouraging results have been obtained from these experiments and auger hole structure was found to be very effective in increasing the groundwater recharge. The infiltration rate before construction of auger holes varied between 2.1 to 2.7 cm/hr. After stabilization of auger hole within a year, the infiltration rate was found to have increased substantially in the range of 30 to 48 cm/hr. Similarly, the accumulated infiltration in the 5-hour duration was observed to vary between 30 to 50 cm before the auger hole construction which increased significantly in the range of 300 to 450 cm after the auger hole intervention. The overall volume of water recharged from the harvesting structure was observed to have increased by 30 to 40 times due to the auger hole intervention. The outcome of study will present a scalable Auger Hole recharge technique through analysis of experimental results for its designing like, spacing, depth, diameter, filter media, cost-benefit, and evaluation of effectiveness, and impacts on the groundwater regime in rural and urban areas.

Auger hole experiments in WALMI campus

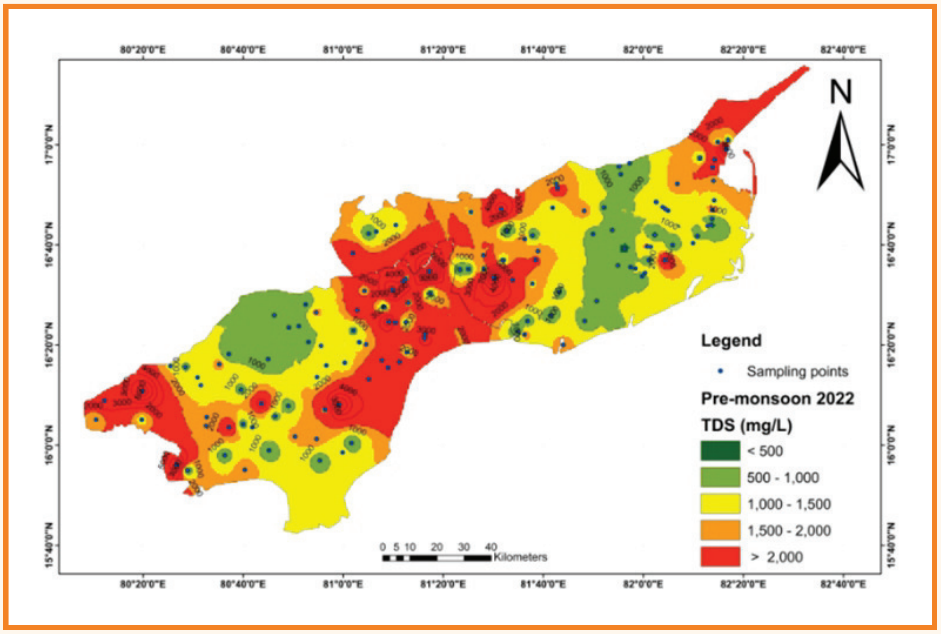
6.2 R & D STUDIES ON-GOING DURING 2022-23

Characterization of Groundwater Dynamics in Krishna-Godavari Delta interims using groundwater levels, Hydrochemistry, Isotopes and Emerging Contaminants

Water Quality is deteriorated due to change in life style. The term emerging contaminants (ECs) is generally used to refer to compounds previously not considered or known to be significant in groundwater in terms of distribution and/or concentration, which are now being more widely detected and which have the potential to cause known or suspected adverse ecological or human health effects. ECs include perfluorinated compounds (PFCs), nanomaterials, pesticides, pharmaceuticals, industrial compounds, personal care products, fragrances, water treatment by-products, flame retardants and surfactants, UV-filters as well as caffeine and nicotine. In view of the above, characterization of groundwater dynamics in Krishna-Godavari Deltas interims has been proposed using geochemical, Isotopes and emerging contamination and their sources and its impacts on human health for sustainable drinking water supply in collaboration of CGWB, Hyderabad.

One hundred thirty seven ground water samples during pre-monsoon (June 2022) and post-monsoon seasons (December 2022) were collected from the study area and analyzed for physico-chemical parameters, metal concentrations, pesticides, polynuclear aromatic hydrocarbons (PAHs), Polychlorinated biphenyls (PCBs) and volatile organic compounds (VOCs). Hydro-chemical data for pre- and post-monsoon seasons was processed as per BIS and WHO standards to examine the suitability of ground water for drinking purpose. Spatial distribution maps were prepared in the form of contour diagrams to identify degraded water quality zones, possible sources of pollution and specific parameters not conforming to drinking/ & irrigation water quality standards. Very high values of TDS and hardness were observed specially in Krishna basin delta. The high sodium values in the study area may be attributed to base-exchange phenomena causing sodium hazards. The presence of heavy metals has been recorded in many samples and the water quality standards have been violated for iron, aluminium, boron, manganese, nickel, lead, mercury and arsenic in few of the samples in Godavari basin delta during the pre-monsoon period while the concentrations of iron, aluminium, boron, mercury, manganese, lead, uranium and arsenic in few samples have been violated in Krishna basin delta. Presence of many pesticides were observed in many samples of the study area and BHC-Alfa has exceeded the maximum prescribed limit in few of the samples of the study area. Polychlorinated Biphenyls have not been detected in the samples of the study area. Total PAHs exceeded the maximum prescribed limit in more than 60% of the samples collected from Godavari basin delta. The presence of volatile organic compounds (Benzene) was also observed in few of the samples of Krishna basin.

Monitoring of Wells in Krishna Godaveri Basin



TDS Distribution in Krishna Godavari Basin

Hydrological studies for the conservation of Rewalsar Lake (H.P.)

Rewalsar lake is facing problems related to water quality, fish mortality, and siltation. Increasing tourism activity and human settlement around the lake create hydrological and ecological distresses. In addition to this, frequent incidents of high fish mortality in the water body due to increasing water pollution has been observed. An increase in nutrient levels in lake from the various non-point sources also leads to eutrophic conditions. As suggested by the Himachal Pradesh State Wetland Authority (HPSWA), a systematic and comprehensive study on the hydrological investigation of Rewalsar Lake has been proposed.The objectives of the study are: (i) identification of hydro-morphological features and water balance study of lake for the sustainable management of water resources, (ii) to identify the causes of fish mortality and eutrophication status of lake, (iii) to assess the rate of sedimentation. Based on the results suggestions and remedial measures will be taken care for pollution abatement.

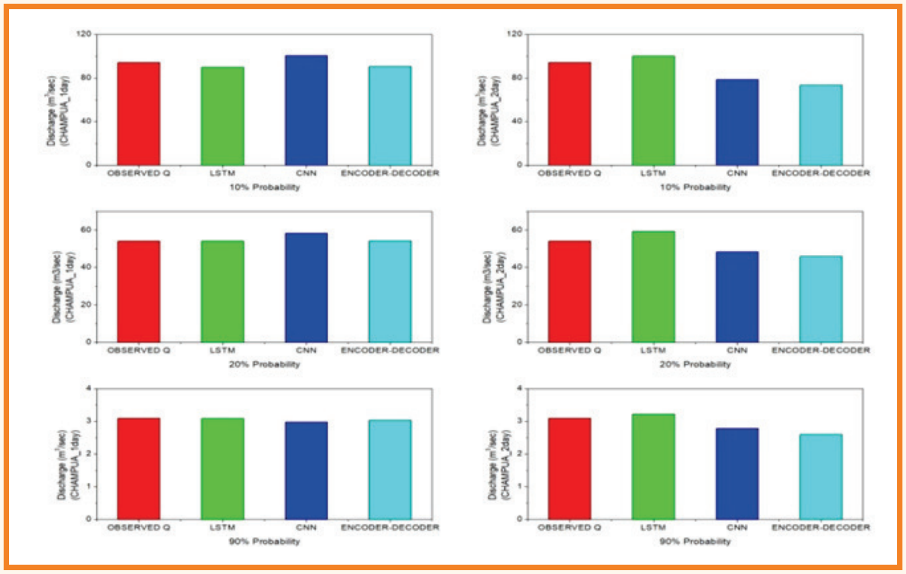
Preliminary study will be carried out to identify the hydro morphological features of lakes and sources of water in the lake. Collection of baseline data of area related to morphological and geographical data. Seasonal and temporal water sample collection from the study area. The water balance study of lakes will be carried out by calculating the inflow and outflow to/from the lake for the sustainable management of water resources. The samples will be collected at different time intervals. Collected samples will be analyzed in the laboratory for physico-chemical and biological parameters. The accumulation of nutrients in the lake will be assessed by using the mathematical equation and nutrient balance of the lake will be estimated.To achieve the objectives of the study, preliminary study has been carried out to identify the hydro morphological features of lakes and sources of water in the lake. Field visit was made to collect the baseline data in the month of Dec. 2022. There is siltation issue in the lake due to which lake capacity is reducing over time. Containment of the silt coming to lake is the major cause of concern for local people. Fish mortality was a concern but after preventive measures w.r.t. fish feeding by the visitors, fish mortality has not been observed since 2019. However, the turbidity in the lake water is a concern. Diurnal variation in DO was observed ranging from 6.3 mg/l at 06:30 hour to 8.7 mg/l at 20:00 hour indicating significant decrease in DO levels and the situation may be worse during summer months. The outflow from the lake has reduced over time.

Field measurements at In let-1 of Rewalsar Lake

Field measurements at Inlet-2 of Rewalsar Lake

Flood Forecasting under Changing Climate Conditions - Role of Machine Learning and Conceptual/Physical based Model

Flood is known to be the worst natural disaster which contributes to the loss of life, economy and natural habitat. There has to be a sustainable development where mankind and nature can live together. According to Rashtriya Barh Ayog(1980) report, the estimated total area liable to floods in the India is 40 Million Hectare (Mha). There are various measures those can be adopted for flood forecasting and the most common nowadays is use of Machine Learning (ML). Recent development in technology explains the use of ML tools for Rainfall-Runoff (RR) modeling. RR modeling plays pivotal role in water management and also for issuing flood warning in the affected areas. Deep learning techniques are becoming famous on developing Rainfall-Runoff models. Here, in the rainfall-runoff modeling three different modeling techniques used named as Long Short Term Memory (LSTM), Convolutional Neural Network (CNN) and Encoder-Decoder (E-D). The modeling is performed at two gauging sites of Champua and Anandpur. The discharge, rainfall and water level data of 30years (1991-2021) is used for flood forecasting. The study shown that the Concurrent Neural Network model performs better at Champua and Long Short Term Memory model at Anandpur gauging site. The values of four performance indices were checked for the study



Probability bar graphs(10%, 20% and 90%) of flows at Champua gauging site named as Efficiency, Root Mean Squared Error (RMSE), Coefficient of determination (R^2) and Noise-Signal ratio as the evaluation checker of models. The R^2 results for all models are above 0.91 values.

Flow Duration curve (FDC) is the plot of cumulative frequency curve are presented in Figures. The plot shows that all three models gives nearly same FDC at both gauging sites. The bar graph is plotted at 10, 20 and 90 % probability of flow exceed level. The 10% flood value shows the severe flood at particular gauging site, 20% shows the moderate flood and the 90% is used for power capacity of turbine. The results for 10% flood at Champua LSTM is better compared to other models, LSTM is over predicting and other models (CNN, E-D) under predicting the flow values for 2 day flood forecast.

Hydrological Study to conserve the water resources of Bikaner, Rajasthan

Bikaner city has had a number of water bodies since ancient times, which disappeared due to ignorance and non-maintenance of these historical water bodies. Due to over-exploitation and increasing pressure on natural resources and biodiversity, water bodies are declining. The study's primary objectives include an inventory of water bodies in Bikaner, long-term spatio-temporal analysis of rainfall and temperature variables, land use/land cover (LULC) change detection, trend analysis of groundwater levels and assessment of recharge to groundwater in Bikaner district, surface water availability analysis of selected pilot water bodies, identification of various issues both quantitative and qualitative, and finally suggesting ameliorative, adaptive and mitigation measures to restore the water quality for rejuvenation and sustenance of these water bodies.

In the present study, 12 pilot waterbodies have been identified falling under urban and rural areas. The catchment area of these waterbodies have been delineated using DEM and Google earth. Moreover, decadal (2000, 2010, 2020) land use/land cover maps for the Bikaner district using Landsat imagery have also been prepared. The non-parametric namely Mann-Kendall test and Sen slope tests have been employed to detect and quantify the trend for rainfall and temperature (maximum and minimum) variables with a resolution of 0.25x0.25 and 1.0x1.0 degree respectively for a period of 70 years (1951-2020) on seasonal and annual time-scale. Decadal average and seasonal variation in groundwater level is also analysed utilizing groundwater level data acquired from Central Ground Water Board (CGWB).

The soil samples are collected from seven different locations in Bikaner district and infiltration test was also performed at four different locations using double ring infiltrometer during the field visits to determine the soil texture and infiltration capacity. Post-monsoon water samples from these water bodies and 2 groundwater samples were collected for examining the water quality including physico-chemical parameters, demand parameters, heavy metals and pesticides. The analysis of physico-chemical parameters DO, BOD, COD were performed as per standard methods (APHA, 2017). Major Cations (Na, K, Ca, Mg), Major Anions (HCO3, Cl, SO4, NO3), Minor Ions (F, PO4) were analysed using Ion Chromatograph.

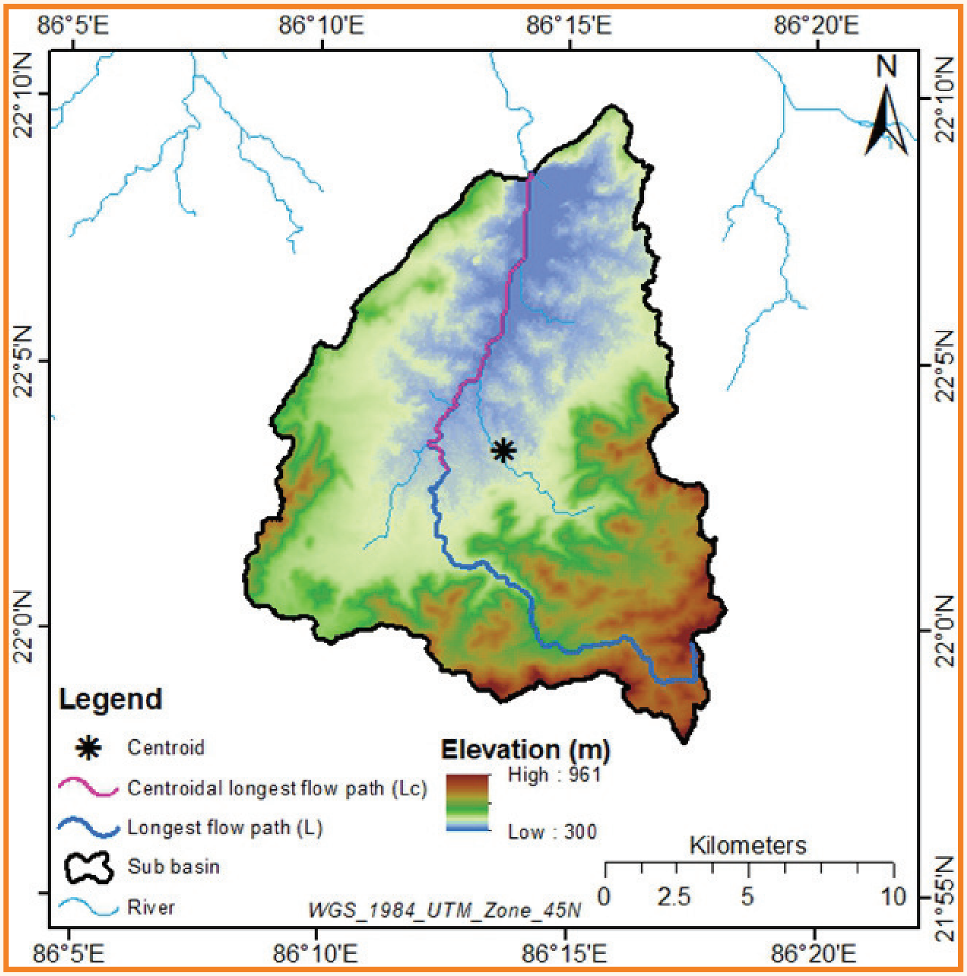
The results reveals non-significant increasing trend in rainfall and maximum temperature, whereas a significant increasing trend is observed in minimum temperature over the Bikaner district. The soil sample analysis exhibits a sandy texture soil over the study area with the infiltration rate varying from 16 to 19 mm/hr, except in the lake near RD-507. Groundwater trend analysis showed a rising trend (in 43% wells) towards the IGNP canal, falling trend is found in the southern parts of district (in 21% wells), whereas, approximately 35% wells show no-trend in groundwater levels. Water quality assessment of the water samples shows that almost all physico-chemical parameters in almost all water bodies except Dharnidhar (SW4) were observed within the permissible limit of BIS (2012) for drinking water (IS: 10500). Safe Biological Oxygen Demand (BOD) level (>2.0 mg/L) is observed in almost all water bodies. Heavy metal concentrations show that Al, Fe, Mn, Pb and B exceeded the prescribed permissible limit of BIS (2012) for drinking water (IS: 10500) in few of the samples.

Review of design flood and dam break analysis of Khadakhai Dam in Odisha

The Khadakhai Dam is an earthen dam of 365.4 m length build across Khadakhai river in 1981. The maximum height above foundation of the dam is 37 m. It has been constructed on two ends of hills i.e., Bhitarmda hill and Karanjharan hill end points. The reservoir is known as Suleipat reservoir, created mainly for irrigation purpose. In April 2012, Ministry of Water Resources, River Development & Ganga Rejuvenation through Central Water Commission with an objective to improve safety and operational performance of selected dams started the Dam Rehabilitation and Improvement Project (DRIP) with World Bank assistance. Design flood review and preparation of EAP are two important activities in DRIP. The older dams are designed with limited data and atmospheric realities of that period. Now, as those realities shift dramatically with the climate crisis, and need to be relooked. A dam operator has to manage the water release and storage cycle in such a manner that at the end of the monsoon period, its reservoir is at its full capacity. The storage and release schedule of a dam is governed by a rule curve. However, these rule curves are based on monsoon patterns of a time when such patterns were far more predictable, and less disrupted by climate change than they are today. Dam breach modelling is a key component to a well-rounded and robust dam safety program. Various researcher and guidelines recommended combination of breach parameters. The parameters are highly sensitive to peak flood and resulting flood inundation extent. This is further increased with uncertainty in design flood, reservoir operation policy, reservoir sedimentation etc. These needs to be addressed systematically while developing flood inundation map and EAP.

It is proposed to develop a rainfall runoff model using HEC-HMS for estimating design flood hydrographs at the dam site. Design flood will be estimated using the recently developed PMP atlas. Further, the future climate projections (INCC), non-stationarity in the rainfall/ discharge pattern along with LULC changes will be analysed for assessing uncertainty in the design flood estimates. Based on the estimates of design flood it is proposed to evaluate and improve the existing rule curve in DSS (PM) platform. The dam break analysis will be carried out using HEC RAS. Sensitivity analysis will performed to access sensitivity of the flood inundation maps due to uncertainty in design flood, reservoir operation policy, reservoir sedimentation etc.

The physiographic parameters of the river catchment at dam site have been estimated by GIS processing of STRM DEM. The catchment area map of the project comprising of elevation band, drainage/ catchment area at dam site is shown in Figure 1. The Synthetic Unit Hydrograph is developed using these catchment characteristics and relationships provided in flood estimation report for Lower ganga plains subzone-1g (CWC, 1994). The manual on estimation of design flood analysed time distribution pattern of storms in the area for which adequate self-recoding rain-gauge data are available. In the manual, depth duration analyses of maximum rainfall depths for standard duration of 6, 12, 18, 24, 36, 48 hours etc., were obtained for each of the storms and expressed as percentage of the total storm depth. Enveloping percentages are then obtained and applied to adjust the design rainfall based on observational data. In absence of hourly rainfall data it is recommended to apply a factor of 1.15 to convert 1-day maximum rainfall to 24-h maximum rainfall. The 24 hour rainfall is divided in to incremental hourly rainfall according to time distribution provided in the CWC report. To obtain the critical sequence of rainfall the largest of increments is placed against the peak of UH, then the next largest against the next UH ordinate and so on until all rainfall increments get arranged. Then the sequence is reversed to get the critical sequence for all spells. In case of 24-h duration rainfall the first and second 12 h blocks are interchanged to get critical situation. The design loss rate is subtracted from the hourly rainfall to obtain effective rainfall hyetograph and then direct runoff hydrograph is estimated by convoluting this effective rainfall with SUH. Finally, the base flow is added to obtain design flood hydrograph. The HEC HMS model has also been prepared with IMD gridded rainfall data as input. The HEC RAS model for Dam break modelling is being prepared.

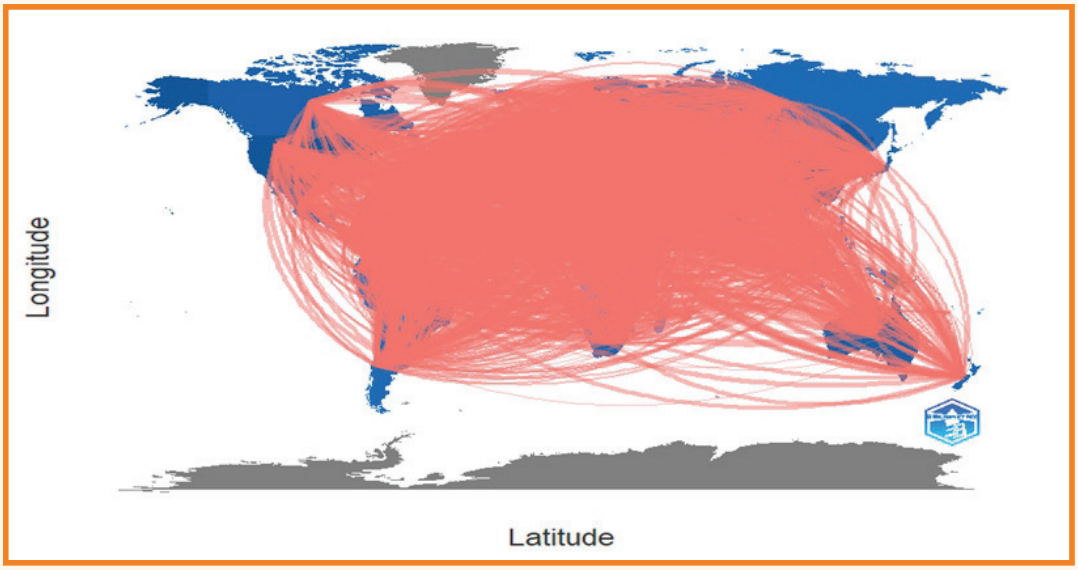


Catchment area map for Khadakhai dam(Odisha)

Investigating gap areas, current trends and future directions of research in Climate Change Impact on Hydrology and water Resources in India through Scientometrics

Scopus cited research database (1992-2021) by Indian authors for the 'Hydrology' and 'Climate Change' keywords was collected from Library of Indian Institute of Technology (IIT), Roorkee. The 31 years Scopus database includes research papers, book chapters, conference papers, review articles, books, editorials, short surveys, and conference proceedings. The collected data were processed and analyzed in R-biblioshiny package to extract the preliminary results related to hydrology- climate change research in India.The main information of the collected data includes the authors contribution to the research articles (single authored, multi-authored, authors per document, Co-authors per documents etc.). The average citations per documents and collaboration index of the research was also highlighted in the main information.The other results of preliminary analysis of Hydrology-Climate Change (CC) database includes most cited documents, most relevant documents, word cloud and thematic evolution. The Word Cloud result showed that research in the hydrology along with climate change are mainly focused on climate models, water supply, hydrological modelling, water resources, environmental monitoring, rainfall, runoff, rivers, evapotranspiration and hydrological response etc. The thematic evolution observed in the research database from 1992 to 2021 shows that in the recent database, the research is not limited to studying the parameters or impact of climate change on hydrology, monsoon patterns and groundwater but impact on humans and environment were evolved in research.

Observed Thematic Evolution in the research database from 1993 to 2021

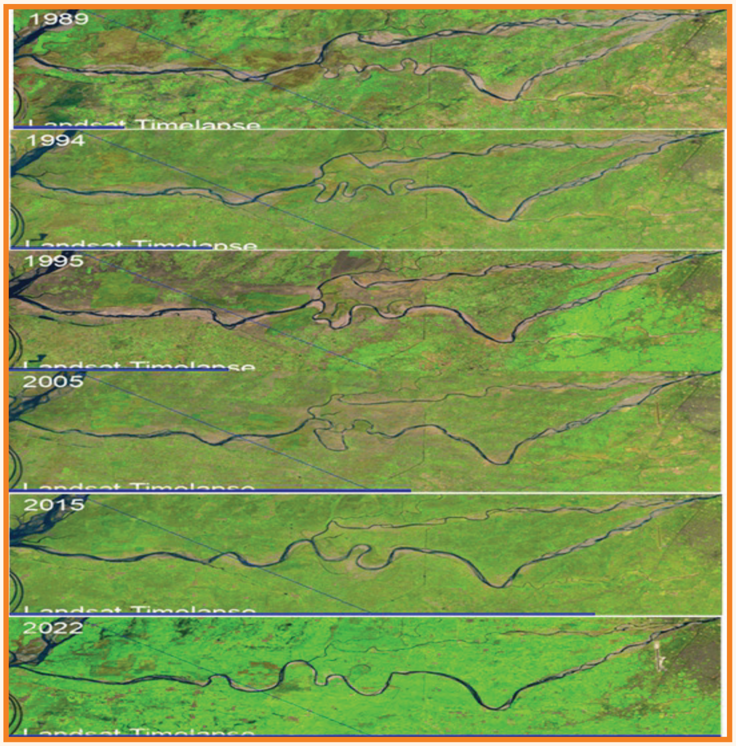


World Collaborationin research on Climate Change Impact on Hydrology and Water Resourses

Investigation of Hydrodynamic approach of flood inundation mapping along with assessment of changes in river planforms using a cloud-based Google Earth Engine (GEE) computing platform in data-scares Western Himalayan River basin

There is a very high societal demand to cope with flood hazards and incurred damages. Usually, in conditions of scarce data availability, a preliminary and cost-effective floodplain delineation can be carried out using procedures that rely on the analysis of geomorphic features (Manfreda et al., 2014). As observed changes in geomorphic dynamics in rivers are strongly timescale-dependent, limiting a geomorphic study to a single timescale can cause biased observations in channel dynamics, with long-term measurements leading to underestimations of the total change occurring over shorter timescales. Based on the various issues the study objectives are (a) To use a cloud-based Google Earth Engine (GEE) computing platform to systematically identify inter-annual changes in river planform morphology (b) To interpret changes in channel conveyance that are relevant for flood risk assessment (c) To evaluate predictive capabilities of Rainfall-Runoff-Inundation (RRI) model in development of flood inundation map (d) To carry out a comparison of the RRI model-based flood inundation maps with those obtained by using HEC-RAS and HEC-HMS models.

A thorough literature review has been carried out to formulate the research approach in the present study. The changes to river planform and geomorphic dynamics have caused, and continue to cause ecological, hydrological and environmental impacts. These river changes can be attributed to processes occurring over multiple timescales. The changes in the Tawi planform from 1989 to 2022 based on the composite Landsat data is shown in Fig. It has been observed that significant changes in the planform of the Tawi river has been observed in the downstream of the Sidhara gauging site. Further, most of the required hydro-meteorological, river cross-section, gauge/discharge, rating curve data and satellite images and thematic maps have been collected. Using these annual active channel masks, various effective techniques were developed in the MATLAB environment to map and measure changes in channel widths, the locations and rates of migration, accretion, and erosion, as well as the space-time characteristics of cutoff dynamics have been analyzed for the Tawi River.



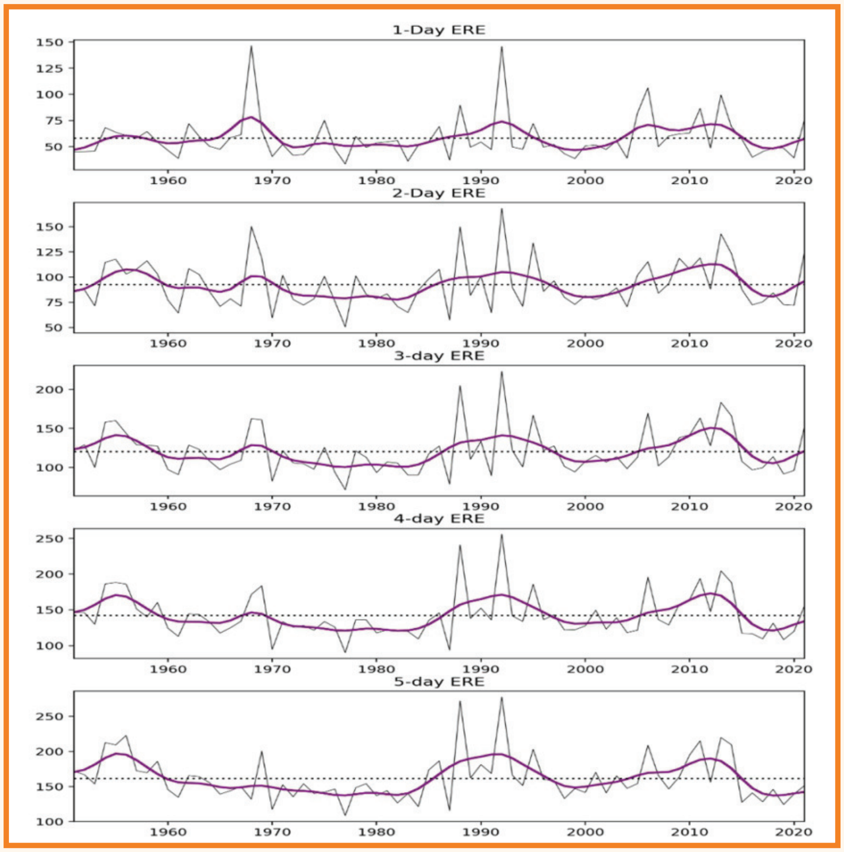
Changes Observed in the Lower Tawi river planform during 1989 to 2022

Investigation on occurrences of extreme rain events across Northwest Himalaya in relation to global atmospheric thermal and circulation changes

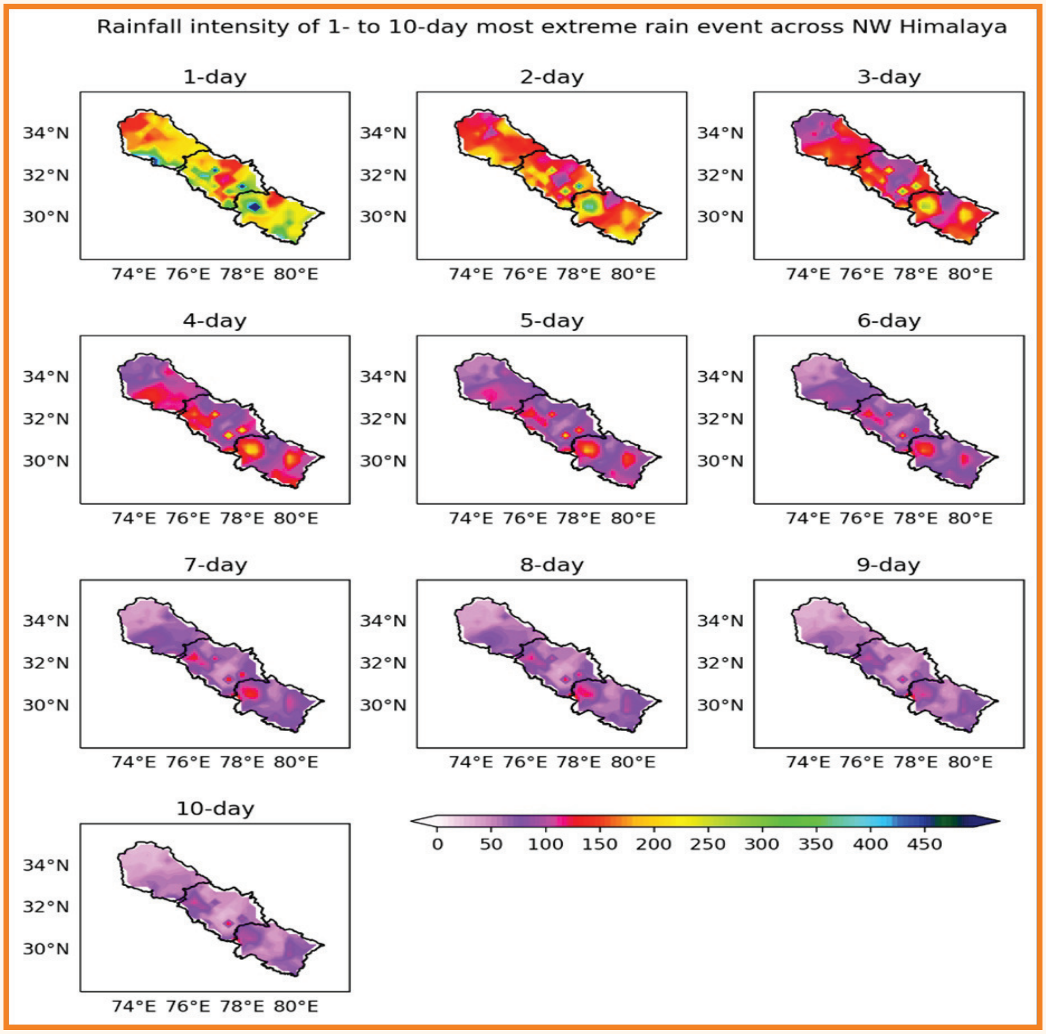
Recent years have seen an increase in the ferocity of heavy rain events over the northwest Himalayas (NWH), which are influenced by the region's highly complex terrain and tropical-extratropical interaction environment. Climatological and fluctuation features of annual and seasonal rainfall of NWH comprising Uttarakhand, Himachal Pradesh and Jammu and Kashmir states are studied in details during 1951-2021. No significant trend is observed in annual and monsoonal rainfall of NWH during the study period. However, in recent 20 years, OND rainfall has decreased significantly by 25% compared to preceding 51 years. The 'Large-scale long-period extreme rain events (LS-EREs)' and 'isolated spatio-temporal extremes (ST-EREs)' of the length 1- to 10-day are identified for each year during 1951-2021 using IMD's 0.25° gridded rainfall data. The LS-EREs intended to quantify the severity of persisting intense rains causing severe flood and ST-EREs indicating unprecedented regional local rainfall.

When LS-EREs occur, the mean rainfall intensity (RI) often declines from 58.0 mm/day for one day to 25.9 mm/day for ten days. No significant long-term trend is observed in RI of 1- to 10-day LS-EREs however the areal extent (AE) of 1-day LS-ERE exhibits a statistically significant increasing trend tested using the Mann-Kendall test. Recent 20-year changes in comparison to the preceding 51 years in parameters of LS-EREs are evaluated using student t-test. The RI and AE of 1-day LS-ERE have significantly increased during last 20 years by 7.75% and 4.6% respectively. However, there has been no discernible change in the characteristics of 2- to 10-day LS-EREs. Increase in seven selected values from the distribution of rainfall amount of 1- to 25-day LS-EREs follow second-degree polynomial with an increase in duration. The standard deviation increases linearly with mean maximum rainfall amount. The mean RI of 1-day isolated ST-EREs spatially varies from 50.3mm/day to 168.9mm/day across NWH, while the cumulative rainfall for 10-day duration ST-EREs spatially varies from 121.2mm to 528.2 mm. The highest experienced RI during the study period of 1-day isolated ST-EREs spatially varies from 106mm to 762.9mm, while for a 10-day ST-EREs, it varies from 26.3mm/day to 142.3mm/day. We observe that, most of the severe ST-EREs of the length up to 3-days are observed to occur below 3000m of elevation mostly in the states of Himachal Pradesh and Uttaranchal.

Persistence in temperature and circulation anomalies are observed to be strongly linked to the occurrences of large-scale extremes. The unusual and abrupt warming of the upper troposphere in the Tibet and Turkey sector promotes the development of deep troughs and reinforced ridges in subtropical westerlies. The abrupt intensification of the monsoon circulation connected to this warming, causes catastrophic spatio-temporal rain events across NWH. The finding of the study will be useful for climate change adaptation and mitigation purposes and development of hydro-infrastructure to store surplus from extremes in NWH region.



Interannual variations in rainfall amount of 1- to 5-day large-scale extremes over NWH during 1951-2021



Spatial distribution of highest experienced rainfall intensity of 1- to 10-day most extreme ERE during period 1951-2021

Climate change scenarios for Andhra Pradesh and its impact on streamflow and groundwater levels in Pennar River basin

Historically observed changes in climate across the globe is altering the hydroclimatic and hydrological systems, which eventually is leading to the changes in the characteristics of hydrological extremes. In addition to the changing climate, the hydrological dynamics of a basin are affected by the changes in catchment characteristics and river flow regime, caused by the land-use/land-cover changes from anthropogenic activities. In brief, the on-going changes in the global climate and the anthropogenic effects on regional/local climate would trigger imbalance in the hydrological systems and eventually result in disproportionate changes in the hydrological extremes. For example, parts of Andhra Pradesh received excess rainfall and warmer temperatures in 2021 when compared to the long period average or normal climate. In addition, Pennar River basin witnessed extreme hydrological events leading to destruction of various water resources infrastructure in the same year. Therefore, to evaluate the impacts of changing climate on the basin hydrology and/or hydrological extremes, the knowledge of complex interactions between climate and hydrological systems is vital. This study analysed the projected rainfall and temperature datasets from CMIP6 GCMs and generated multi-model climate change scenarios for the state of Andhra Pradesh. In addition, a VIC model is built and calibrated for the Pennar River basin to simulate projected streamflow at the selected gauging sites. A model based on machine learning algorithm is also built and validated to simulate watershed levels at selected locations across the Pennar River basin. Later, hydrological scenarios for the 21st century are projected using the calibrated and validated hydrological models to evaluate the impacts of climate change on the hydrology and extreme hydrology of the Pennar River Basin. The generated hydrological scenarios and results from this study will benefit water managers, irrigation and hydro-electric engineers, to plan and allocate water appropriately for its effective use and reduce negative impacts of hydrological extremes.

Studying arsenic genesis and developing alternate water supply management strategies in Ganga basin

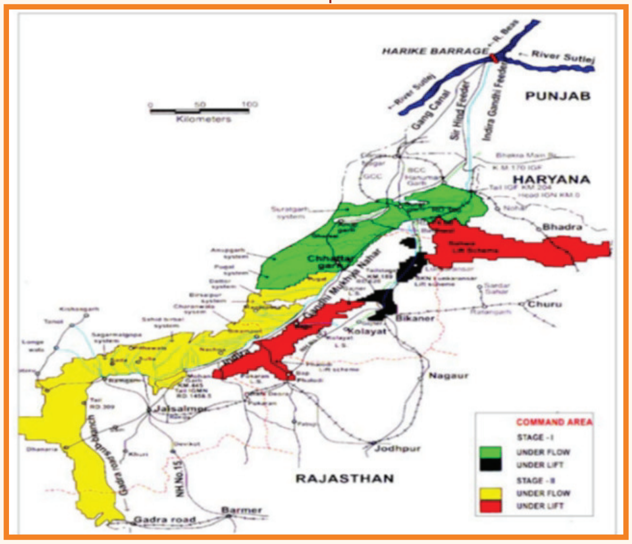
Arsenic (As) contamination of water is producing the greatest impact on livelihoods in terms of public health. Arsenic calamity in the Ganga River basin put millions of populations in danger. The river Ganga and its major tributaries originate from the Himalaya and carry lots of sediment and these sediments may determine the chemistry of water. In the mid Holocene period, the river Ganga likely to transport metals from Himalaya to the plains by erosion and sedimentation. The rivers originating from the Siwalik Hills are reported to release more arsenic and heavy metals from their sediments in comparison to those major rivers originating from the Higher Himalaya. In order to study the causes of arsenic occurrence in Ganga basin and its mobilization from solid to water phase, it is planned to carry out mineralogical, geochemical and mobilization study. The objective framed under the study are (i) Mineralogical characteristic of sediments and water chemistry in the Indian Himalayan region to detect genesis of arsenic, (ii) Demarcating safe aquifer for drinking water supply in arsenic affected areas, (iii) Performance evaluation of existing treatment units and their comparison in terms of cost, efficiency and ease of operation etc in the central Ganga basin, (iv) Developing a new treatment technique with high removal efficiency in optimized cost. Thus, the study will cover the detailed hydrogeology and geochemistry of the As-contaminated aquifer of the Ganga basin. The grid-wise water and sediment sampling are being done from Gangotri upto Patna and the spatio-temporal variation of water quality parameters including arsenic would be assessed. The groundwater and surface water samples are being collected during multiple field campaigns from both deep and shallow aquifers. Different analytical instruments are being used for analyses of ions and metals. The sediment characterization using XRD & XRF techniques are under progress. The mineralogical study would help in identifying the minerals of arsenic present in the Ganga basin. Performance of existing treatment technology which are being used in arsenic affected areas would be evaluated. The influent and effluent of treatment unit would be tested and then removal efficiencies may be ascertained. It is also planned to develop cost effective treatment units in Lab and it may be upscaled at later stage. The outcome of the study may be highlighting the genesis of arsenic and its mobilization from solid to liquid phase. The research output and development of new technique for arsenic removal may help stakeholders for deciding the water supply management strategies in arsenic affected areas.

Conjunctive Management of Water Resources in IGNP Command

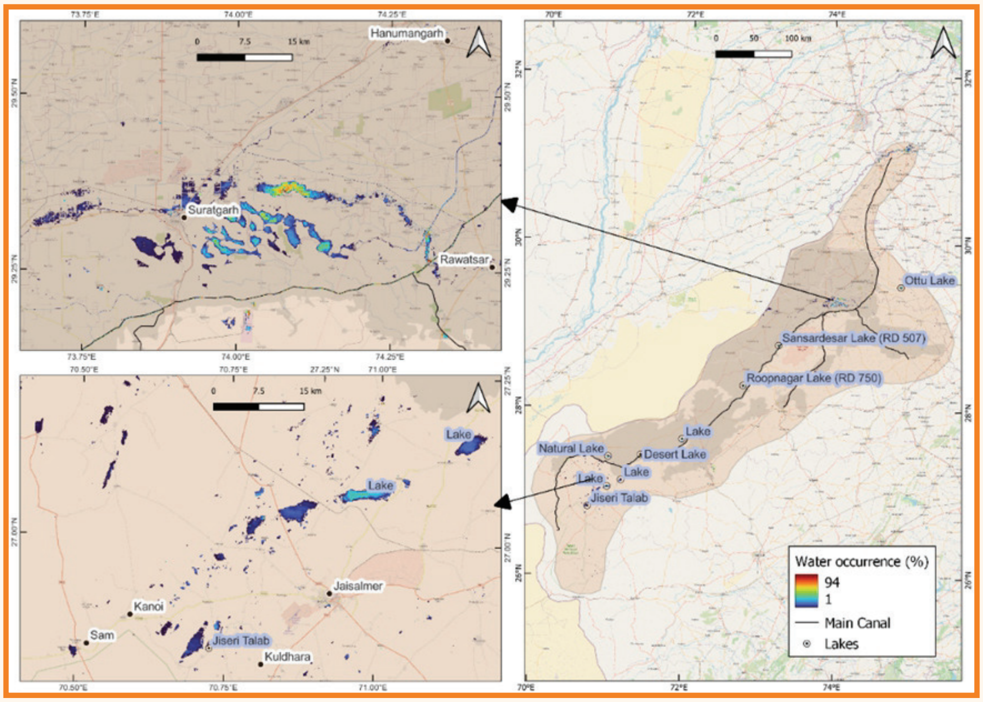
Conjunctive management of surface water and groundwater for irrigation is recognized as an effective solution to water logging and root zone salinity. The conjunctive utilization of water resources also ensures consistent water availability for irrigation and support sustainable water management. However, despite these advantages the conjunctive management of water resources is scant in canal commands. The Indira Gandhi Nahar Pariyojana (IGNP) provides irrigation to an area of 1.963 million hectare (CCA) in Rajasthan. The project also provides domestic water supply to most of Thar dessert of Rajasthan and is therefore the most important water source in the arid Rajasthan. Since the inception of the project, there has been various issues related to rising water table and increasing soil salinity. Several studies were conducted to assess the impact of canal on groundwater levels and water logging. It was observed that before the canal construction (before 1952) the depth to groundwater used to vary between 40 and 50 m. After the inception of irrigation through stage-I of IGNP groundwater level started rising. In 1972-82 the rise in groundwater level was observed to be 1.17 m/year. Later in 1995, an area of around 10% of CCA of stage-I was waterlogged and around 25% area was under critical condition (depth to GW in range 1-6 m). Such rise in groundwater level transports the salts from deeper soil layers to surface and impact the agricultural productivity in the area. The present scenario of groundwater and mapping of water-logged area is essential in the IGNP command for effective management of land and water resources. Such analysis would help in quantifying the current potential of groundwater in conjunction with canal water to maximize the irrigation potential in command and to contain salt mobilization in root zone.TheObjectives of the study are: (i)Analysis of present groundwater scenario in enroute command of IGNP (ii) Mapping of water-logged area in IGNP command using GW observations (iii) Estimation of GW recharge from rainfall, canal and irrigation under present and future climatic scenarios (iv) Conjunctive management of water resources in enroute command area of IGNP canal.

The assessment of the present groundwater scenario will be done utilizing the groundwater observation of Central Ground Water Board (CGWB). A model developed at NIH which integrated Google Earth Engine (GEE), an surface water module and MODFLOW, will be utilized for estimating recharge to groundwater. The Effect of climate variability will be considered using the most recent data of climate projections.

The groundwater level data obtained from CGWB are processed for the assessment of present groundwater status in the IGNP. Trend analysis was performed on the groundwater data from 2001 to 2018. It is found that approximately 60% of the wells having significant rising trend in groundwater, while 16% of the wells indicate falling trend. To investigate the area under water-logged in the command, global surface water data is used which shows percentage of occurrence of water during the past ~35 years. The preliminary analysis shows two hotspots of water logging in the area, one near Suratgarh and one in the North of Jaisalmer (Fig.). Further investigations to quantify the waterlogged area using time series analysis of Landsat images is in progress. The database development is in progress.



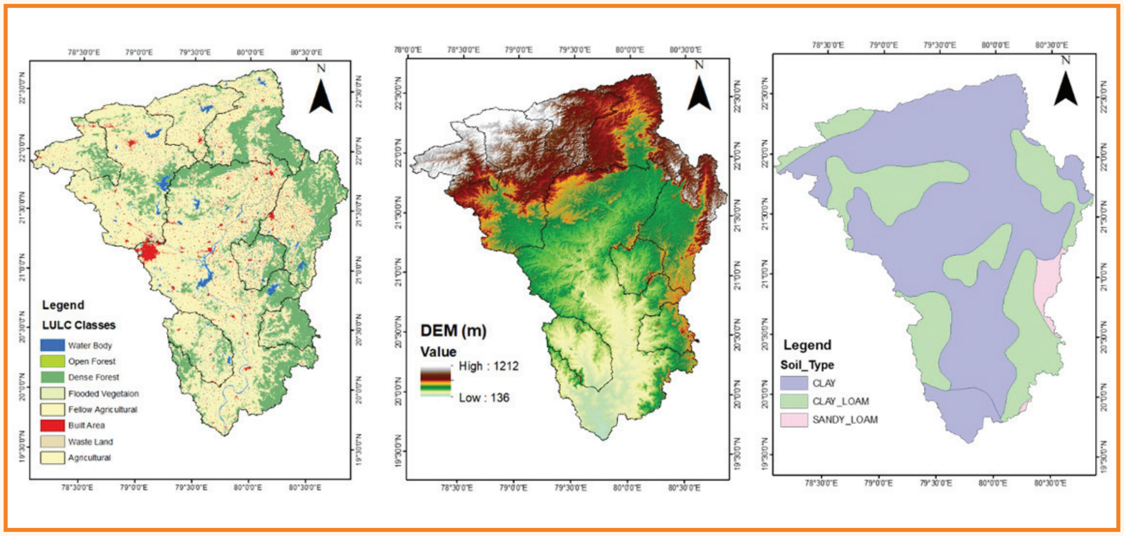
Indira Gandhi Nahar Pariyojna (IGNP) command under stage-I and stage-II



Patches of water-logged area identified using remote sensing data

Spatio-temporal water availability under changing climate and land-use scenarios in the Wainganga river basin

The water availability of a river basin is primarily governed by climatic factors and basin characteristics. Changes in these two may alter the various attributes of water resources and hydrology of the region. With the pronounced enrichment of carbon emissions in the atmosphere, worldwide warming is leading to changes in many climatic variables. The impacts of changing climate have been witnessed on every sphere of our planet. The hydrosphere, which is vital for sustaining life on Earth, is closely linked to various climatic phenomenon. The evaluation of the impacts of climate change on the hydrologic responses of river basins is vital for optimised planning and management of water resources for the sustenance of developmental projects.



Spatial Modelling Inputs of Wainganga Basin for SWAT Model

To meet the various demands such as food, water, settlement, etc. of the ever-growing population, the land-use and land cover (LULC) have changed drastically, i.e. urban sprawling. The LULC change can alter land surface interactive processes, thus affecting the hydrological cycle. This research has examined the impacts of various scenarios of varying climate and land-use on the water availability of the Wainganga River basin, in India.

As a first step, the trends and variability of regional climatic characteristics of the Wainganga basin were carried out for the past and future under two SSP scenarios, i.e. SSP2 and SSP5. Thus, the impact of changing future climate on rain is analyzed by way of assessing future rainfalls in terms of projected rainfalls for different time steps. The simulations of the changes of varying land-use for three periods in the coming future were performed for the study basin. Five bias-corrected and statistically downscaled GCM model variables with SSP2 and SSP5 are considered to ascertain the impacts of climate change. Precipitation and temperature for baseline (1981-2015) and three future periods: early of the 21st century (2016-2035), mid of century (2046-2065) and end of the century (2081-2099) have been used for hydrological simulations using a semi-distributed hydrological model on a monthly time scale. An MLP-ANN-Markov process based land-use change model was applied to predict the land-use conditions for the year 2030, 2060 and 2090 in future. For hydrological simulation Soil and Water Assessment Tool (SWAT) model with GIS-based GUI was calibrated for the period of twenty-five years of period (1980-2005) including three years of warm-up period and validated for five years of period (2000-2005). The study also includes a detailed uncertainty analysis to identify and quantify the various components for the assessment of hydrological response under changing climate and land-use of the basin. The study results in the assessments of water availability in the future periods with various percentages of dependability and can aid policymakers in effective planning and implementation of different water resources strategies.

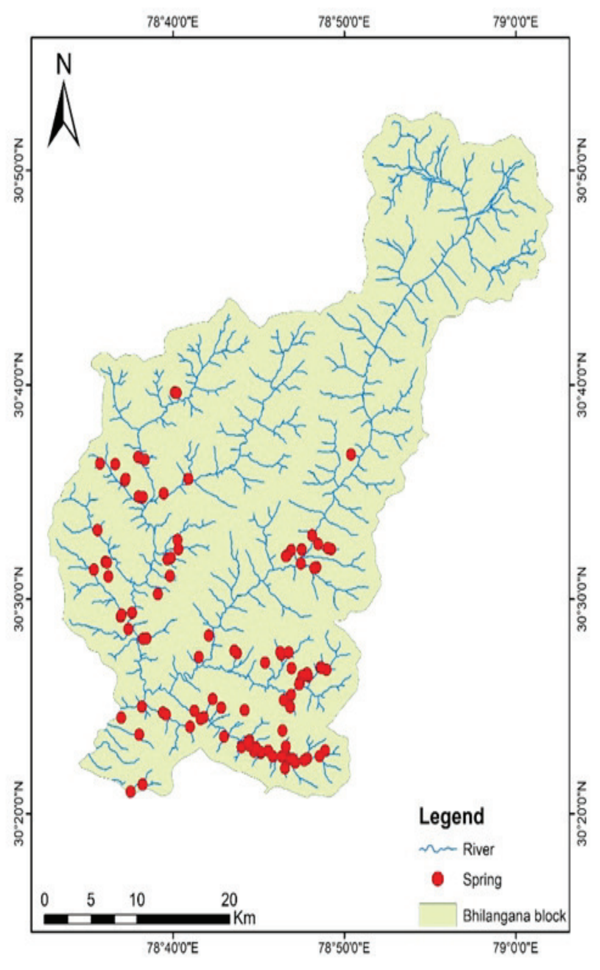
Assessment of the Possible Impact of Climate Change on Evapotranspiration for Different Climatic Regions of India

Evapotranspiration is one of the key components of the hydrologic cycle. Precipitation which falls on the land is subjected to evaporation and evapotranspiration before it reaches back to the oceans, causing a significant loss of the available water. Increasing scarcity of water due to increased ET losses may lead to difficulties in meeting the various demands of the growing population and its development needs. Most of the water bodies in the warm tropical regions undergo heavy evaporation losses. As per the CWC (2006) report, average annual evaporation loss from reservoirs/water bodies in India is about 27,000 MCM. As such, any change in evapotranspiration is likely to significantly affect the global hydrologic as well as energy cycle (IPCC, 2013). Being a cause of significant water loss, evapotranspiration plays a major role in determining the stream flow regime. Therefore, understanding the impact of temperature rise or climate change on evapotranspiration is essential for a proper understanding of the impact of climate change on the hydrological regime of the stream and water availability in the basin or water body. It shall provide a proper assessment of how much more or less water shall be available and, if less water is available, then how much additional water shall be required to meet the various demands. Unfortunately, not many studies have been reported on assessment of impact of climate change on evaporation and Evapotranspiration, more so for India. The major objectives of the study are: (i)To assess the present ET regime of some selected climatic regions of India, (ii) To assess the impact of rising temperature on various hydro-meteorological parameters used for ET assessment, (iii) To predict and compare the possible impact of climate change on ET regimes of the selected climatic regions of India.

The study is proposed to be carried out for different climatic regions of India. About five areas are to be identified to represent different climatic regions. The present average ET rates for selected climatic regions of India shall be estimated from the present hydro-meteorological data of last few decades, using the Penman-Monteith model. All temperature dependent hydro-meteorological parameters shall be identified. Projected climatic data variables such as minimum and maximum temperature from the latest GCMs developed under CMIP6 project shall be obtained to analyze the impact of climate change on ET factors. For this purpose, the evaluation of four best GCMs with SSP245 and SSP585 scenarios (total eight scenarios) will be done for selected climatic regions and then the bias correction and spatial downscaling of the GCM variables will be performed for selected climatic regions of India. The downscaled and bias corrected GCM variables shall be used as input to the Penman-Monteith model and future changes in ET rates will be estimated by performing probabilistic linear and non-linear trends analysis (e.g. Quantile regression, Q-Q plots, and CDF). The present and projected ET rates shall be compared to assess the impact of climate change on ET variability (in terms of magnitude of change) for different regions.The present and predicted rates of different climatic regions shall be compared and factors responsible for variation shall be identified.

Ascertaining the Efficacy of Use of State of the Art Technologies for Spring Mapping and Sustainability of Springs through Suitable Interventions

The present study was conducted in Bhilangana valley of Tehri District, Uttarakhand. The study area lies in the watershed of the Bhilangana river which originates from the Khatling Glacier (N 30.83°, E 78.90°) at an elevation of about 3750 m asl. From its origin at the mouth of the Khatling Glacier, Bhilangana travels for about 95 km and meets the Bhagirathi River at Tehri. The major tributaries of Bhilangana are Balganga and Dharamganga. The climate of the catchment is tropical monsoon type. The area experiences summer season from April to June, monsoon months of June to September and cold winter from December to March. The average air temperature in the region varies from 4.6°C to 36.5°C. The annual rainfall ranges from 1409 mm to 2000 mm with the mean of 1600 mm and the relative humidity in the region fluctuates between 36% and 75%. The objective of the study was to check the adequacy of the state of art technology such as LiDAR data for mapping of springs. Locations of 76 springs in the Bhilangana block were provided by the Survey of India. Till date, National Institute of Hydrology mapped 103 springs locations during the verification of locations provided by SOI in Bhilangana block during the field excursions. Besides this, spring water samples from 95 locations have been taken from around 80 villages of the block. The springs were geotagged, discharge measurement and the measurement of physical parameters i.e., pH, Electrical conductivity, temperature, Oxidation Reduction Potential and Dissolved Oxygen were made onsite. Various aliquots of samples were taken for their analyses in laboratory following the standard protocols of American Public Health Association (APHA) guidelines. The measurement of major ions, trace metals, bacteriological and stable isotopes are under process in various laboratories of NIH, Roorkee.



Location of springs surveyed along with drainage network of Bhilangana block of Tehri Garhwal district of Uttarakhand

Hydrology-based scenario planning for water productivity and optimization of income from farming practices in Mewat region, Haryana

The objectives of the study are to evaluate the existing cropping pattern and farming practices for estimation of farmer's income; to carry out scenario analysis considering combinations of crop types and cropping pattern, land allocation, water allocation under climatic variability, etc. and to develop plan for optimized income from farming practices encompassing food and water security. The optimal income from agricultural for various scenarios of crop types and land resources in Mewat region, Haryana has been evolved by setting up of WEAP tool with the combination of LINGO. Mewat district consists of five blocks such as Nuh, Taoru, Punhana, Nagina and Firozpur Jhirka. Three blocks, Nuh, Nagina and Punhana of Mewat District have been selected for the setup of WEAP model based on the drainage network created from the toposheets of Survey of India. The total area of three blocks is 957.78 Sq.km. The total population by the end of 2020 is 7,71,093 (Urban- 80101 and rural - 690992) based on the 2011 census and the population projection of Haryana State by National Commission on Population. The gridded data of rainfall, maximum and minimum temperature for the period 1951 to 2019 have been obtained from IMD. The evapotranspiration has been estimated by Hargreaves method using the average maximum and minimum temperature and extra-terrestrial radiation obtained from Internet (https://www.engr.scu.edu/).

The study team visited district head Quarter Nuh, Agriculture department and Animal Husbandry and Dairying Department on 24.09.2021 and collected crop area for Kharif and Rabi season and livestock population as per 20th Livestock census. The monthly water consumption for urban and rural population are taken as 135 lpd and 70 lpd and for livestock are obtained from literature. The percentage share of landuse for agricultural land, forest land, settlement, fallow land and water bodies are 74, 8, 12, 5 and 1 respectively based on the satellite imagery of Landsat 8 from USGS Earth Explorer for 24 December 2018. The monthly crop coefficient (Kc) for different landuses and crops (Kharif - Sorghum, Millet, Cotton, Paddy, Fodder (Sorghum), Sugar cane, Vegetable (Brinjal); Rabi – Wheat, Mustard, Barley, Chickpea (Chana), Lentil (Masoor), Tomato, Vegetable (Cauliflower), Berseem fodder) and the effective precipitation for evapotranspiration for different landuses are estimated based on the literature and FAO report. The yield and market price of the Kharif and Rabi crops are obtained from literature. The ground water draft for all uses is taken from the CGWB report of 2012 for Mewat District (annual maximum withdrawal – 79.29 Mm^3). The canal supply for four months July, August, September and October is considered as 3.39 cumec. The cost of cultivation for major Kharif and Rabi has been obtained from the report of Directorate of Economics and Statistics, Ministry of Agriculture and Farmer Welfare for the year 2018-19. The cost of cultivation for Sorghum (dry fodder) and Brinjal (Kharif) and Berseem (green fodder) and Cauliflower (Rabi) have been obtained. The water year type is determined based on the IMD criteria and is classified as normal (-24 to 24 % of 556.19 mm (average annual rainfall)), wet (25 to 39 % of 556.19 mm (average annual rainfall)), very wet (≥ 40 % of 556.19 mm (average annual rainfall)), dry (-25 to -39 % of 556.19 mm (average annual rainfall)) and very dry (≤ - 40 of 556.19 mm (average annual rainfall)). The year 2020 is taken current accounts year. The WEAP model is run with the inputs generated from different sources and literature for reference and population growth scenarios for the years 2021 to 2050 to find out demand and supply gap. The unmet demand for population growth scenario 1 (2021-25 – 1.10%, 2026-30 – 1.10%, 2031-35 – 0.96%, 2036-40- 0.83%, 2041-45-0.83%, 2046-50 – 0.83%) suggest either to develop additional storage or change the cropping pattern considering the food security.

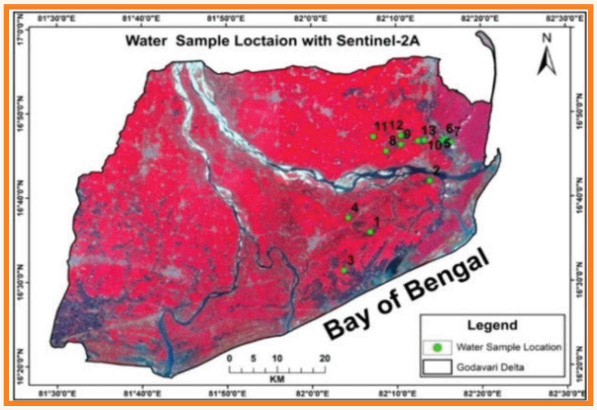
Identification of Recharge and Discharge areas of Palar Basin in Tamil Nadu

The study is carried out with the objective of identifying the groundwater recharge and discharge zones using hydro-geological and isotopic signatures. The progress of the study is as follows: The Palar River Basin base map has been prepared using DEM (SRTM-30 m). The total catchment area of the basin within Tamil Nadu is 10,273 km^2. To incorporate the latest details, a land use-land cover (LULC) map has been prepared for the year 2022 using Sentinal-2A satellite data with spatial resolution of 10 m. The hydrological data monitoring network of stream flow, observation wells, piezometer wells, rain gauges have been demarcated on base map and historical data collected for a period of twenty years (2000 to 2020). The thematic maps, such as soil, geomorphology have been collected from Tamil Nadu state water resources department. Further, Firka-wise categorization of groundwater resource assessment (as on March 2020) of the Palar Basin has also been collected and it was found that the Firakas are mainly classified as over-exploited (49), critical (12), semi-critical (53), and safe (16). The analysis of groundwater levels, and water quality data indicated that there is a significant spatial and temporal variation in ground water levels and groundwater quality within the Palar River Basin. Post-monsoon groundwater samples have been collected for stable isotope analysis. The historical groundwater level, rainfall trends and hydrochemistry data analysis are in progress.

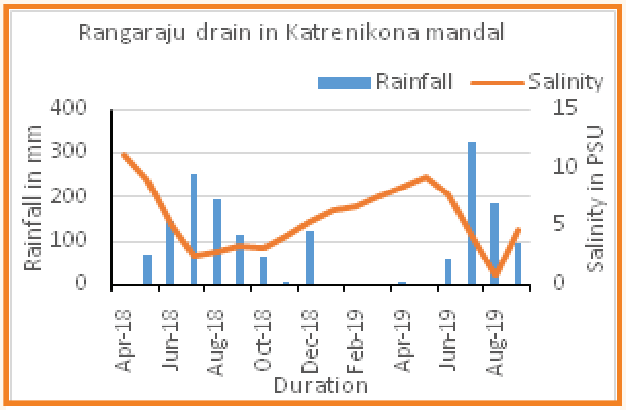
Impact assessment of backwater through drains, creeks and river mouths on groundwater salinity in the Godavari Delta, Andhra Pradesh

The study is carried out with the objectives of (1) Mapping of water pathways using high-resolution satellite data and identification of locations for monitoring of salinity w.r.t tides/seasons; (2) Monitoring and demarcation of salinity levels, and water flow assessment in major outfalls into the Bay of Bengal; and (3) Impact assessment of water pathways on groundwater salinity/contaminants using hydrochemistry and environmental isotopes. Groundwater salinity is a significant challenge to the sustainable development of coastal regions, and it plays severe implications on potable water supply in rural areas, soil fertility, and agricultural productivity. In the Godavari delta region, the surface water pathways such as river mouths, drains, and creeks are well connected to the Bay of Bengal and acted as flood relief measures. However, at present, these surface water pathways (backwater during high tides) are one of the major contributors to the development of marine aquaculture practices in the Delta. Therefore, historical water quality data at various drains have been collected from A.P. Pollution Control Board to understand the salinity levels of drains in the Godavari delta. The hydrochemistry (pH, DO, Salinity, TSS, TDS, COD, BOD, NH3-N and P) information for eight drains' (Rangaraju Drain in Katrenikona mandal, North Addalakaluva in Polavaram mandal, Vasalatippa Drain in Uppalaguptam mandal, Vrudha Gowthami in Mummidivaram mandal, Vadalanali Drain and Atreya Godavari in Tallarevu mandal, Teki and Andrangi Drains in Kajuluru mandal) samples at 13 locations (Fig.) were collected for the period from April, 2018 to September, 2019.

It is observed from the data that the salinity of all drain waters varied widely every month from April 2018 to September 2019. In order to find the effect of rainfall on drain water quality in every drain, the graphs have been drawn for salinity values and monthly rainfall during this period. Salinity values and rainfall variation during this period in the Rangaraju drain in Katrenikona mandal is shown in Fig. It is clearly observed from water quality data at the eight drains that high salinity values are observed in the months of less rainfall events. The sources for these high and low salinity values are further studied by demarcating surface water pathways for monitoring groundwater salinity with respect to seasons. An intensive field survey has been conducted in the delta and collected thirty samples from the river mouths and drains in the month of June 2023 for mapping salinity levels in the delta and the same samples are used for trace metal assessment and stable isotope characterization. The hydraulic particulars of all the drains were collected from AP Water Resources Department. The study is under progress.



Water sample locations (13) in various drains in Godavari Delta



Mandal rainfall (mm) and Drain water Salinity (PSU) variations

Design flood estimation for small structures in the south Bihar area

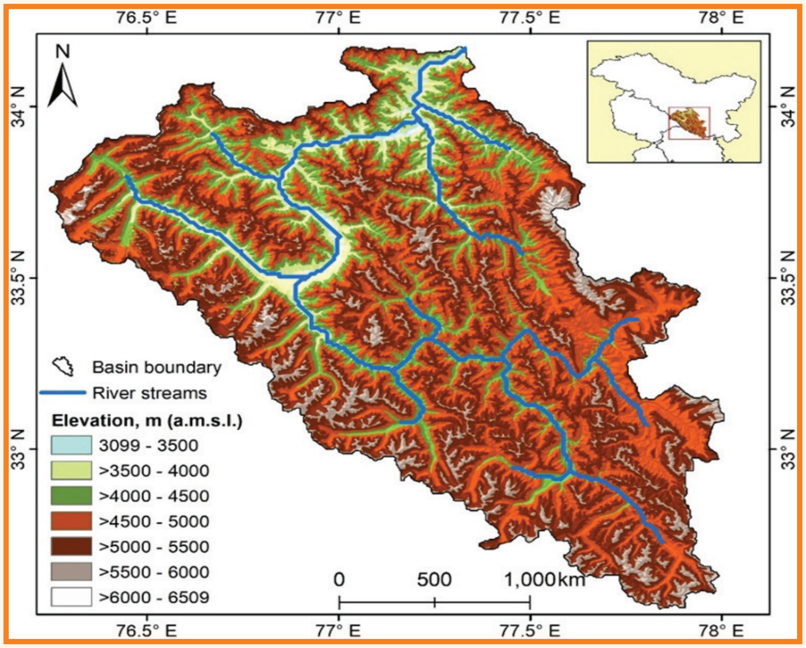
Flood frequency analysis (FFA) is used in flood risk assessment studies and for the design of various hydraulic structures. Often, this information is required at locations where streamflow series are too short to allow a robust estimation of flood quantiles corresponding to long return periods or where no data at all are available. Regional flood frequency analysis such as the index flood method offers a solution to this problem and has widely been used to estimate flood quantiles in such situations. The idea is to compensate for the lack of temporal data by spatial data, taken within a region with similar flood behaviour and transfer information from gauged to ungauged sites. The underlying assumption is that flood data within a homogeneous region is drawn from the same frequency distribution, apart from a scaling factor. The objectives of the study are (i) to develop the regional homogeneity of the study area, ii) to identify robust frequency distribution for the study area based on L-moment based frequency analysis, (iii) to develop regional flood frequency relationship between mean annual peak and physical characteristics of gauged catchments, (iv) extending the relation for unguaged catchments to compute the flood of various return period based on physical catchment characteristics. Several recent studies illustrate applications of L-moments in frequency analysis of environmental data sets including flood data. A regional flood frequency relationship is developed for gauged catchments based on the robust identified frequency distribution. This relationship is coupled with the regional relationship between mean annual peak flood and catchment attributes and a regional flood frequency relationship is also developed for ungauged catchments of the study area. Flood frequency estimates of the gauged and ungauged catchments based on data of the gauging sites constituting the homogeneous region and the available data of all the gauging sites. The study area for this study includes the watersheds of all the rivers in the south Bihar except Sone river. The geographical extent of the study area is 83.8˚-88˚ E and 23.7˚-26˚ N.

The method involves two major steps i) the identification of a set of hydrologically homogeneous watersheds and ii) a regional estimation method which transfers a normalized regional flood frequency curve or growth curve at each site of interest, after proper rescaling by the so-called index flood of the target site. The index flood is often taken to be the mean of the annual maximum flood. At ungauged sites, the index flood is estimated indirectly by developing regression equations between the index flood and catchment attributes. The annual flood peak series of various GD sites have been obtained from WRD, Bihar and CWC. The physical catchment characteristics of various watersheds are delineated in ArcGIS using online ALOS Pulsar data. The extracted drainage lines are verified from satellite images. For streams at higher elevations, the drainage lines are found to be in good match while the extracted drainage line in low elevation region, mostly at their confluence with Ganga river are showing large deviation. The study will provide estimation of design flood of various return periods for small structures in the south Bihar region.

Early Signatures of 21st Century on Snow Cover Dynamics in Zanskar River Basin, Ladakh

Glaciers and transient snow significantly cover the Himalayan landscape, impacting water resources globally. However, their effects are not well understood, especially in Ladakh. Snow cover plays a crucial role in the global water and energy cycle, affecting radiation feedback and freshwater storage and release. The North West Himalaya receives substantial snowfall, and the meltwater from snow and glaciers contributes significantly to river discharge. Traditional mapping of snow cover is challenging due to various factors, but space-based remote sensing satellites, like Terra and Aqua, equipped with MODIS sensor, offer high-resolution products for monitoring snow cover, glacier extents, and high altitude lakes since 2000. Global warming has increased glacier melting in the region, affecting snow cover and river discharge. Reanalysis products like ERA-5 can be used to study the climate-cryosphere connection. To enhance existing knowledge, a comprehensive investigation of snow cover extent concerning regional climatology is necessary. Most previous studies have focused on large scales, overlooking regional intricacies. Utilizing satellite imagery and finer scale reanalysis products can provide valuable insights into climate change impacts. In this context, the Zanskar River basin in Ladakh (Fig.) was selected for analysis with the following objectives: (i) To analyze the spatial distribution of snow cover extent in Zanskar River basin with respect to elevation, slope, and aspect, (ii) To analyze the seasonal variability in snow cover extent in Zanskar River basin (iii) To investigate the impact of climate change on snow cover extent during 2001-2020.

The mean temperature of the basin is found to be -9.9 °C as revealed by the ERA5 reanalysis data during 1950-2021, and only few months were found to show positive temperature during monsoon season. While analyzing the first 20 years of data from 21st century, it was found that mean temperature of the basin has increased by 0.4 °C, from -9.9 °C (1950-2021) to -9.5 °C (2000-2020). However, only monsoon months showed the positive temperature which is mostly during July and August. Further analysis is underway to get more insight about the regional climatology.



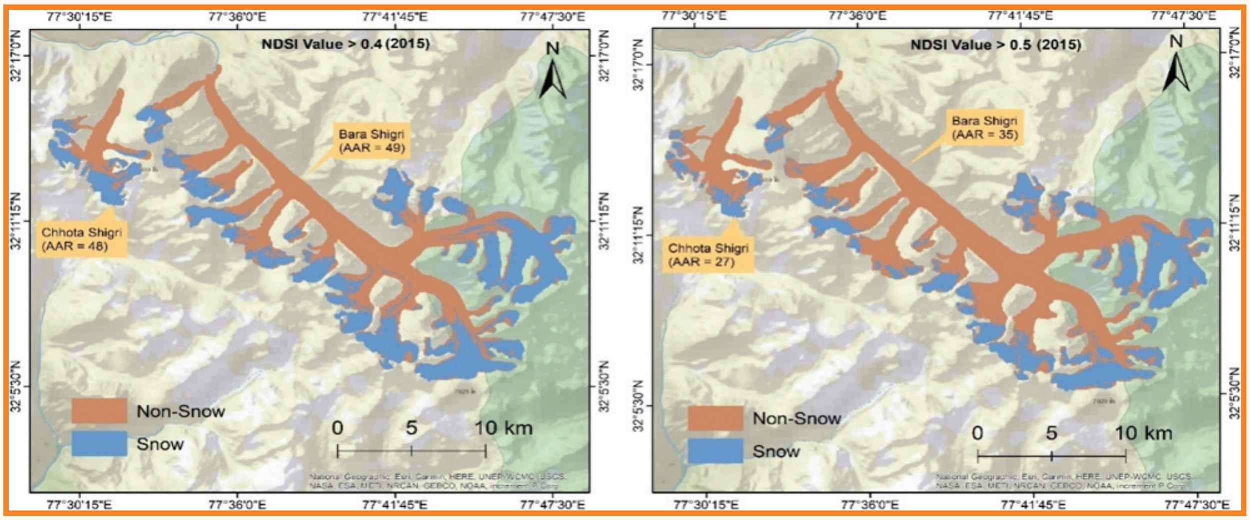
Topographic map of study area of river Zanskar River Basin

Estimation of changes in snow cover and glacier mass balance for Upper Chenab River Basin

Snow and glaciers are important components of the Himalayan Cryosphere, critical to fulfilling water requirement in the Himalayan region. Upper Chenab basin (~3,700 km2) composed of Chandra and Bhaga sub-basins has reportedly 50-80% snow and glacier contributions, and climatologically falls under the monsoon-arid transition zone, being alternately influenced by mid-latitude Westerlies and Indian Summer Monsoon, although most of the accumulation happens in winter months. There is also a gradual increase in aridity as we go from SE to NW. Moreover, the basin is important from the point of hydropower generation, and several run-of-the-river HEPs, depend on snow and glacier melt contributions for their power generation in summer months. In view of this, the study aims to estimate changes in snow cover and glaciers investigate climate-cryosphere linkages in Upper Chenab River Basin.

The snow cover dynamics in Upper Chenab Basin was estimated for the period of 2000-2020 using 939 MOD10A2 images, dividing the entire basin into different zones based on elevation, slope, and aspect. While almost the entire basin was snow covered between February and April through the first two decades of the 21st century, the minimum snow cover was mostly observed in August. Glacier mass balance of selected glaciers in Upper Chenab River Basin has been attempted using Area Accumulation Ratio (AAR) method (Fig.). Calibration and validation of AARs from NDSI values with the help of glaciological mass balance and AAR data from Chhota Shigri glacier for 2003-2019 is ongoing. Initial results suggest that NDSI threshold of 0.4 is optimum.

A comparison of over the last seven decades to the first two decades of 21st century, shows that mean monthly precipitation has reduced slightly from 91mm for 1950-2020 to 87mm during 2000-2020. Also the peak winter precipitation has shifted from March to February, while the monsoon peak has shifted from July to August, during the last 20 years.



AAR estimation using NDSI values extracted from Landsat Data for Chhota Shigri and Bara Shigri glaciers, Upper Chenab Basin

Mass Balance of Phuche and Khardung glaciers, Ladakh Range with implications for downstream water availability under changing climate

Quantifying the impact of changing climate on glaciers and downstream water resources requires long-term mass balance data build up spanning across decades. Long-term mass balance and meteorological measurements on representative glaciers are also important to link the glacier dynamics with climate change forcing. Phuche glacier being the headwaters of Ganglass catchment, the water tower for Leh town and in view of their marked difference in mass turnovers, the objectives of the study are to continue winter & Summer Mass Balance studies of Phuche and Khardung glaciers for building a long- term mass balance data series, study of glacier –climate linkage and runoff modeling using improved understanding of temperature-precipitation gradients and permafrost thaw.

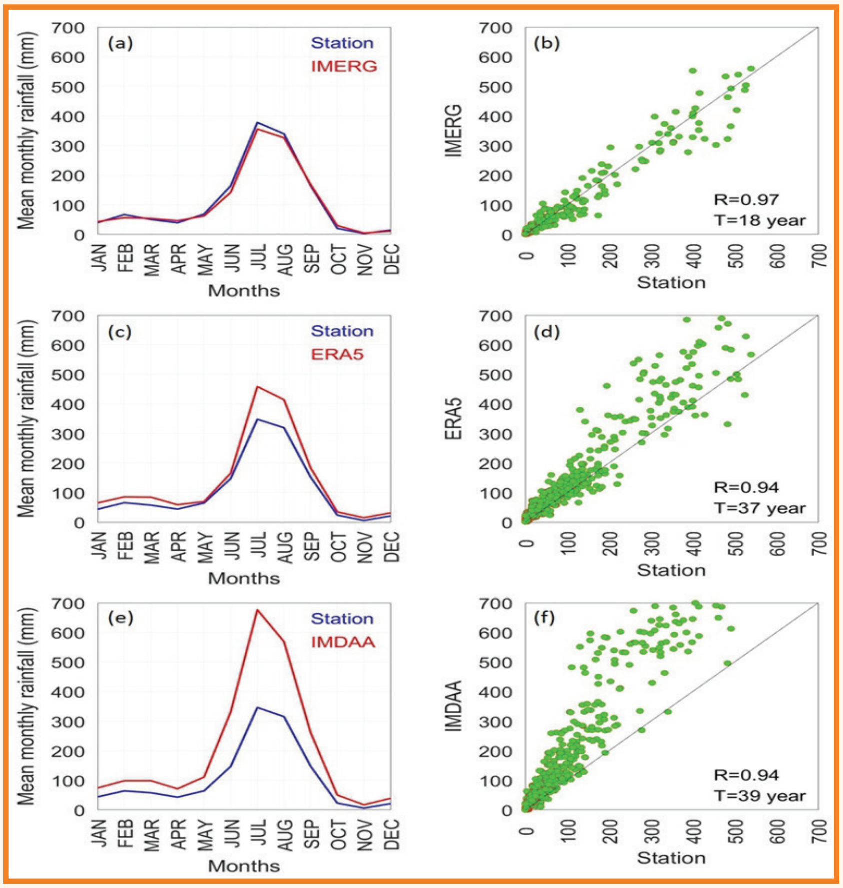
Ablation and accumulation measurements are ongoing on Phuche and Khardung glaciers as well as discharge and meteorological data collection at various locations in the study area, using automatic and field instrumentation.

Stream discharge monitoring of Phuche proglacial, South Pullu, Leh

Comparative Analysis of Fine Scale Satellite & Reanalysis Precipitation Products in Upper Ganga Basin using Multicriterion Decision-Making

One of the recent studies conducted by the NIH focused on precipitation records in the Upper Ganga Basin. The study collected data from a rain gauge network maintained and operated by IMD and CWC, totaling 47 and 11 stations, respectively. After processing the data, 37 stations (19 IMD and 11 CWC stations) were used for the study. However, it was observed that a significant portion of the basin remained uncovered, and this raised the need to explore other resources to achieve seamless spatial coverage for hydrological modeling. In recent years, several fine-scale precipitation products, such as IMERG, ERA5 land hourly data, and IMDAA, have been released by different agencies. These products offer spatial resolutions ranging from 0.05o to 0.12o and have been widely adopted by researchers. However, their suitability for the Upper Ganga Basin using station records has not been thoroughly investigated. Additionally, there is a lack of studies that specifically rank the performance of these products concerning observed station data. A previous study by Choudhury et al. (2021) demonstrated the use of a Multi-Criteria Decision-Making (MCDM) approach to evaluate various gridded precipitation products in the Satluj River basin. This statistical technique proved valuable for analyzing the efficacy of gridded products in a specific region. Building on this, the current study aims to assess the suitability of fine resolution gridded products using station records to capture the local precipitation patterns in the Upper Ganga Basin. The study has two primary objectives: (i) To perform statistical evaluation of fine scale satellite and reanalysis precipitation products in Upper Ganga Basin vis-à-vis station records,(ii) To estimate performance ranking of fine scale satellite and reanalysis precipitation product in Upper Ganga Basin using Multicriterion Decision-Making and Group Decision-Making.

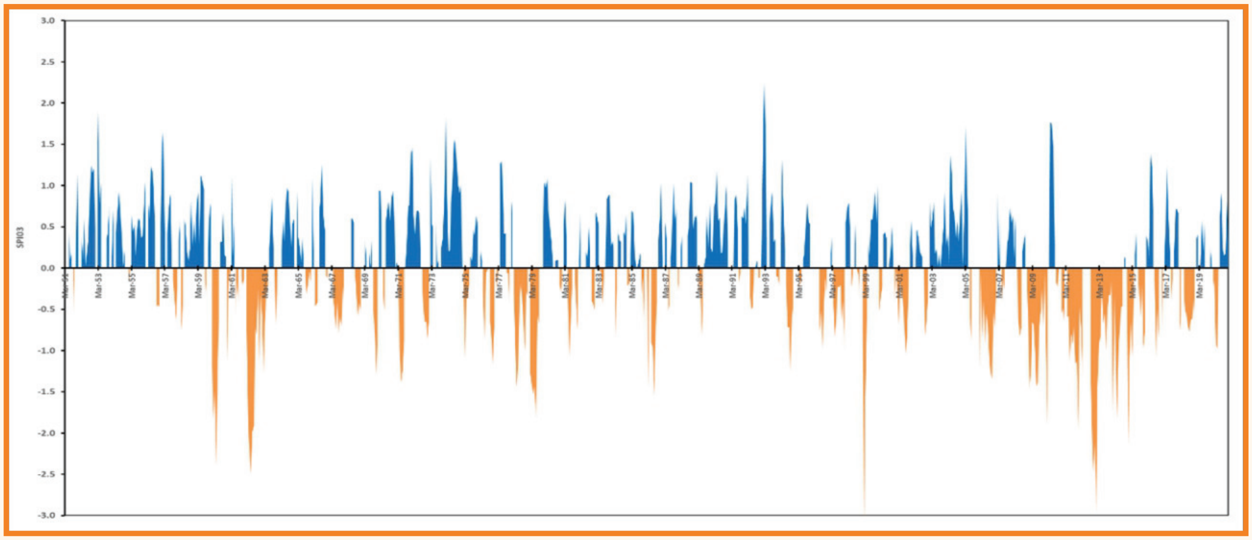
As per the preliminary analysis that comprises result for the precipitation estimates of IMERG, ERA5, and IMDAA, it was observed that IMERG is a better choice over ERA5 and IMDAA products for studying the precipitation regime of the Upper Ganga Basin (Fig. 1). Notable, the IMDAA showed the maximum overestimation in capturing the precipitation cycle of the region.



Comparison of areal monthly rainfall with precipitation estimates in the Upper Ganga Basin

Drought characterization and vulnerability assessment in Assam

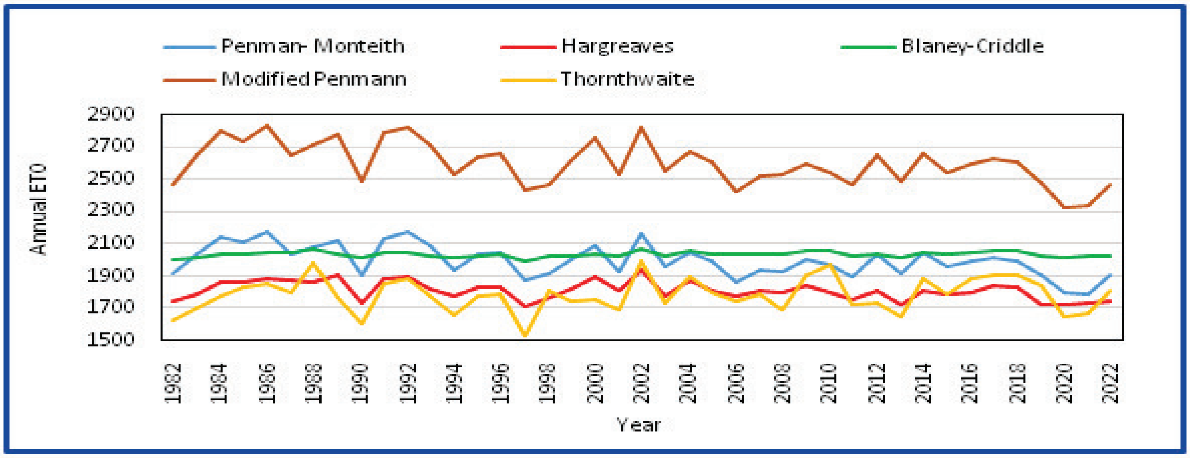
Assam is generally a flood prone state but the distress caused due to occurrence of drought cannot be neglected. Past studies stated that due to declination of southwest monsoon in the region in recent times and over-exploitation of water resources by the people results in reduction in availability of water to meet the demands of the people. Assam has been traditionally affected by floods, however, in the last few decades, droughts had been occurring due to erratic rainfall patterns. So, a study is carried out to characterize historical drought occurrences for all the districts of Assam, to project future drought occurrences at district level using projected precipitation, and to generate drought vulnerability map of Assam at district level. A drought indicator–Standardized Precipitation Index (SPI) was used in this study. Here, in the study, a district wise (35 districts) analysis for characterization of drought in the state is performed to observe and understand the past drought condition of Assam from 1951 to 2020 with the observed data of IMD. And with a focus on predicting the future possibility and condition of drought from 2026 to 2055 through the projected data generated by ensemble of five CMIP6 models. This study found that, 91% of the average annual rainfall occurred during pre-monsoon and monsoon seasons collectively, suggesting great dependency on these two seasons for growth of agriculture sectors. This also led to suggestion that there is an urgent need to turn on the irrigation-based system from the traditional rainfed ecosystems. The dominant positive SPI series in the results also suggested that there is enough potential for development of irrigation system and recharge the groundwater resources. The total percentage of historical drought in Assam, as an overall, was about 14.5% of the entire 70 years period (1951–2020). The results also suggested that irrespective of the season, drought will be occurred. For the historical droughts, in terms of number, BishwanathChariali districts was the most affected district, while KarbiAnglong was the least affected one. Further, in terms of severity, Sibasagar district was found to be affected by the greatest number of droughts of extreme nature. The average duration of drought in Assam was found to be about 5.2 months. It is concluded that districts with a greater number of droughts, and greater duration of drought spells needed to set up drought mitigation planning. The findings of this study will aid the efforts being made by the Assam Disaster Management Authority, Agriculture Department, Irrigation Department, and Water Resources Department in proper planning, action, and management of multiple entities with regard to the state's drought.



Three-month SPI in Assam during 1951–2020

Re-assessment of evapotranspiration (ETo) estimation for irrigation planning in Madhya Pradesh

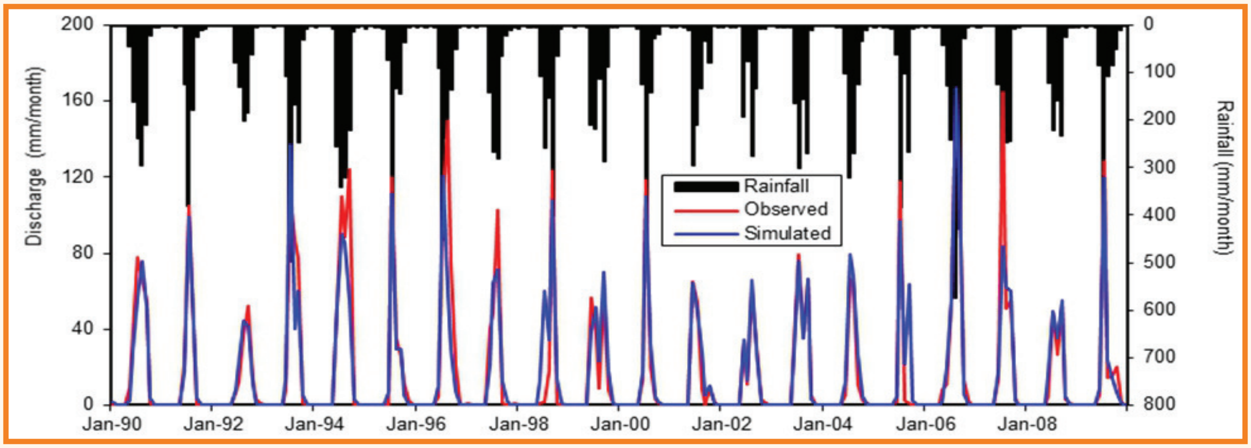
In Madhya Pradesh (MP), the crop water requirement and irrigation water requirement is estimated as per the methodology suggested in Technical Circular (TC) – 25 of the Water Resources Department (WRD) of June 1990. Due to climatic changes, biotic evaluation, changing agricultural practices, and anthropogenic interferences, the evapotranspiration (ETo) estimates seem to have been overestimated and need to be re-assessed for irrigation planning in MP. The major aim of this study is therefore to verify the facts behind the change in estimation of ETo and irrigation requirement in the command area and suggest changes in TC-25 and accurate methods or software for estimation of ETo. The objectives of this study include, conducting review of different ETo estimation methods, assessment of ETo using different methods and their inter-comparison, investigating facts behind change in estimation of ETo and crop water requirement (CWR), and irrigation requirement (IR) in the command area, and study of different online open source online software for ETo estimation. The study area for the hydrological investigations is Kolar dam and its command area. The literature review is in progress, and the meteorological data, cropping pattern, water release data, daily water levels, have been collected. The ETo estimation has been carried out using different methods viz., Blanney-Criddle method, Thornthwaite method, Hargreaves method, Modified Penman, and Penman Monteith method using climatic data of Bhopal station during 1980 to 2019. The average annual ETo estimated by Modified Penman was 2598 mm whereas other four methods estimated average annual ETo in the range of 1785 to 2035 mm. The Modified Penman method being used in TC-25 seems to be overestimating ETo as compared to other methods. The remaining objectives will be covered in the work program of subsequent year. The assessment of ETo and verifying the factors affecting ETo will be carried out so as to make possible modifications in TC-25. The study will suggest more accurate software and methods for estimation of ETo, suitable for specific regions, under the constraint of limited data requirement and adaptable to climatic changes, which will be easily available online with open access.



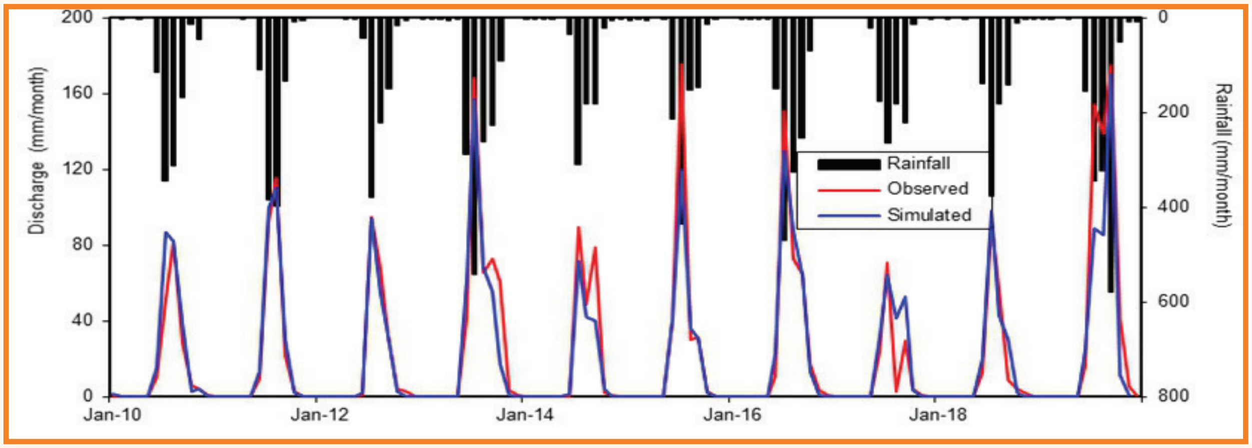
Annual ETo at Bhopal

Water Availability Assessment for Project Formulation in Sub-Basins of River Ganga in Madhya Pradesh

Govt. of Madhya Pradesh is developing a number of water resource projects to supply water for irrigation, power, industrial, and domestic uses. For developing these projects, firm water availability is one of the important prerequisites. Most of the time, long-term runoff data are not available at the point of interest and this can be simplified by transferring data from a neighboring location, but data collection and analysis concerns are still prone to planner bias in terms of donor catchment selection and record length. Linear regression equations for different basins were developed. Ken River basin has six sub-basins namely, (Sonar, Pandwan, Kopra, Niwari, Nohta, and Tigra) with basin areas (2562.32, 4520.03, 867.40, 1288.37, 3380.53, 4188.79 sq. km.) respectively, where the observed data were available. The R2 value for the rainfall-runoff relationships during seasonal months falls in the range of 0.4 to 0.6. Similar types of equations were developed for the Betwa, Tons, Sindh, and Chambal basins. The GR2M model that works on a monthly basis was applied for different G/D sites of the Betwa, Chambal, and Ken basins and found to be most suitable to assess the monthly water yield required for the assessment of project water availability. The calibration and validation of the GR2M model for the Badnagar G/D site in the Chambal basin are presented in Figures. The study is in progress.



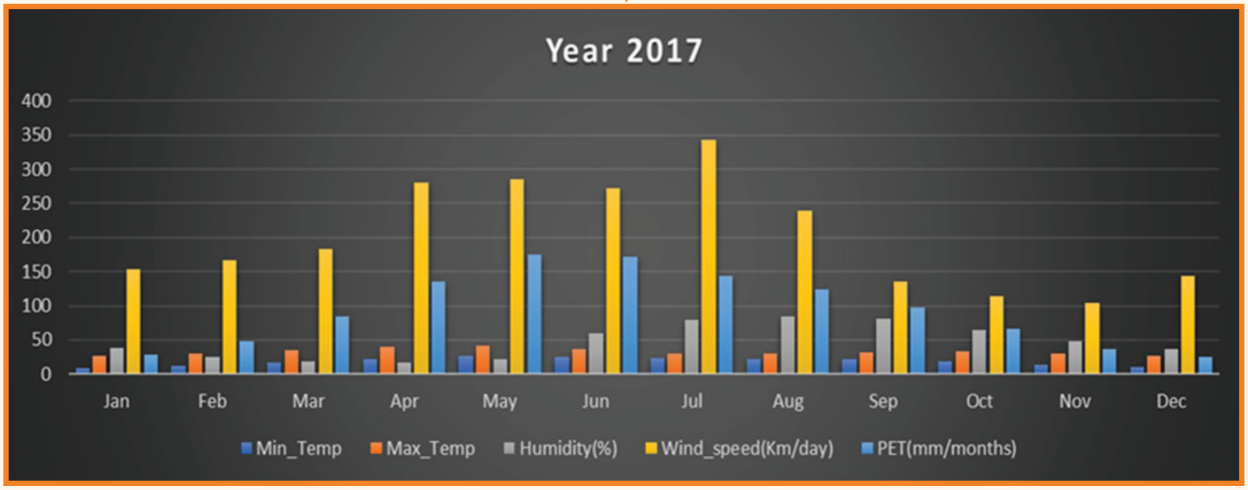
Comparison of observed and computed runoff during calibration for Badnagar G/D site in Chambal basin



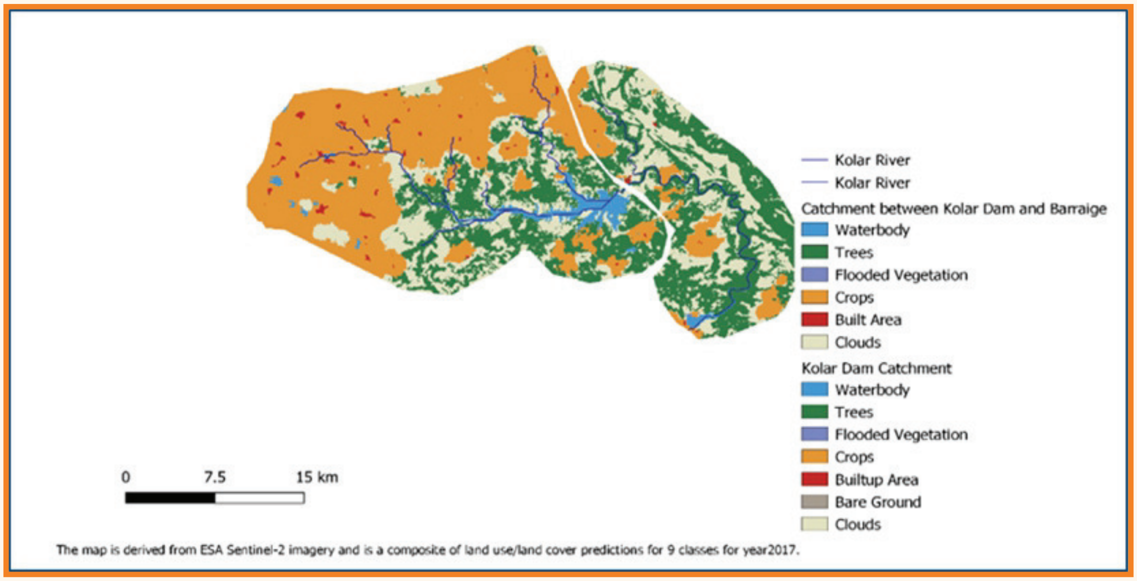
Comparison of observed and computed runoff during validation for Badnagar G/D site in the Chambal basin

Development of Reservoir Operation Plan under Climate Change Scenarios for Kolar reservoir in Madhya Pradesh

Kolar reservoir is an important source of potable water supply for the Bhopal city, as well as for irrigation. The project was proposed to irrigate an area of 45078 ha but, only 31,000 ha is being irrigated presently due to water shortage. Looking into the deficit in reservoir storages in the past years, this study is envisaged to assess scenario based demand-supply analysis and management options for optimal use of water in Kolar reservoir. The present study has, therefore, been undertaken with the objectives including, development of rainfall-runoff model for assessment of water availability, assessment of future demand and supply for Kolar dam, scenario development under changing hydrology, population growth and management aspects and development of reservoir operation policy under climate change scenarios. Collection of hydrological, meteorological data, soil and geology from diverse sources is under progress. Preparation of GIS database consisting of drainage, canals, digital elevation model, soil, land use/land cover map of Kolar reservoir catchment and command area has been completed. Assessment of various components pertaining to present scenario of supply and demand using established water balance techniques is under progress. The database for Kolar Command Area has been arranged based on present supply and demand for the years 2019, 2020 and 2021. The study is in progress.



Climate of study area of Kolar river basin in year 2017



Land use/Land cover map of Kolar catchment and area between Kolar Dam and Jholiapur Barrage

Monitoring and Evaluation of Ground Water Quality of Belagavi City, Karnataka, India

The study was proposed to monitor the ground water quality of Belagavi city, one of the fast-growing cities of Northern part of Karnataka state. Since last 2-3 decades, city has seen a large migration of people due to industrialization, enhanced commercial activities and improved education system. The huge migration has induced stress on the natural resources and led to the degradation of quality of these natural resources. The water being one of the major natural resources and has been deteriorating in its quality around the city due to improper management. Therefore, there is a need to assess the water quality in the city and around to understand its status in comparison with the earlier levels. The objectives of the study are; to evaluate the Groundwater quality of Belagavi city, to Identify the groundwater quality problems in various parts of the city, to classify the groundwater based on the chemical quality, Application of DRASTIC model for assessing the vulnerability to groundwater pollution. The study involves identification of wells under quality problems throughout the Belagavi city and classifies the ground water based on chemical characteristics. Evaluate the water quality index for Belagavi city based on chemical quality of the wells. The application of DRASTIC methodology for assessing the vulnerability to ground water pollution. The study aims to assess the sources of ground water pollution and suggests the guide lines for proper management of waste disposal systems and adequate drainage facilities for the entire city to safeguard the ground water for future purpose.

Sampling of groundwater from an open well in Kakati, Belagavi

Collected samples of open and bore wells around 40 locations during post monsoon 2022.The locations of the samples are classified as: Residential areas, Industrial areas, Commercial areas and semi-urban areas. Also water samples have been collected adjacent to Bellary nala throughout the city.Results shows that higher content of bicarbonate, chloride, sodium, potassium, hardness, EC and TDS werereported in some samples due to sources such as industrial and domestic wastes dumped without treatments. It is also noticed that higher concentration is noticed in some unused wells as compared to used wells. Therefore, renovation and utilization of the wells is necessary to improve the quality. Bacteriological analysis indicates that, higher coliform bacteria (1100 -1300/100 ml) were noticed in some wells along the side of Bellary nala which carries untreated domestic sewages. Concentration of DO and BOD (200 mg/l) also exceeds the permissible limits especially in shallow dug wells which are located close to the sewer drains and along the course of Bellary Nala. Samples collected from close to the solid waste disposal sites at Khasbag shows the higher concentrations of hardness, sodium, chloride etc. and decreases away from the sites. The earlier studies during 1999, 2004 and 2007 indicate that, higher concentrations of chemical parameters were due to the discharge of industrial effluents and domestic sewages. In thickly populated areas of the city indicates the impact of industrial and domestic wastes on ground water.

Descriptive Statistical Analysis of chemical parameters during post monsoon 2022

Parameters	Min	Max	Mean	Median	Mode	Standard deviation
pH	6.15	8.25	7.29	7.35	7.50	0.56
EC	228	2280	632.08	620	650	384.00
TDS	110.6	1522	341.42	332	408	244.67
CO_3	0.00	16	3.54	0.00	0.00	5.60
HCO_3	52	318	139.64	124	110	59.84
Alkal	52	328	143.18	130	110	61.64
Hardness	21	385	137.58	118	128	78.15
Ca	40	232	88.46	80	100	38.69
Mg	12	180	57.85	44	44	42.84
Na	34	525	128.80	105	33	49.99
K	05	168	35.50	27.55	08	7.57
SO_4	1	120	42.72	33	28	33.900
PO_4	0.19	8.20	2.40	0.54	0.28	2.66
NO_3	0.80	27.50	9.67	7.0	1.80	7.97
Fe	0.01	2.55	0.17	0.06	0.05	0.41
Mn	0.50	1.20	0.92	0.06	1.00	0.17
Cl	25.20	437.20	126.90	105.20	89.20	437.20
Fluoride	0.75	2.20	0.95	1.10	0.98	0.67

Sponsored and Consultancy Projects 7

For the past many years, the Institute is carrying out projects sponsored by International and National agencies. During 2022-23, work on 47 sponsored projects was carried out, in which 6 projects were internationally funded and 41 projects were funded by national agencies. The list of sponsored projects is given in Appendix-VIII.

NIH is providing solutions to problems faced by industry and field organizations through consultancy projects. The consultancy projects are being referred by State Governments, Public Sector Undertakings, and also by private companies. During the year 2022-23, the scientists of NIH worked on 47 consultancy projects of which 11 projects were completed. The list of consultancy projects is given in Appendix-IX.

The details of some of the sponsored projects are given below:

7.1 SPONSORED PROJECTS COMPLETED DURING 2022-23

Dam break studies of Somasila, Kandaleru and Pulichintala dams in Andhra Pradesh

Flood generated by dam breach are more disastrous as compared to ordinary precipitation generated runoff flood. Dam failure analysis is considered very essential because dam break has high hazard potential to the downstream area. It gives enough warning time to the nearby people to vacate that place and reach to the nearby safe place with the help of inundation map information. The purpose of dam break analysis is to illustrate how the flood wave propagates and attenuates along the river. In two dimensional modelling the cross section of river data is an important parameter. The HEC-RAS model designed by U.S. Army Corps of Engineers is used for modelling purpose. In this work two-dimensional modelling is performed and the required data for one-dimensional modelling is provided by Water Resource Department of Andhra Pradesh and some information is extracted from the available project documents. The suitable values of roughness of river and river bank are taken with the help of Chow's table and breach parameters are assumed using different equation provided by various analysts. For Pulichintala dam, the generated peak hydrograph is about 121368.90 m^3/s and the cross-sections are taken for 85km downstream. For Kandaleru dam the generated peak of hydrograph is about 59,209.70m^3/sec and it is analysed for different cross-section upto10km downstream distance. A sensitivity analysis is performed for breach width, breach formation time, Probable Maximum Flood change and for roughness variation. Based on the study finally the flood inundation map is prepared for both the dams. The inundated area for Pulichintala dam is 1980.984 sq.km. with affected population about 2,170,385 and for Kandaleru dam is 45.68 sq.km with the affected population about 8,826.

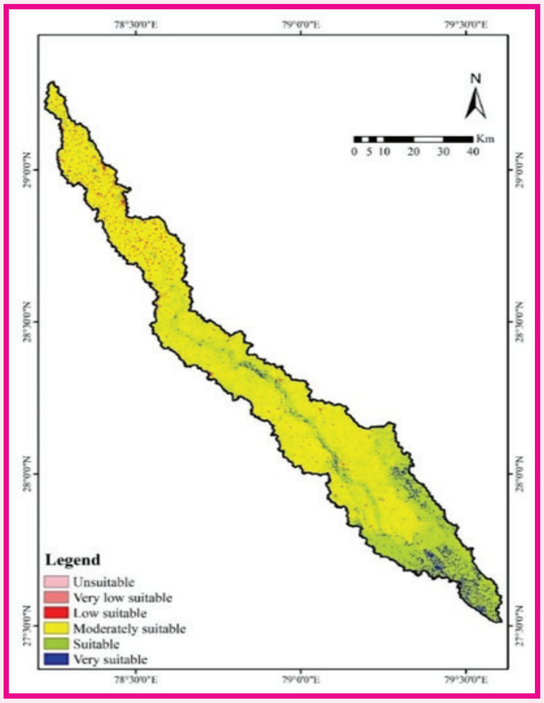
Ganges aquifer management in the context of monsoon runoff conservation for sustainable river ecosystem services – A pilot study

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

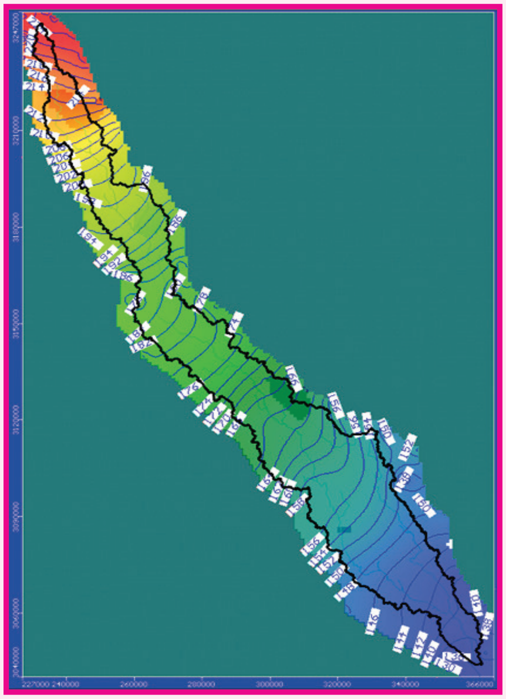
Ganga and the Ramganga river. Though both these rivers have good water potential, the Sot river is drying-up in recent years after monsoon season, and its catchment faces acute water problem and many hydrological problems, including extra-deep groundwater levels, recurrent droughts, soil erosion and desertification in some of the areas. The catchment area falls in districts of JP Nagar, Moradabad, Budaun, Shahjahanpur and Farrukhabad. The objectives of the study include: (i) hydro-geological characterization of the area, (ii) analysis of meteorological and hydrological variables *vis-a-vis* cessation of river flows during lean season, (iii) estimation of surface water and groundwater availability, (iv) analysis of stream-aquifer interaction, and (v) aquifer management measures for enhancing river flow during lean season.

The study area comprises of 3,027 sq.km of Uttar Pradesh. The elevation of the catchment varies from 138 to 245 m above mean sea level. Various thematic maps such as catchment boundary, catchment location, DEM, drainage, slope, soil, sub-basin, district/tehsil/road network, grid and land use have been prepared. Daily river flow data was collected and processed to analyze variations of river flow along with rainfall variation. Groundwater modelling was done using the Visual MODFLOW software to model the four-layer groundwater system and assess impacts of groundwater recharge interventions in the catchment. The data for the period from 2009 to 2018 were used. The model was calibrated for the period 2009 to 2014 and validated for the period 2014 to 2018. This calibrated and validated model was then used for assessing the impact of groundwater recharge structures in the catchment. To implement the groundwater recharge structures in the Sot catchment, potential zones for groundwater recharge were identified. Eleven thematic layers, namely ground elevation, LULC, surface slope, soil, geology, geomorphology, drainage density, recharge, depth to aquifer, depth to groundwater and groundwater fluctuation, were used for identifying these zones. Saaty's Analytic Hierarchy Process (AHP) was used to finalize the consistent weights of various thematic layers. The groundwater potential zones were delineated into six classes viz. unsuitable, very low suitable, low suitable, moderately suitable, suitable and very suitable, using the Prajal tool. The maximum area was found under the moderately suitable condition followed by suitable and very suitable condition. The zones were used to implement the groundwater recharge structures in the catchment. Finally, few scenarios on groundwater recharge structures were suggested in the Sot catchment for augmentation of groundwater so as to contribute to river in the form of base flow. Three types of recharge structures were suggested depending on the local conditions. These structures include check dams, percolation tanks and recharge shafts. Eight check dams are suggested mainly in the upper part of the catchment. Seven percolation tanks are distributed in the catchment wherever thickness of surface soil is less. Seven recharge shafts were suggested where upper unconfined aquifer is deeper and separated by thick aquitard layer. The impact of these structures has been presented with and without these recharge interventions in the form of change in groundwater level profiles. It was observed that the groundwater levels rise in water table profiles after implementation of the recharge interventions. The water table profiles show rise during the period of recharge and decline during the period of no recharge. It was also observed that in general the water table profiles show rising trend after the recharge interventions. Similar structures can be implemented at other feasible locations (falling under the suitable and moderate suitable zones). In the study, various measures were suggested for rejuvenation of the Sot river. The study will help line departments and stakeholders to provide (i) surface water and ground water availability, (ii) scenarios on augmentation of groundwater in the catchment, (iii) groundwater recharge measures, and (iv) measures for revival of river.

Infiltration and hydraulic conductivity tests in the catchment of Sot river



Groundwater potential zones in the catchment of Sot river

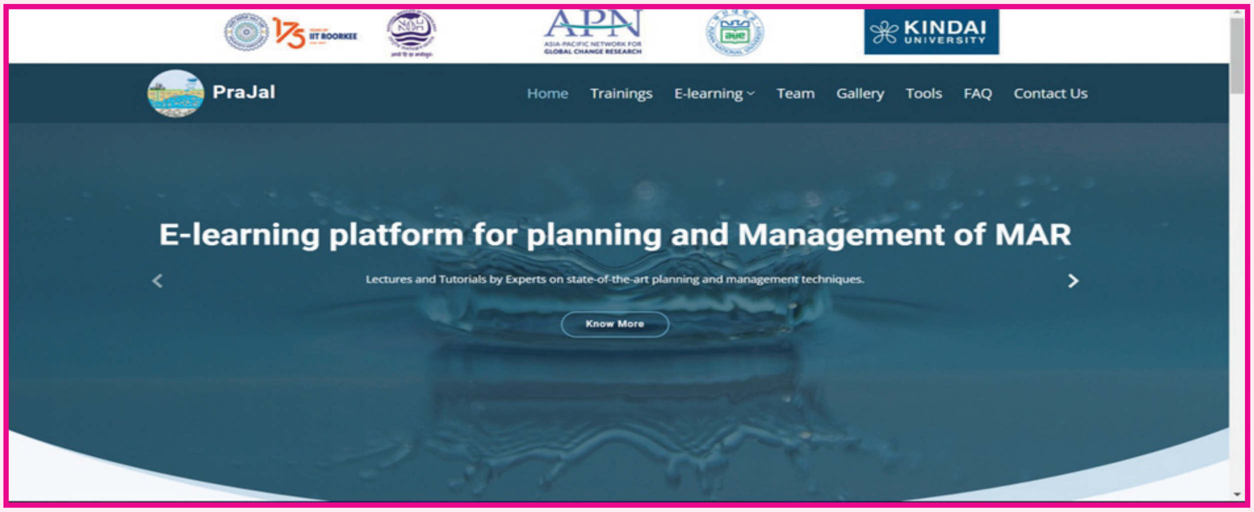


Spatial variation of groundwater table in the catchment of Sot river

Capacity Development Program on Site Suitability Mapping for Managed Aquifer Recharge (MAR) under Varying Climatic Conditions using Remote Sensing and Machine Learning based Hydrological Modelling Tools

In the states with inadequate surface water supplies and low rainfall, the major part of irrigation water is provided using the groundwater source. Under the threat of climate change, groundwater resources, therefore work as a cushion against climate variability. Managed aquifer recharge (MAR) has already been accepted as a reliable approach for groundwater recharge, however, the implications of such recharged water on groundwater quality are still not well understood. Nevertheless, to tackle the twin hazards, alarming decline in groundwater levels, and consequent deterioration of groundwater quality, artificial recharge has now been widely propagated in India. Central Ground Water Board (CGWB) in 2013 proposed the master plan for artificial recharge to groundwater in different states. Recently, a detailed master plan for artificial recharge to groundwater (2020) is proposed identifying the total area for artificial recharge of 11.23 lakh sq. km. However, this large-scale recharge project can only succeed if the implications of MAR on environment and health at the local, regional and global scale are well understood. Global knowledge sharing and capacity building at the local scale would make sure that the MAR projects are well planned and have the potential to tackle challenges in MAR development, operation, and management. The main objectives are: (i) Disseminate knowledge on MAR, climate variability, and emerging planning tools and techniques. This would primarily be aimed at forming a necessary base in the trainees to understand various groundwater processes, groundwater-climate interactions, and sustainable MAR planning, (ii) Develop and disseminate an integrated approach, considering quantity and quality, for site suitability mapping for MAR under changing climate to support effective MAR planning in the identified Indian hot-spots. The integrated approach will utilize remote sensing and machine learning-based hydrological modeling tools, (iii) Evaluating the MAR projects using available field observations and hydrological models.

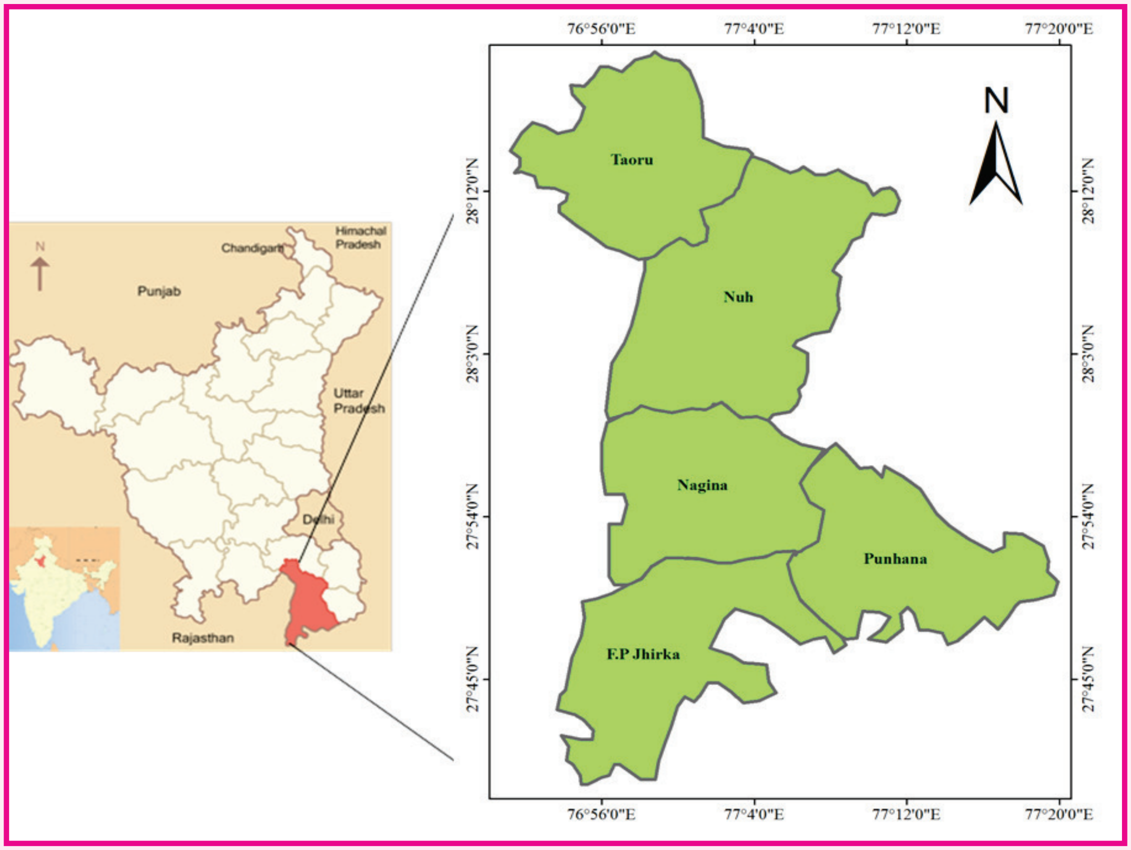
A web-portal (PraJal) and web-based tool (G-MCDA) was developed for site suitability mapping of Managed aquifer recharge (Fig.). The developed websites consist various information on upcoming trainings, videos lectures and manuals. The G-MCDA, which also hosted on PraJal, is an integration of Google Earth Engine (GEE), Multi-criteria Decision Analysis (MCDA), python and web, which allows quick site suitability mapping for MAR. G-MCDA can be accessed free of cost using the URL "http://prajal.org/".



A view of web-portal (PraJal) developed for site suitability mapping of Managed aquifer recharge

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

Groundwater salinity is a widespread problem in many productive agricultural areas in India including many districts of Haryana. Aquifer salinization gradually affects the agro-economy, livelihoods and drinking water supply in local and regional scale due to lowering of groundwater levels.Salinity is the main factor limiting the continued use of groundwater in surface water scarce area, and future reliance on groundwater is further diminished as groundwater levels decline, creating increases in salinity and in exploitation costs. A systematic groundwater development and management fulfilling the technical needs of supply-side and demand-side components can arrest the aggravation of salinity and provide sustainable solution to problem. The proposal aims to undertake a comprehensive study on hydrological and hydrogeological features together with chemistry and isotopic characteristics of groundwater for evaluating the causes of aquifer salinity including its aggravation and effect on agro-economy, drinking water supply and livelihoods considering the problem of Mewat district in Harayana as the pilot study areas. Few demonstrative schemes as resilience building measures towards arresting the aggravation of salinity and increase of managed aquifer recharge together with their impact assessment on overall groundwater resources are also proposed to undertake. Development of a model to predict changes in groundwater salinity as a result of aquifer recharge and extraction is another focus of the study.



Map showing study area of Mewat district

Map showing study area of MMap showing study area of Mewat This work was accomplished in five phases:In Phase 1, Socio-economic based survey was being carried out by Sehgal Foundation, Gurgaon to find out the impact of salinity on the socio-economic conditions of the people on the basis of some selected indicators. The findings of the study are certainly going to in initiating the development activities as coping strategies for the survival of humankind in the presence of salinity in the district of Mewat. The study proposed to employ both qualitative and quantitative method. Under the quantitative method, a well structured coded interview schedule was used. Focus Group Discussion (FGD), as a qualitative method, wasadministered to collect information on the above socio economic characteristics of the farmers. Phase 2 of the study was to develop a hydrogeological framework of the aquifer system in Mewat district based on all existing lithologic, stratigraphic and hydrologic information collected from various agencies. The saline areas in the district are mapped.Phase 3 include a hydro-chemical characterization (on the basis of anions, cations, physico-chemical characteristics etc.) and quantification of salinity. Phase 4 is to target the areas surrounding the drinking water wells that showed presence of salinity in Phase 2 using existing and new tube wells. Further, the water extracted from tube wells within and down gradient from the industrial areas was examined where untreated wastewater may have been disposed on the surface (e.g., in infiltration ponds) or injected into the subsurface. The main purpose of the study in Phase 3 was to identify cause/source areas using isotopes (source locations). Phase 5 includes suggestion and development of resilience building measures. Some proposed measures are development of fresh water bubble using Aquifer Storage and recovery technique.

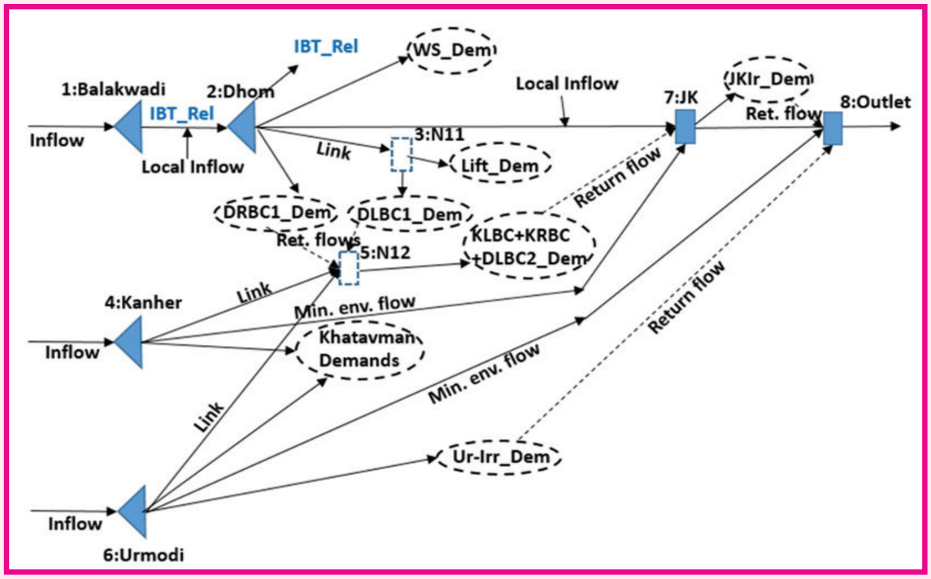
Socio-economic survey was carried out and it was found that the people residing in high salinity areas had to walk long distances to get the fresh water or they have to purchase it. The percentage of households purchasing drinking water is 54% which is more in the high-saline groundwater villages and it remaining 20% in the moderately saline villages and 8% in the villages that have fresh groundwater sources.From the water level map of the study area, it is evident that water tables are deeper in the western region. The water is potable in these areas resulting in higher water withdrawals. In the eastern and southern sides of the study area, water is saline, and water tables are high. The contours of groundwater level show a natural gradient from the Aravalli hills towards the central region but due to high groundwater extraction in the foothills regions of the area, there is the apprehension of movement of water from salinity-affected areas to freshwater areas.Salinity has been found in most of the places in the district and a notable increase in TDS values found during the period 2012 to 2016. An increase in TDS values ranging between 500-1000 mg/l in 74% area while 35% increase in area in the category of 1500-2000 mg/l TDS. In addition to the temporal increase in TDS values, seasonal variations are also observed in the groundwater for the years 2018 and 2019. About 54%, 93%, and 62% of samples were found above the maximum permissible limit of 2000 mg/L in pre-monsoon, monsoon, and post-monsoon seasons respectively. About 8%, 7%, and 14% of samples were found within the acceptable limit of 500 mg/L in the pre-monsoon, monsoon, and post-monsoon seasons of the year 2018. About 54%, 62%, and 58% of samples were found above the maximum permissible limit of 2000 mg/L in pre-monsoon, monsoon, and post-monsoon seasons respectively. About 8%, 0%, and 4% samples were found within the acceptable limit of 500 mg/L in the pre-monsoon, monsoon, and post-monsoon seasons of the year 2019.For the source identifications, salinity mechanism, and residence times of groundwater, the water samples were analyzed for stable isotopes ($\delta^{18}O$ and δD) and tritium (H3). To examine the evaporation effect on groundwater of the study area, $\delta^{18}O$ is plotted against δD. The slope of 5.64, 6.10, and 5.48 is observed for pre-monsoon, monsoon, and post-monsoon seasons, respectively. Since the regression lines are sub-parallel to Global Meteoric Water Line (GMWL) and LMWL (8.83) with slopes less than 8, it suggests the occurrence of evaporation before the infiltration of water in the unsaturated zone. It is found that salinity increases and d-excess decreases during the process of evapo-concentration in all seasons. A linear relationship between d-excess and remaining fraction was found in all three seasons in all samples. However, more scatter is found in the values of salinity and the remaining fraction in 16% of the total samples indicating seasonal variations. It has been observed that the groundwater of the district showed an increase of 0.7g/L salinity from pre-monsoon (6.7g/L) to post-monsoon season (7.4g/L). The d-excess shows a decline of 1.6‰ in post-monsoon when compared to pre-monsoon, it decreases from 2.4‰ in pre-monsoon to 0.8‰ in post-monsoon. It was found that in the pre-monsoon season, salinity was due to mineral dissolution. However, in the monsoon and post-monsoon seasons, initial salinity also contributes to salinity. The contribution of mineral dissolution is found by separating the salinity value of evaporation from dissolution; the results were further tested by using Tritium (3H) to distinguish between modern groundwater (recharge occurring during the last 60 years) and pre-modern groundwater (recharge occurring >60 years). This shows that groundwater has a long residence time in high saline-affected areas. A majority of the samples show a contribution from mineral dissolution in the pre-monsoon season, with a slight decrease in monsoon and post-monsoon seasons. There is wide variation in tritium activities which may be due to discontinuous water flow or poor connectivity between aquifers.Similar observations to isotope analysis were found using Principal Component Analysis (PCA), KMO and Bartlett's tests were found valid for both the years 2018 & 2019, and PCA is found suitable for the study area. Three principal components were selected based on the Eigen value which explains 79.58% and 85.08% of total variation in the year 2018 and 2019 respectively. The first Principal component (PC-1) is identified with salinity is governed by rock-water interactions and agricultural return flow. The second Principal component (PC-2) with alkalinity and the third Principal component (PC-3) described the pollution. A laboratory experimentation followed by ASR setup at site Karhera, Mewat district, Haryana to inject fresh water into a saline aquifer with the help of an inlet tank. Recovery efficiency (RE) ranged from 28 to 71.69 % with an average of 57.32 %. In such situation, where there is no surface water source, this recovery rate is very much advantageous.

Simulation analysis of reservoirs in Upper Krishna basin using NIH_ReSyP - 20223

The Upper Krishna Basin (UKB) which is a pilot basin for the application of DSS (PM) modules, developed under the National Hydrology Project (NHP), has been simulated using NIH_ReSyP – 2022 software. The UKB consists of five hydraulic structures, namely Balakwadi dam, Dhom dam, Kanher dam, Urmodi dam, and Jihe Kathapur barrage. The representation of UKB system showing linkages of various projects, various demands along with their return flows, is presented in Figure.

Simulation in NIH_ReSyP - 2022 can be carried out at daily/10-daily/monthly time steps. For daily and 10-daily time steps, average 10-daily demands are specified for water supply (1^{st} priority), min. environmental flow (2^{nd} priority), irrigation demands through power plant (3^{rd} priority), irrigation demands by-passing power plant (4^{th} priority) and hydropower demands (5^{th} priority). After meeting its own demands, a project can also meet the demands of the d/s project (6^{th} priority) and the demands for inter-basin water transfer link (7^{th} priority). Hydropower can be assigned higher priority in comparison to irrigation demands. To account for variation in demands in different years, percent increase/decrease in demands in different years is specified and the 10-daily demands in any year are calculated accordingly.

For the Balakwadi project, the only demand considered is the inter-basin water transfer (IBT) to Nira valley in Upper Bhima basin for which water is



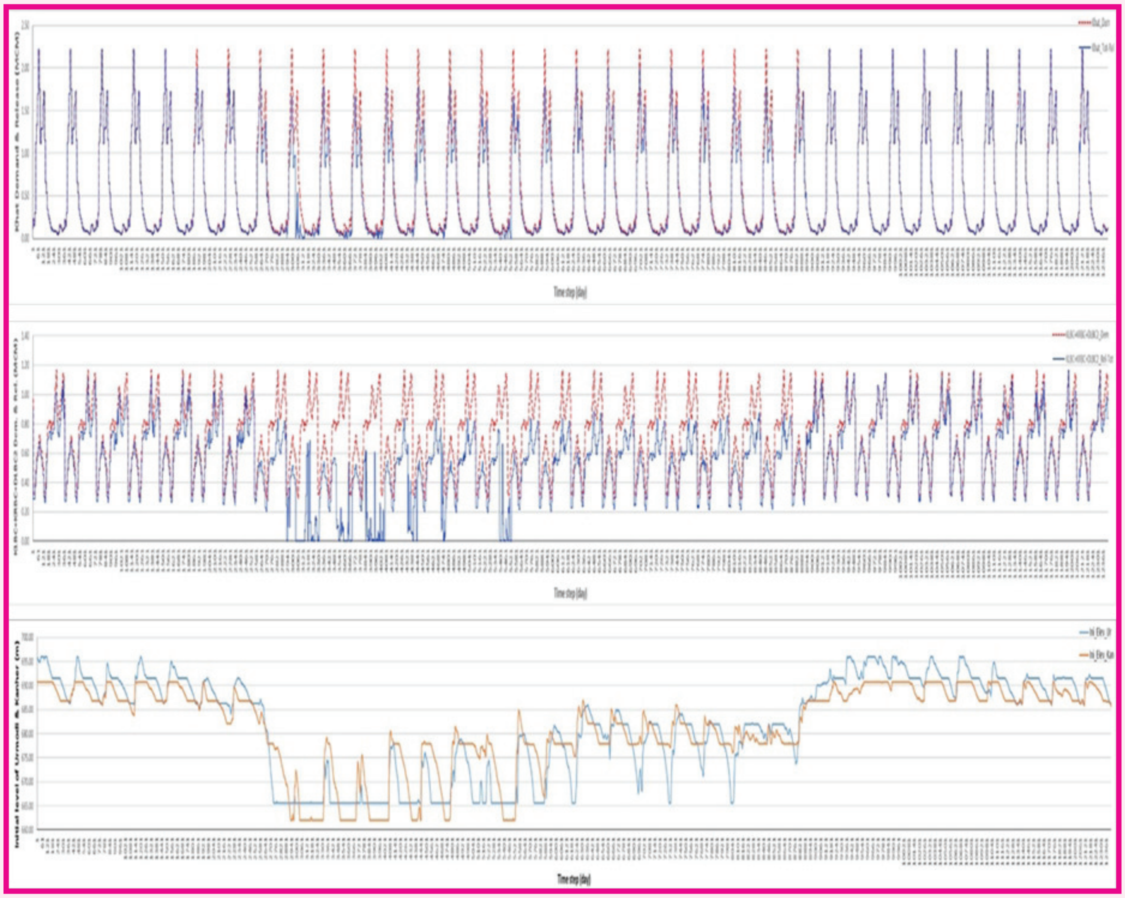
Line diagram of various projects in UKB and their demands/return flows

stored in this reservoir and released towards the Dhom dam. Dhom dam provides water supply for drinking and industrial demand (with no return flow), IBT diversion for the Nira valley, irrigation demands in command areas DRBC1 (with 10% return flow towards KLBC command), lift irrigation demands (with no return flow), and irrigation demands in command area DLBC1 (with 10% return flow towards DLBC2 command). In addition, it also releases water for meeting net demands of Jihe Kathapur (JK). The spills from this project and flows generated from the intermediate catchment join at JK in the d/s.

Kanher dam provides minimum flow (10% of inflow) in the d/s river. Next in priority is the demand of Khatav-Man command which can be met from the Urmodi as well as Kanher dams in integrated manner. Next in priority is the demand in commands of KLBC, KRBC and DLBC2 which have been combined at a hypothetical diversion structure (represented with ID-5) and met from separate link canals from Kanher as well as Urmodi reservoirs which are operated in integrated manner. Urmodi dam provides minimum flow (10% of inflow) in the d/s river. Next in priority is the Urmodi irrigation in its command. Next in priority is the demand of Khatav-Man command. Next in priority are the demands in KLBC, KRBC and DLBC2 commands which are met after accounting for return flows from utilizations in DRBC1 and DLBC1 commands. For the JK project, only irrigation demand is specified.

For simulation of integrated operation of the Urmodi – Kanher dams, the program for conservation operation module of NIH_ReSyP – 2022 has been modified so as to incorporate the specific operation conditions of these two dams. At each time step, the operation is initiated from u/s projects and it moves towards the d/s projects such that the contributions from the u/s projects (return flows, spills, releases from u/s projects for meeting d/s demands) can be duly accounted for. Most of the data for the study was provided by TAMC International Consultant (Dr. Nesa Ilich), NHP at daily time step from May 28, 1977 to May 31, 2011. The system has been operated with rationing policy. Five reservoir levels and reduced supply to be made at/below these levels for various demands have been specified for each project.

Detailed working tables of all projects has been generated and time reliability for meeting 100%, 90%, 80%, and 75% of each demand and volume reliability have been computed. The results indicate that IBT demands from the Balakwadi project can be met with 100% reliability. Similarly, the domestic supply and IBT supply from Dhom dam can also be met with very high reliability exceeding 90%. However, irrigation demands of DRBC1, link demands (lift irrigation + DLBC1 demands) appear to be substantial in comparison to the average annual inflows at the dam site resulting in lower reliabilities with average volume reliabilities of 71.64% and 68.21% respectively. Average annual d/s demands of JK project are around 33.75 MCM (after accounting for intermediate inflows, eflows, spills, and return flows) and these can be met with 97.35% reliability. From the integrated operation of Urmodi & Kanher projects, Khatav-Man demands can be met with an average volume reliability of around 88.47% while DLBC2, KLBC, and KRBC demands can be met with average volume reliability of 82.16% and UIr demands can be met with average volume reliability of 82.58%. Variation in meeting different demands/supply from Kanher and Urmodi reservoirs and their relative reservoir levels during integrated operation is shown in Figure.

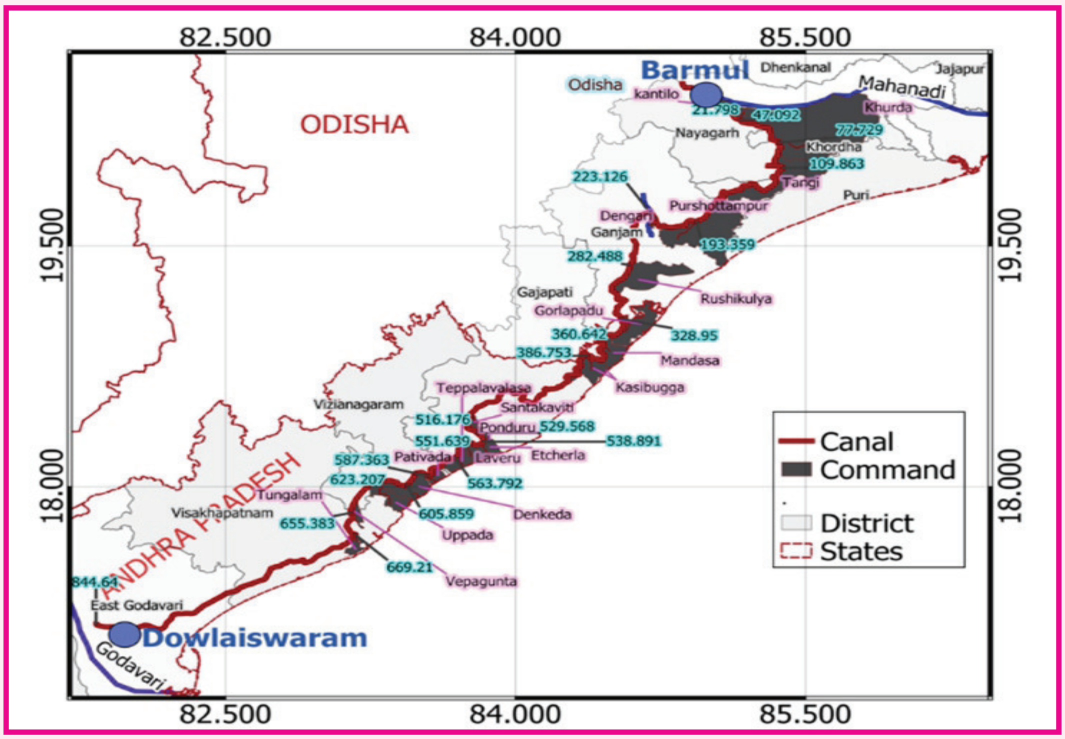


Demands/supply and reservoir level variation during integrated operation of Urmodi & Kanher projects

Study of various possible scenarios for understanding the long-term effect of enroute canal irrigation for proposed Mahanadi-Godavari link

The interlinking of rivers is a long term plan which aims to effectively manage the water resources in India by linking the Indian rivers by a network of reservoirs and canals. Under the National Perspective Plan (NPP) prepared by Ministry of Water Resources (now Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation), the National Water Development Agency (NWDA) has identified 14 links under Himalayan rivers component and 16 links under Peninsular rivers component for inter-basin transfer of water. The

Mahanadi-Godavari link (M-G link) from proposed Barmul dam on the Mahanadi River to the Dowlaiswaram barrage on the Godavari River is the first and critical link of the nine link system of Mahanadi-Godavari-Krishna-Pennar-Cauvery-Vaigai-Gundar link system under the Peninsular component. It is proposed that after meeting the enroute needs in the M-G link, more than 5000 MCM of water will be transferred annually to the Godavari River. Under the Special Committees on the Interlinking of Rivers, the Govt. of India formed Sub-Committee-II related to "System Studies for identification of most appropriate alternative Plan". On the request of the Sub-Committee-II, the NIH carried out the study on hydrological aspects and multi-reservoir simulation analysis for the seven new dams up to and including the Barmul dam and the water availability at Barmul dam has been worked out. Subsequently, the Sub-Committee-II recommended to carry out the scenario analysis to find the probable impact of M-G link canal and its enroute utilization on the groundwater resources in the adjacent area. The impact analysis also included the issues of climate change, change in cropping pattern, change in irrigation efficiency, and water availability in the canal system. The length of proposed M-G link canal is about 845 km and it is proposed to provide irrigation (CCA) to the total area of 363959 ha in 20 Enroute commands as shown in Figure.



Proposed M-G link canal and 20 distributary enroute commands

Most of the data for the study was provided by NWDA and NRSC while some data were taken from India – WRIS. For climate change analysis, CMIP5 and CMIP6 scenarios under moderate and extreme emission conditions were synthesized for the study area. Enormous database for the study area, which included LULC map, topography, soil map, hydro-meteorological data, cropping pattern, crop characteristics, demographic details, CGWB groundwater level data and withdrawal estimates, daily rainfall and temperature data from gridded IMD database canal system characteristics etc., was developed.

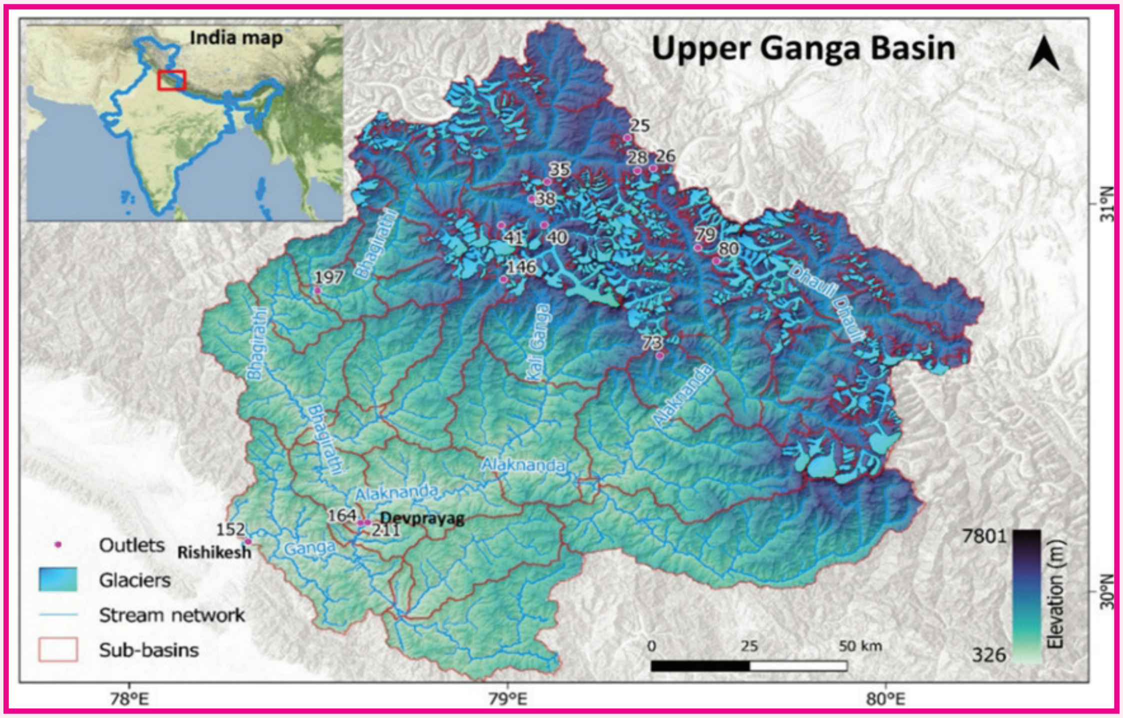
To account for the impact of daily/10-daily variation in actual rainfall and temperature under climate scenarios on the crop water demands, a separate program has been developed for computation of daily reference crop evapo-transpiration using Penman-Monteith method corresponding to historical data (June, 2001 to May, 2021) and expected future (June, 2021 to May, 2071). Domestic and industrial demands have been worked out using the projected population in different commands and in different segments of M-G link canal. Present groundwater scenario in the command areas has been assessed by analyzing the spatial variation of historical groundwater levels of various observation wells of CGWB and State Groundwater Departments. Rainfall recharge has been estimated using a hydrological model "Soil Water Balance (SWB)" of USGS while recharge from other sources, including irrigation, has been estimated using Groundwater Resources Estimation Committee - 2015 methodology. To assess the impact of various scenarios on groundwater (GW) resources, a Visual MODFLOW model has been set-up for the study area.

In view of the unique requirements of the study, a new systems model has been developed using the Python programming to study the surface water – groundwater interaction in study area under different scenarios. In addition, MS-Excel-based approach has been developed for estimation of block-wise net pumping and recharge in the study area. All such modeling inputs and outputs were linked through the Systems model. A total of 35 scenarios were analyzed corresponding to various water availability series at the canal system head and four averaged climate scenarios and the results have been compiled at seasonal (Kharif/Rabi) and annual time step for the historical period (June, 2001 to May, 2021) and the future period (June, 2021 to May, 2071). Various components of water balance have been evaluated for the M-G link canal system under different scenarios. It is concluded that the water transfer through the link would result in additional recharge of around 700 MCM through the canal seepage and around 500 MCM through the irrigation utilizations in various commands. This will subsequently result in groundwater would rise in the range of 1 – 2 m in different commands. Conjunctive use options have been analyzed in the study which can be used to check the development of water logging conditions. Further, lining of some distributary canals can be considered and their capacities can be lowered so that groundwater is extracted in such commands for stabilization of the groundwater conditions. There are some limitations of study with regard to the available database which have been elaborated in the study report.

Assessment of seasonal variations in Hydrology and Cryosphere of upper Ganga Basin

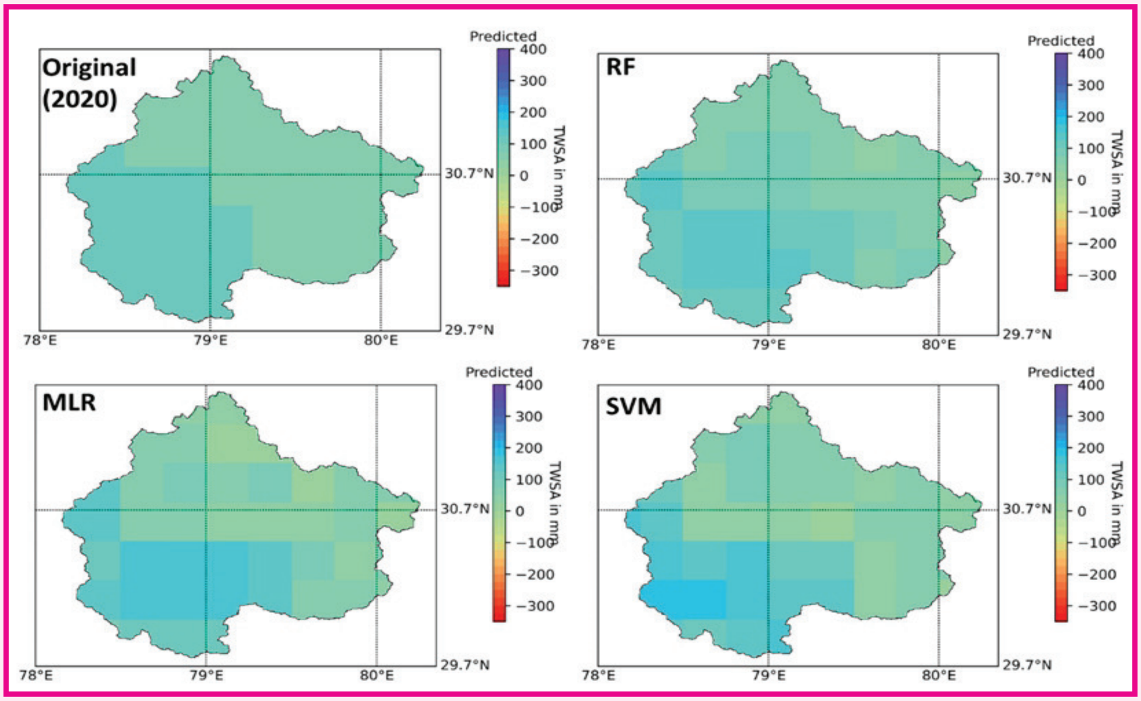
Seasonal snow water is the crucial source of water in the Upper Ganga basin of north western Himalayan region and it is of great significance to be estimated. In this study we have estimated seasonal snow water equivalent (SWE) in the Upper Ganga river basin for the 16 snow season from the period 2001 to 2020 at 9 snow-glacier dominated sub-basins. For this purpose, the spatially distributed Spatial processes in Hydrology (SPHY) hydrological model in conjunction of Gravity recovery and Climate Experiment (GRACE) satellite data has been utilized.

This model separates the contribution of snowmelt, glacier melt, baseflow, runoff induced with rainfall from the total runoff at different watersheds. The calibration and validation have been done using observed discharge and GRACE satellite derived total water storage anomalies (TWSA). The modeled snow covers and melt runoff have been evaluated with MODIS derived snow covers. For the assessment of glacier changes and corresponding melt runoff, different glacier maps (i.e. for years 1990, 2000, 2010, 2020) have been prepared using LANDSAT imageries. The contributions of all these runoff components have been analyzed from upstream to downstream portions under different retreat conditions in different time scenarios (e.g. 1986-1995, 1996-2005, 2006-2015 and 2011-2020) by incorporating glacier maps of different times. This study relies more on the real time observations of glacier changes rather than incorporating climate model scenarios to explore the current situation of



Study area map of Upper Ganga Basin (up to Rishikesh) with 221 stations

glacier melting in one of the important Himalayan river basins viz. Upper Ganga river basin. The model calibration and validation have been done utilizing the observed discharge and MODIS derived snow cover datasets. To capture the seasonality in snow and glacier melt runoff in a more effective manner, the MODIS derived snow cover area (SCA) is compared with the SPHY derived SCA.



Comparison between downscaled and original GRACE TWSA in 2020 year

At the Rishikesh outlet, the coefficient of determination R^2 is recoded ~0.6 with respect to the observed discharge. The seasonal snow cover computed by SPHY is validated by snow cover derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) 8-day snow cover maps with a coefficient of determination 0.73 (2015). For validation purpose, the GRACE data is downscaled from 1° × 1° to 0.25° × 0.25° for working at watershed scale by incorporating simple Multilinear Regression (MLR), Random Forest (RF) and Support Vector Regression (SVM) machine learning models. For predicting downscaled GRACE data, a statistical relationship is established with Global Land Data Assimilation System's (GLDAS) soil moisture, canopy water, root moisture, and snow water equivalent hydrological variables with GRACE data and results have shown a well match between GRACE and GLDAS variables (the R2 varies from ~0.4 to 0.7). It is observed that the RF performed superior as compared to other methods in predicting the downscaled GRACE data in the upper Ganga river basin. The downscaled predictions at watershed scale combined with SPHY simulations for estimation of the SWE. Results showed that the estimated SWE & TWSA (by the coupling of SPHY+GRACE) is found comparable with GLDAS SWE & TWSA, which is almost 33% underestimated than our computation.

Chemical & Isotopic Characterization of Deep Aquifer Groundwater of Middle Ganga Basin

Uttar Pradesh is one of the most populous states in the country. The population of the state in the last two decades has increased from 166.2 million to 235 million. Agriculture is the largest source of economy in the state. Groundwater exploitation in the state has increased from 54.31% in the year 2000 to 73.78% in the year 2013. Freshwater resource is shrinking both due to excessive use and quality deterioration. Further, climate change is disrupting the rainfall pattern which is also aggravating the water demand. Keeping these aspects into consideration, the present project was undertaken with the following objectives: (i) Identification of groundwater recharge sources, (ii) Water quality of deep & shallow groundwater, (iii) Measures for the sustainability of groundwater resource.The study area (Fig.) includes 27 districts of Uttar Pradesh (UP), enclosed between the river Ganga in the south, and the rivers Sharda and Ghaghara in the north, and covers 95,100 km2 geographical area.

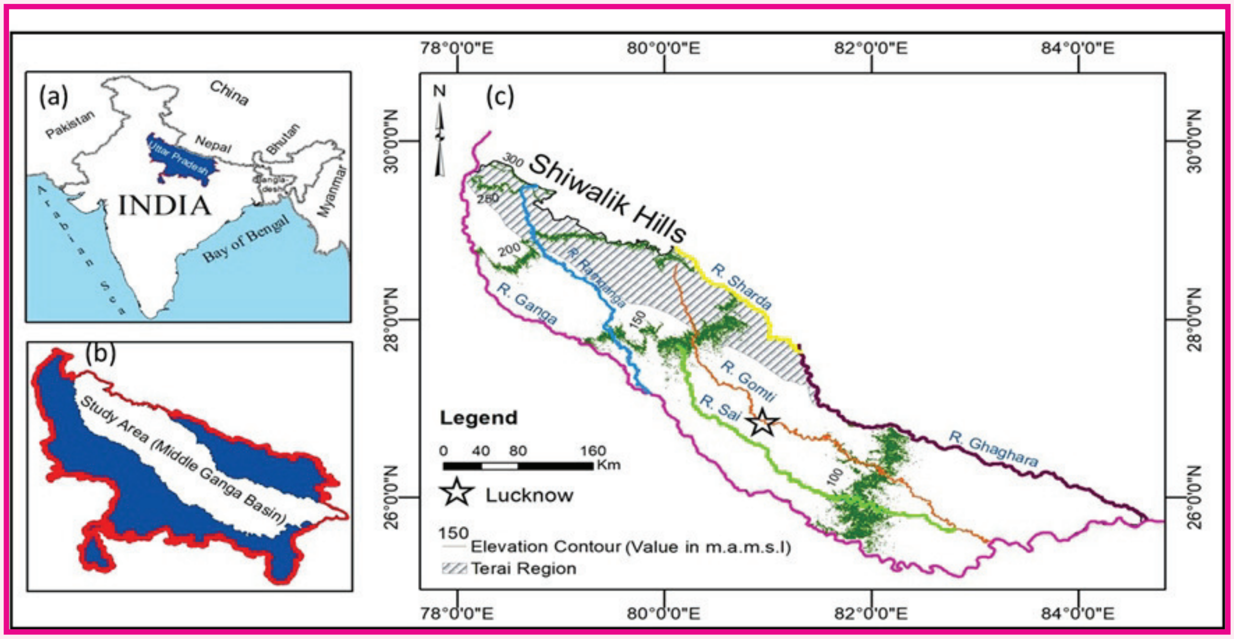
Groundwater samples were collected at multiple depths and analyzed for major ions, heavy metals, stable isotopic composition, and environmental tritium. Hydro-statistical methods were employed for analysis. Decadal-scale rainfall, temperature, and groundwater level data were analyzed to assess long-term trends and correlation with climate parameters. Potential groundwater recharge zones were mapped using various thematic maps.The Piper plot and its spatial distribution of the data indicated that 80% of the water type is of Ca^{2+}-Mg^{2+}-HCO_3^- type, and this type of water is spread over 80% of the study area. Na-K-Cl-SO4 type of water is observed mainly in the lower reaches of the study area, and Na-K-bicarbonate type of water is distributed at few locations in the upper reaches of the study area. The Gibbs plot showed that 90% of groundwater is evolved from rock-water interaction. The interaction has resulted in low chloride and high bicarbonate type water; and varying relative proportion of Na^+ and Ca^{++} ions varying over a range from 20% to 70%. TDS and EC for drinking water quality have shown that 95% groundwater is fresh but hard to excessively hard (total hardness in the range 500mg/l to 4000mg/l). Wilcox's diagram, Permeability Index, and Magnesium Hazard estimations showed that more than 90% of groundwater falls in good to the excellent category for irrigation use. Analysis of groundwater for Water Quality Index (WQI) has shown that 74% area (~71,084 km^2) is of excellent quality, while very poor to unsuitable quality is distributed in small pockets in the North and southwest regions covering an area of 2795 km^2.Heavy metal analysis has shown that Fe and Al are above the permissible limit in 5% locations, in 3% locations accumulation of arsenic over a lifetime may lead to non-carcinogenic risk, whereas, the dissolved concentration of As, Cr, and Cu is observed in the high carcinogenic risk range in 70%, 10%, and 80% samples respectively. is observed for the heavy metals Based on the heavy metal pollution index (HPI) it is inferred that 10% of the area (~9590 km^2) is affected by heavy metal contamination, mainly due to the dissolved Al, Mn, and Fe in groundwater.

The isotopic composition of groundwater (at shallow and deep depths) has shown depletion in isotopic compositionin the direction towards the Shiwalik hills similar to the expected trend in the isotopic composition of rainfall (depleting with increasing altitude). On this basis, it is inferred that local rainfall is the major source of the groundwater (shallow and deep depths) of this region. This trend reversed in the central region to southeast region. From the central zone (Lucknow district) to the south-eastern region isotopic depletion increases indicating recharge from the water source of depleted isotopic composition. This part of the region is covered by a dense network of canals that carry the water of depleted isotopic composition, and is probably the reason for the observed isotopic trend in this part of the study area. It is further seen that the isotopic composition of the shallow aquifer, in general, showed more fluctuations than that of the deep aquifer. Such large fluctuations in the isotopic composition suggest that the shallow aquifer is getting recharged at multiple locations along its pathways by the water of different isotopic compositions arising from different water sources, such as highly depleted water (canal water), moderately enriched water (rainwater), and highly enriched water (municipal wastewater), etc.

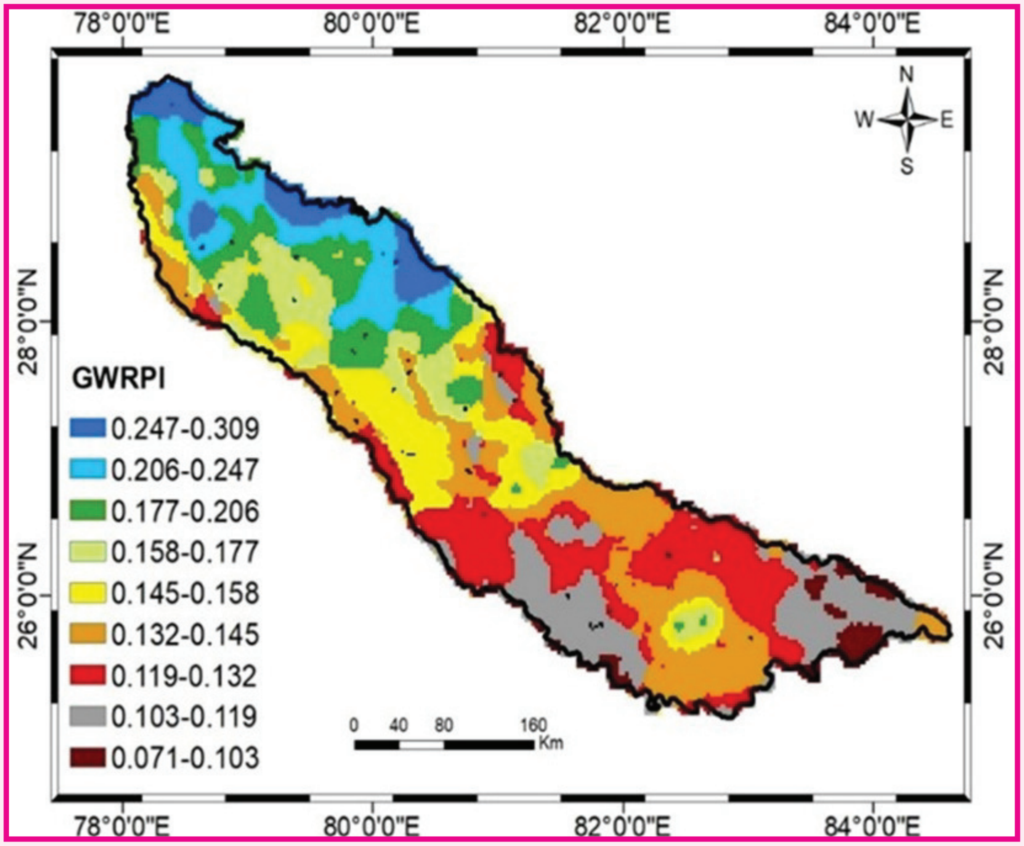
This semiconfined condition of deep groundwater and semi-confined to the unconfined condition of shallow groundwater was further confirmed by the tritium dating of groundwater. The tritium-based age data distribution of groundwater, and the area percentage enclosed in four age range (<15years, 16-30 years, 31-45 years, and >45 years). The shallow groundwater shows its median age of ~ 23 years, and that for the deep aquifer, ~30 years. Through multi-technique investigations, it is concluded that from Shiwalik foot-hills to the central part of the study area (Lucknow district) rainfall is the major source of recharge to groundwater, and beyond this, canal water is the equally important contributing recharge source to the groundwater. The shallow groundwater is of the semi-confined to unconfined type and, hence, is getting recharged from different surface water sources along its pathway in addition to the rainfall as the major source. The deep groundwater is of the semiconfined type and is receiving recharge from the overlying aquifer in most of the study area.

The groundwater recharge potential zone of the study area is mapped by integrating 8 thematic maps (rainfall, geomorphology, slope, drainage density, lineament density, lithology, LULC, and groundwater fluctuation) using the Analytical Hierarchical Process. The potential recharge zone map prepared using this method (Fig.) shows high groundwater potential in the NW-N region and poor potential in the SE-S region.

The specific recommendations of the study include: Using artificial recharge measures (at the suggested locations),the falling groundwater trend can be controlled. This can also help in diluting the heavy metal contamination, and in improvement of the groundwater quality, and in coping with the climate change impact on groundwater resource.It is essential to monitor and regulate groundwater usage, especially in regions with high water demand and vulnerable groundwater levels.In areas of falling groundwater levels awareness among farmers need be developed to control on the excessive groundwater exploitation and in the use of water intensive crops.



Location map and elevation contours and major rivers in the of Middle Ganga Basin



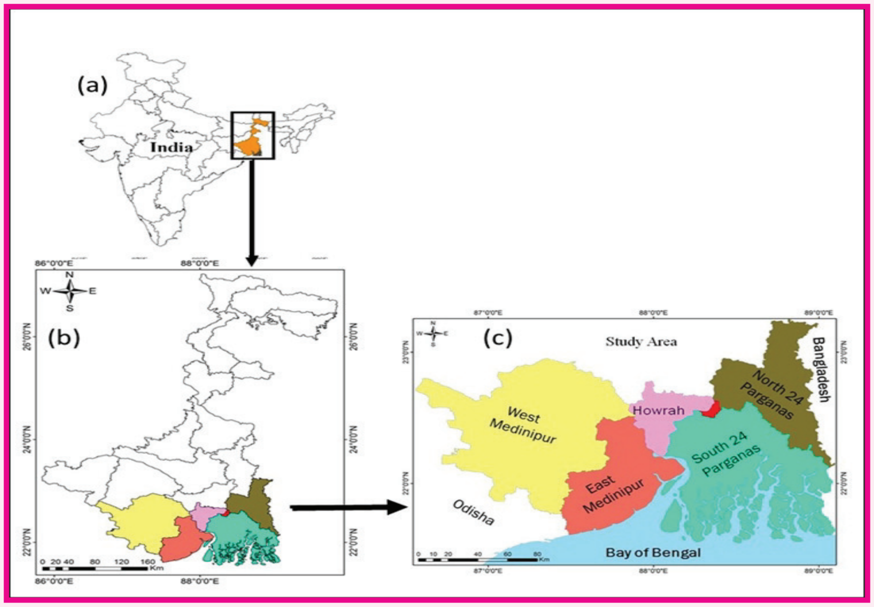
Groundwater recharge potential index (GWRPI), and the proposed locations for artificial recharge measures (black dots)

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

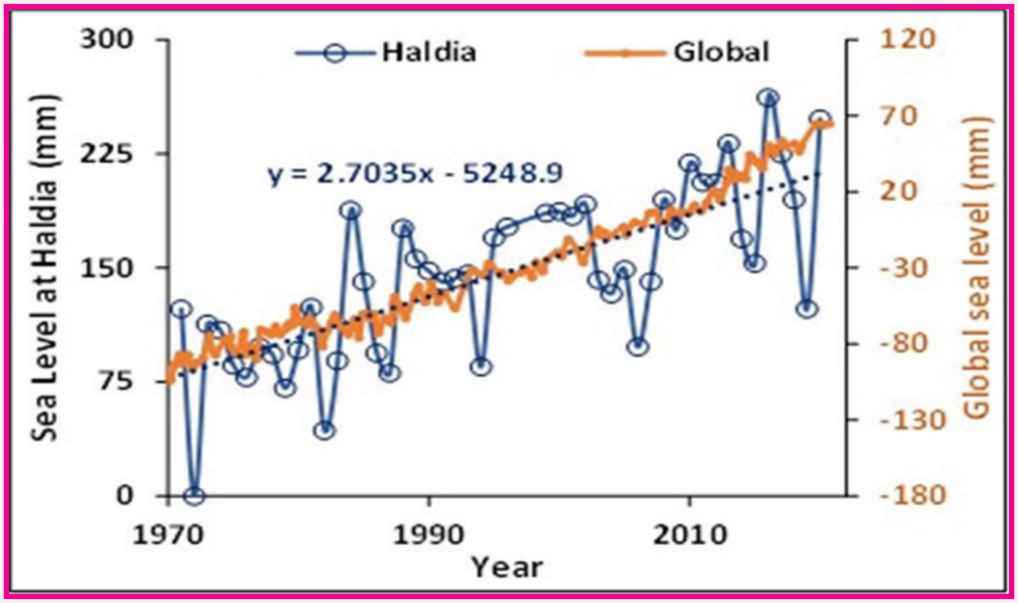
The deltaic fan of West Bengal resulted from the active sedimentation by the distributaries of the river Ganga at the river mouth near the Bay of Bengal. In the tidally active deltaic zone, the river streams carry seawater inland during high tides and discharge freshwater to the sea during low tides. Due to ever-present saline tidal rivers, saline soils, the fresh water demand in the coastal zone is continuously increasing to meet the demands for irrigation, growing population, and economic establishments. As well, the increasing pollution load from these sectors is not only contaminating the surface water sources but also contaminating the marine water. Considering these factors, the present project aims to address the following objectives: (i) Identification of groundwater recharge sources, (ii) Water quality of deep & shallow groundwater, (iii) Vulnerability of groundwater due to salinity (iv)Groundwater management.

The study area covers 5 coastal districts of West Bengal (Howrah, North 24 Paragana, South 24 Paragana, Purba Medinipur, and Paschim Medinipur), along with Kolkata Municipal Corporation (KMC), spanning a total area of 26,500 km^2. This region is drained by eight rivers.To understand water quality, evolution, and hazards, multi-depth groundwater samples were collected, measured for major ions and heavy metals, and analyzed using various hydro-statistical methods and isotopic techniques. Long-term changes in climate parameters (rainfall and temperature) were also analyzed. Potential groundwater recharge zones were mapped for groundwater management measures.The average rainfall in the study area from 1993 to 2018 was 1740±165 mm. Extreme rainfall years were 2012 (905.64 mm), 1999 (2089.7mm), and 2014 (2089.7 mm). Groundwater, however, exhibited a continuous fall at a rate of 0.34m/year. The depletion in groundwater, despite constant rainfall, alerts for decreasing fresh groundwater resource and possible risk of seawater intrusion if the process continues for long periods. Urgent steps are needed to augment groundwater resources through artificial recharge measures. Annual sea level data from 1970-2022 showed a rise in the study area at a rate of 2.7 mm/yr, lower than the global rate. Daily tidal data from 2018-2023 indicated inflow of marine water up to 120 km from the sea coast during peak amplitude, posing a risk of salinization of surface soils and groundwater.

The study area's average population density is 1,269 persons per sq. km (census 2011). During 2001-2011, the population density increased mainly in the eastern region (South 24 Parganas). This growing population may face fresh groundwater resource crunch and coastal flooding in the near future, necessitating sustainable resource planning. Analysis of surface water salinity data for rivers and tidal stream waters collected from 2010-2022 indicated a decrease in salinity by 5-66%, indicating freshening of surface water sources. This improvement in surface water quality is expected to benefit groundwater quality. Groundwater quality analysis showed that shallow groundwater (depth <100m) is saline (EC> 3400µS/cm) in the central region, and the deep aquifers (d>100m) are saline in the Eastern, Central, and South of central parts of the study area.Stable isotopic analysis revealed that groundwater is formed from meteoric water and undergoes varying extents of evaporation before infiltration. Recharging sources to groundwater are of continental origin with no contamination from seawater. Groundwater age dating estimated the average age at about 30 years, with 43% in the age range 26-37 years, 47% in the age range 15-25 years, 8% with age >38 years, and remaining 2% as groundwater of recent origin (<15 years).



Location map of the study area covering 5 coastal districts of West Bengal

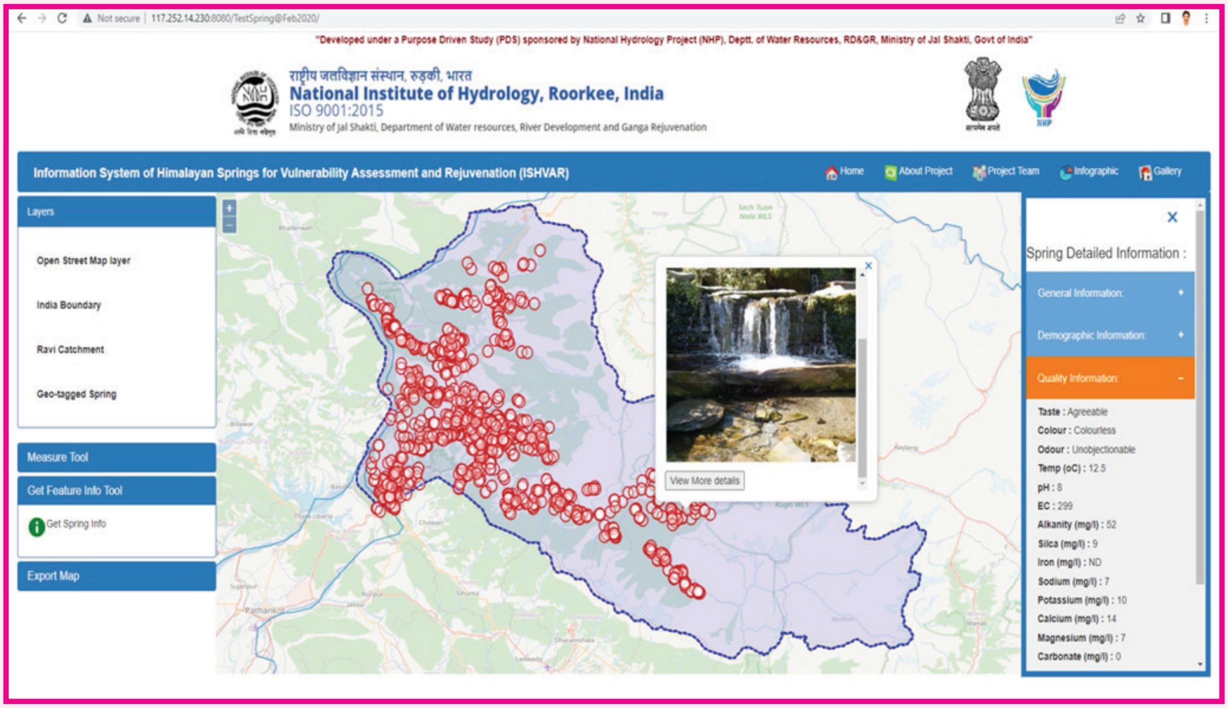


Comparison of sea level rise in the study area with global sea level rise rate

Web-GIS Based Spring Inventory for Vulnerability Assessment and Hydro-Geological Investigation of Selected Springs for Sustaining Local Water Demand in Ravi Catchment of Himachal Pradesh

HP State Council for Science, Technology and Environment has carried out a survey in 169 *Panchayats* of seven districts in the state of Himachal Pradesh on traditional water sources, which clearly shows that only 30% of the sources are in good working condition and recharging properly throughout the year, while the remaining 70% sources are not in proper working condition and are likely to dry up in near future. Keeping in view of the importance of traditional water resources in sustaining the water demand of the state, a Purpose Driven Study (PDS) has been taken under National Hydrology Project (NHP) for investigations of the springs of Ravi River Catchment of Himachal Pradesh.

Total 981 springs have been surveyed and geotagged during the field survey performed in Ravi River catchment of Himachal Pradesh. Water samples have been collected for these springs for and water quality analysis was carried out in water quality lab at WHRC, Jammu. Different thematic maps have been prepared to understand the spatial distribution of various water quality parameters in the Ravi River catchment. Web-GIS based portal named, ISHVAR (**I**nformation **S**ystem of **H**imalayan springs for **V**ulnerability **A**ssessment and **R**ejuvenation) having information of the 981 surveyed springs on 35+ parameters has been created with all supporting GIS layers and geotagged spring photographs. All data pertaining to the springs are also available in the form of infographics for easy understanding.

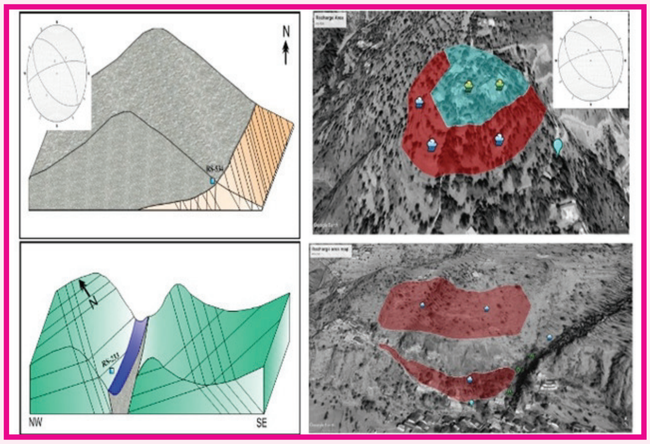


GIS based Web-Portal (ISHVAR) for springs of Ravi river catchment of Himachal Pradesh developed under NHP-PDS

Assessment of vulnerable springs have been carriedout based on the information collected during the field survey and all springs have been categorized in three classes viz., highly vulnerable, moderatelyvulnerable and least vulnerable. Surprisingly, no springs in the catchment was found least vulnerable. Out of 981 springs, 231 springs have been identified highly vulnerable while 750 springs were found moderately vulnerable. Highly vulnerable springs are to be needed urgent treatment for their rejuvenations. Five vulnerable springs were selected for the detailed hydro-geological, chemical and isotopic analysis. Seven ordinary raingauge stations were installed at different altitudes of the catchment for capturing the isotopic signature of the rain in the catchment. Daily discharge of springswas measured to understand the hydrological behaviour of the springs. Water chemistry of selected springs water was carried-out for the pre and post monsoon. Based on hydro-geological, chemical and isotopic analysis rrecharge areas of springs were demarcated. Identified recharge areas of springs are immensely useful for the development of adaptive measure for the revival of vulnerable springs.

One training programme was conducted at Chamba for the data collector of Irrigation & Public Health Dept. (I&PHE). Under this training programme hands-on sessions were conducted on geotagging of

Field investigation for in-situ water quality analysis and geological investigation in Ravi River catchment



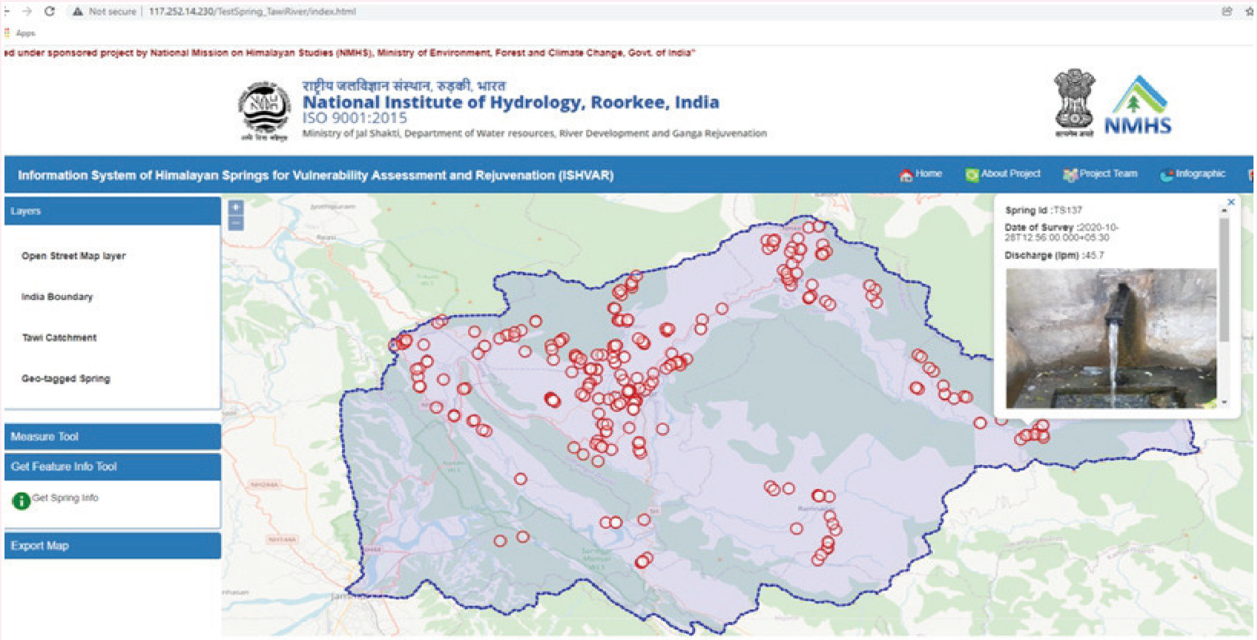
Developed geological cross-sections and identification of recharge area of selected springs of Ravi river catchment

spring, spring discharge measurement, sampling techniques for chemical and isotopic analysis of the spring water. A stakeholder workshop was organized in the presence of Secretary, DoWR, RD&GR, ministry of Jal Shakti, GoI. This one-day stakeholder workshop, organised in virtual mode, was attended by 91 participants from 51 institutions and 16 States within the country and 01 overseas. Feedback of the stakeholders have been incorporated in the ISHVAR portal developed under the PDS for Springs of Ravi River catchment.

Web-Enabled Inventory of Natural Water Springs of Tawi River Catchment of Jammu and Kashmir State of India for Vulnerability analysis and Developing Adaptive Measures for Sustaining Tawi River

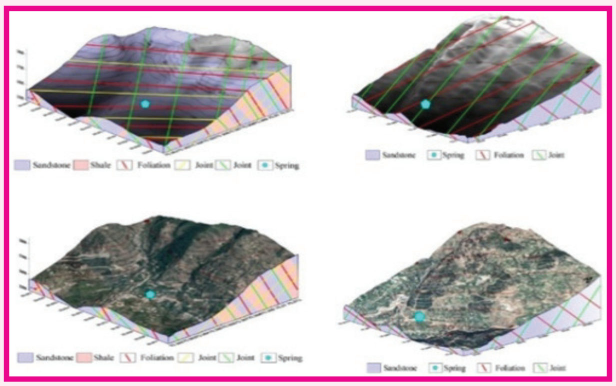
About 250 villages of four districts viz. Jammu, Udhampur, Riasi and Samba fall in the Tawi catchment and depend upon Tawi River and springs in its catchment for their drinking as well domestic water demands. However, there is quite low flow in the river during the lean season and the people of the area are facing acute shortage of water impacting their very livelihoods. Water demand in the catchment is on the rise due to rapid urbanization and high population growth (20% per decade).As per SoI toposheets more than 350 major springs are emerging from Tawi catchment and are responsible for maintaining the base flow of the river. So, in view of cultural, social and hydrological importance of the Tawi catchment and lack of base data on springs, thisstudywasenvisagedfor the sustainable water resource management in the catchment wherein revival of drying springs plays a vital role.

For collecting the data for creation of spring inventory, a survey form covering questionnaire related to the various parameters pertaining to the springs was created using open source technology such as KoBo tool box. These parameters were monitored during field visits along with geotagging of springs. A total of 40+ parameters have been recorded in the field which cover the general, hydrological, social and demographic factors related to the spring. Total of 471 springs have been geotagged and surveyed. Out of 471 springs, 51 springs have been identified highly vulnerable in the Tawi catchment. These highly vulnerable springs are to be needed urgent treatment. Spring web-portal for Tawi catchment having the information about 40+ parameters of the surveyed springs have been created with all supporting GIS layers and geotagged spring photographs.



Web-GIS based spring portal for Tawi catchment of J& K

Five vulnerable springs were selected for the detailed hydro-geological, chemical and isotopic analysis. Four ordinary raingauge stations were installed at different altitudes of the catchment (Jammu, Udhampur, Chanani and Maan Talai) for capturing the isotopic signature of the rain in the catchment. Daily discharge of springs were measured on daily scale to understand the hydrological behavior of the springs. Water chemistry of selected springs water was carried-out for the pre and post monsoon. Based on hydro-geological, chemical and isotopic analysis recharge area of springs were demarcated. Identified recharge area of springs are immensely useful for the development of adaptive measure for the revival of vulnerable springs

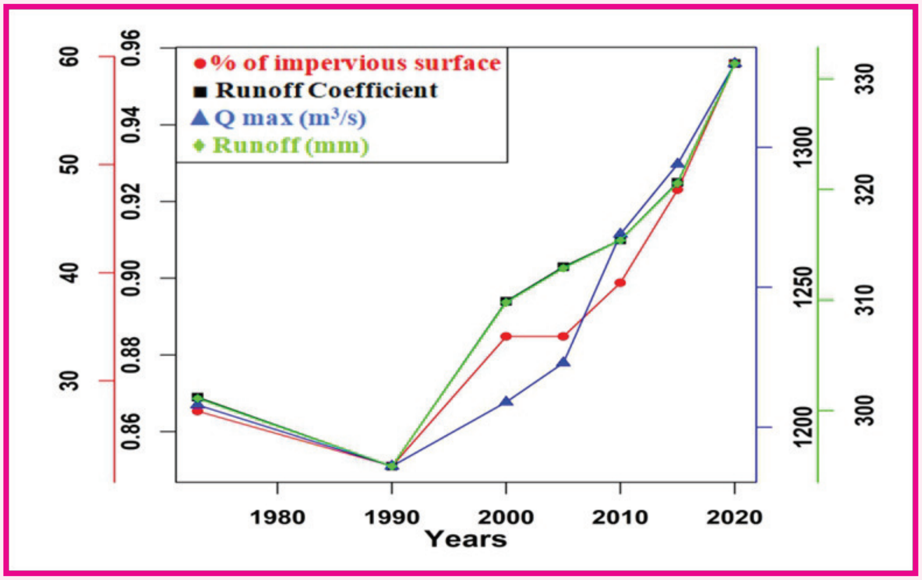


Geological cross-sections developed for selected springs of Tawi river catchment

Recharge area demarcated for selected springs of Tawi catchment

Urban hydrological studies of critical pilot area using of hydrological instruments in Greater Hyderabad Municipal Corporation (GHMC) area Hyderabad

The study was carried out with the objectives of (i)Evaluation of urban stormwater network and preparation of flood inundation mapping in pilot area of GHMC, Hyderabad; (ii) Development of the Intensity-Duration-Frequency (IDF) curves and flood simulation for design storm for various return periods in the pilot area; and (iii) Dissemination of results to the concerned departments of GHMC and Water resources department (Irrigation & CAD). The work done, major insights and the findings of the study are as follows: Mitigation of urban floods and waterlogging, majorly in metropolitan cities, has drawn recent attention due to aggravated flooding in cities hindering socio-economic activities and ecology. The complexity of urban floods can be attributed due to rapid urbanization and extreme climatic events. The encroachment of water bodies and drains, unplanned construction, and destruction of natural storm conveyance need to be acknowledged to improve the drainage system to varying climatic conditions. Therefore, this study was carried out to address the inadequacy of the storm drainage network in Zone-IV GHMC (Greater Municipal Hyderabad Corporation), Hyderabad, Telangana. Environmental Protection Agency's (EPA) SWMM (Storm Water Management Model) software has been used to simulate the runoff in integration with the GIS application. Five tipping bucket rain gauges and three automatic water level recorders were installed in the pilot area for collecting observed data. IDF curves were prepared for 2, 5, 10, 25, 50, and 100 year return periods to evaluate the adequacy of existing drains and flood mitigation measures with design storm. The model was calibrated with observed data on 8-10 July and 13-14 July 2022, which showed excellent performance, as evident from coefficient of determination (0.84 & 0.81), and Nash-Sutcliffe efficiency (0.86 & 080). The model was simulated different LULC periods from 1973, 1990, 2000, 2005, 2010, 2015, and 2020. The peak discharge, runoff coefficient, runoff depth, and percentage impervious area exhibited excellent correlation for the pilot area, as evident from Figure shown below. The model simulated the flood event for more than 100 years return period on 13 October 2020 and generated the flood inundation map using with HEC RAS. Flood inundation depths were compared with respect to field observation marks. Flood routing through the natural drainage network resulted in flooding for a prolonged period for the design storm of 2-year return period, particularly in the upstream portion from the Saroornagar tank to the region connecting Peddamma Cheruvu. The pilot area model of the storm drainage network was modified by changing the geometrical parameters and revoking the natural drainage system for 10-year return period design storm to meet flood mitigation measures. The dataset, the results obtained and the methodology followed in the current study can be used by urban planners to identify the potential flood risk zones and nodes and incorporate them to plan the mitigation and management strategies.

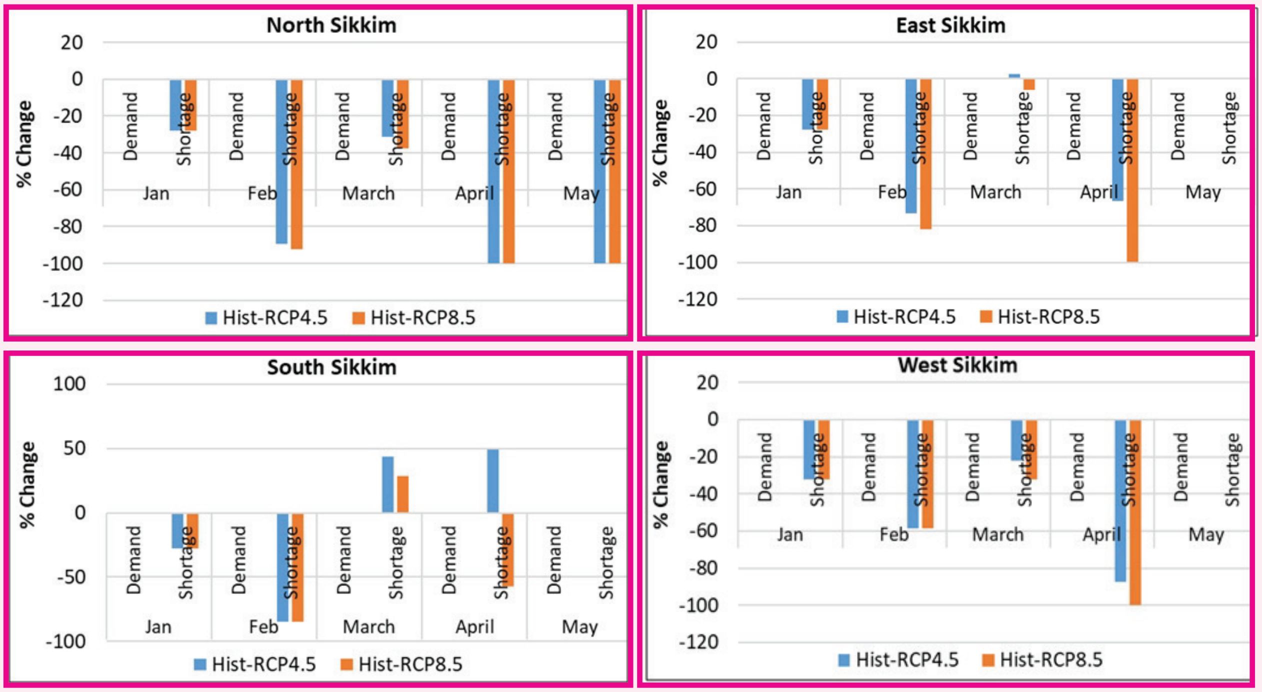


Model simulated parameters with LULC periods from 1973 to 2020

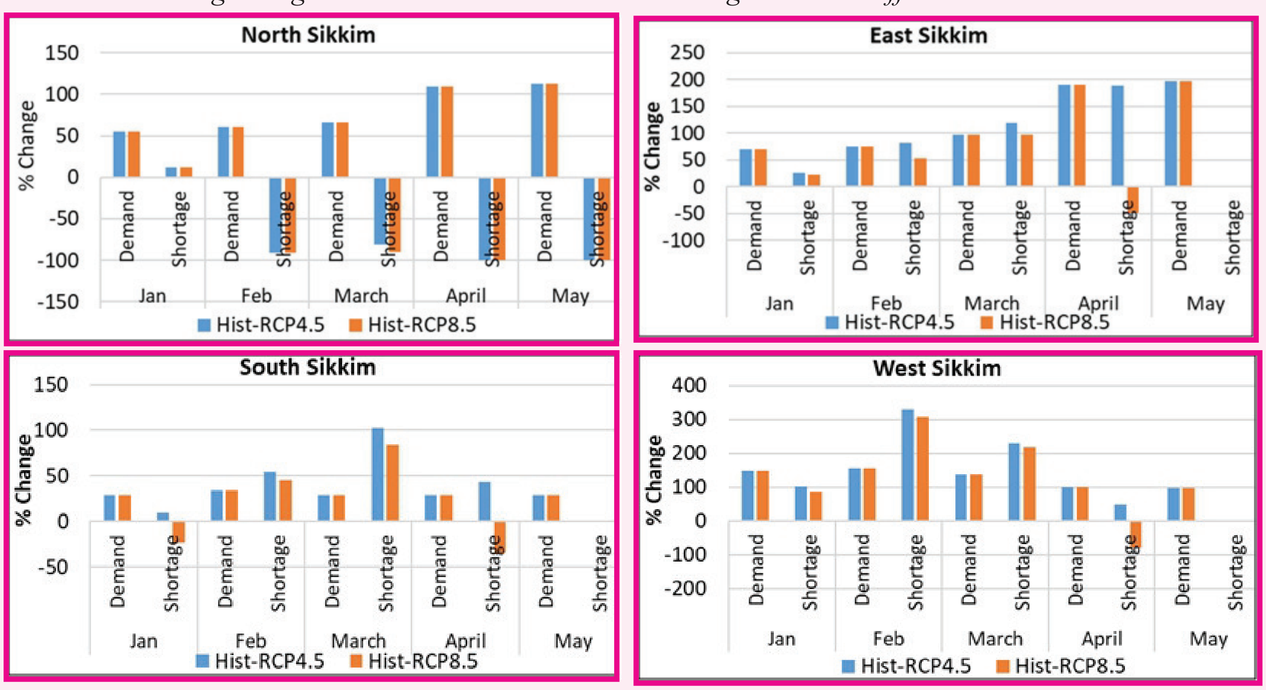
Drainage network physical survey in Zone-IV, GHMC Hyderabad

River basin planning and reservoir operation studies for Teesta basin in Sikkim

The present study has been taken up for the Teesta Basin in Sikkim with three main objectives: (i) Assessment of trends of precipitation, temperature, and snow cover area in the basin; (ii) Hydrological modeling approach for prediction of water yield, analysis of trends in streamflow and variations in streamflow in the basin and (iii) Assessment of water availability at different hydroelectric project sites for various water demands in the basin and determination of the power potentials of the projects in Sikkim.Using IMD gridded rainfall and temperature data, the seasonal variation of rainfall, and maximum and minimum temperature have been analyzed from 1902 to 2019. Sen's slope estimator indicates a rising trend of precipitation over the Teesta basin in Sikkim from 1902 to 2019 for winter, pre-monsoon and post-monsoon seasons. However, a decreasing trend in rainfall is observed for the monsoon season. The trend analysis of IMD minimum temperature showed more or less increasing trend for all the four seasons. In case of minimum temperature, the significant rising trend is observed for the monsoon season. The maximum snow cover area of 6571.35km^2 was observed in the year 2006 and the minimum of 902.43km^2 was in 2016. For both maximum and minimum snow covers, there were decreasing trends for the entire period from 2000 to 2018.The R^2 during calibration for SWAT and HydroRAM were found to be 0.87 and 0.85, and for validation these values were 0.87 and 0.88 respectively. NSE values were 0.78 and 0.84 for calibration, and 0.68 and 0.89 during validation for SWAT and HydroRAM respectively. Based on these, for monthly analysis, HydroRAM outperformed SWAT for the Teesta basin in Sikkim.From WaterALLOC simulation, it was found that North Sikkim faces the minimum shortage against agricultural demand in all the three scenarios. Maximum shortage would be faced by South Sikkim in the month of March under RCP4.5 and RCP8.5 which is more than two times the corresponding shortages estimated for East and West Sikkim districts. For the month of March in South district, the shortage may increase by 43.26% and 28.66% under RCP4.5 and RCP8.5 compared to the historical period. Like the agricultural demand, for domestic demand too, the South district would face the maximum shortage, especially in the month of March, followed by East, West and North districts respectively. There is a possibility that, in the South district, w.r.t. demand, the shortages under RCP4.5 and RCP8.5 respectively would increase in March by 102.71% and 84.29%.The percent change in agricultural and domestic demands and shortages between historical, and RCP4.5 and RCP8.5 scenarios are represented in Figures.



Percent change in agricultural water demand and shortage between different climate scenarios



Percent change in domestic water demand and shortage between different climate scenarios

The primary focus of the project was an integrated river basin study for the Teesta basin in Sikkim.Under the climate scenarios (Historical, RCP4.5 and RCP8.5) the shortages against agricultural water demand were mostly observed in the winter and pre-monsoon period. South Sikkim district was observed to be the highest affected district with shortage followed by East Sikkim district.For domestic demand.For the climate change impact analysis, the most affected district has been found to be the South Sikkim district followed by East, West and North districts respectively, and for all, the shortage was maximum in the month of march. Also, compared to the historical period, the shortages under RCP4.5 and RCP8.5 would increase in future for the period 2025-60.The future shortage against agricultural and domestic demand analysed in this study under different climate scenarios can be used as the basis for proper river basin planning and management by making decisions over the competing uses and different demands for water resources in the Teesta basin.

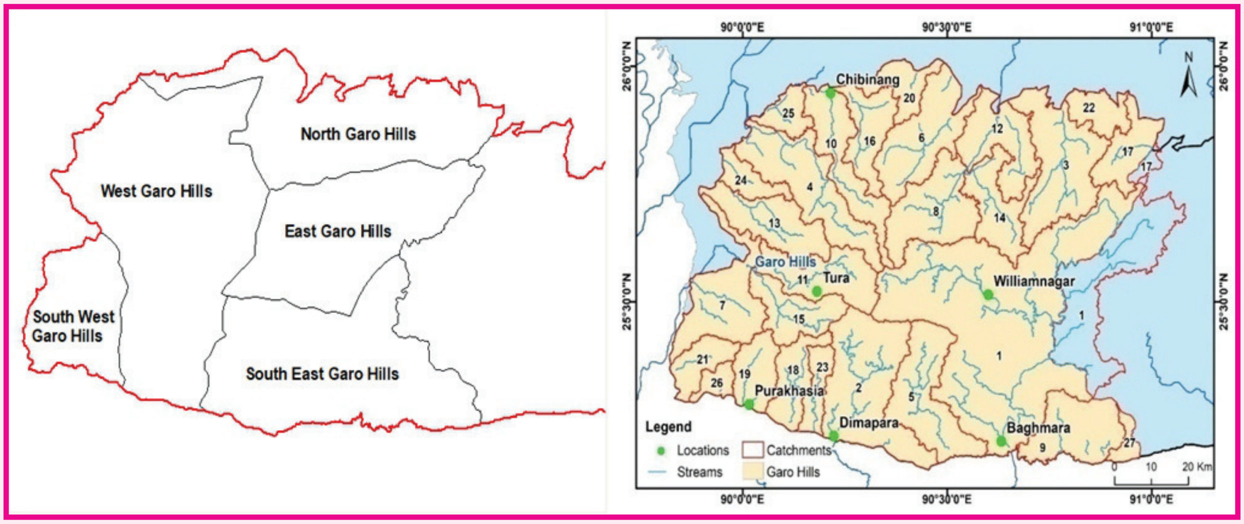
Study on Behaviors of Flooding and Unexpected Drought like Situation in Garo Hills District of Meghalaya

The North East region of India is characterized by diverse climate regimes which are highly dependent on the southwest monsoon. In this region, water resources management and disaster preparedness need to be investigated through drought and flood conditions, which is now heightened within the context of climate change and variability. The problem of floods and drought like situations in different parts of the Garo Hills District, Meghalaya are addressed in this study. The Garo Hills are low lying areas of Meghalaya whose altitude ranges from 50 to 1400 m above mean sea level with an average elevation of 350 m. The total administrative area is 9715.85 km^2.

Frequent floods result in increasing the flow in Brahmaputra and in some parts of Garo Hills. Most of the floods go unreported or improperly documented in the region due to their small scale of impacts in the downstream. The region also never experienced scarcity of water in the past. However, due to unpredictable weather over the last few years drought like situation has been observed. Looking at the effect of these extreme events, there is a need to quantify the water resources availability for proper management of water resources in the region.

The major objectives of the study are: i) to assess Land use and Land cover change for the past two decades (2000-2020) in Garo Hills, ii)) to assess the frequency of occurrenceand severity of drought and dry spells in Garo Hills, iii) to identify areas vulnerable to drought risk in Garo Hills using physical social and climatic factors including satellite rainfall data and other thematic information, iv)to carryout flood frequency analysis and to map the flood inundated areas in Garo Hills using Rainfall-Runoff-Inundation (RRI model) and to prepare region specific plan for drought mitigation and flood management in Garo Hills. The work was carried out by procurement of Indian Satellite data as well as utilization of freely available global satellite Data. Assessment of the frequency of occurrence and severity of drought and dry spells in Garo Hills was ensued using drought indices. Flood frequency analysis and mapping of flood inundated areas in Garo Hills area carried out using Rainfall-Runoff-Inundation (RRI model).

Automated weather stations for weather monitoring and digital water level recorder for stream discharge monitoring are installed in the study. Satellite data IRS Resoursesat-2 LISS-III & LISS-IV as well as Landsat-8 OLI/TIRS was used for detection of Land use/Land cover change for the catchments in the Garo Hills. Supervised Image Classification of the above satellite images were derived based on False Color Composites (FCC) as per the NUIS Standards 2008 Scheme. The classified output were cross verified using random sampling followed by post classification smoothing and statistical correlation of Catchment wise Decadal changes of land use & land cover pattern for assessment of drought in the Garo Hills District. The proposed study will help in demarcation of areas vulnerable to drought and flood inundation. It is expected to be helpful in quantifying the availability of water resources in space and time in the catchments of Garo Hills. This research outcome is expected to be useful for planning and design of water resources utilization and management of floods and droughts in Garo Hills Districts.



Study area for the projectin Garo Hills (District Meghalaya)

Impacts of Upcoming Irrigation Projects and Climate Change on the Droughts and Desertification Scenario for Chambal Basin in Western Madhya Pradesh.

Water resources management in arid and semiarid areas is a challenging task as large number of hydrologic, environmental and management factors have to be considered. Climate change, drought and desertification are all closely interlinked and their impacts are projected to increase in arid and semi-arid areas in future. The study focuses on carrying out comprehensive analysis including evaluation of drought characteristics, investigation of desertification, hydrologic modeling, climate change assessment, impact of upcoming irrigation projects, and development of a framework for integrated assessment of vulnerability to drought, desertification and climate change.

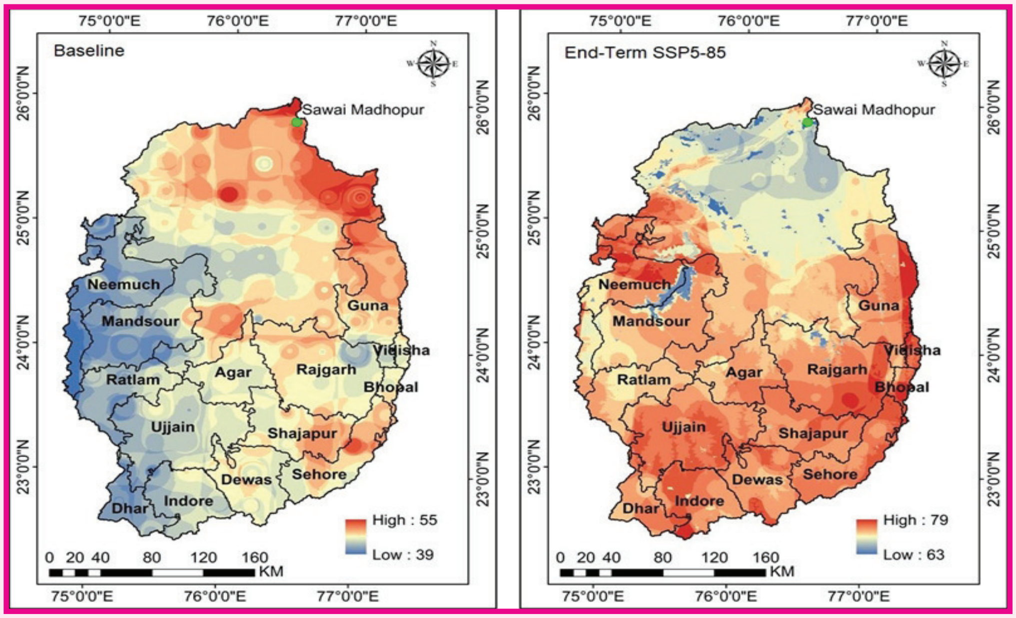
Climate change impact assessments have been carried out for five time zones viz., i) baseline (1961-1990), ii) present (1991-2015) using the historical observed datasets and three future time zones, iii) near-term (2021-2040), iv) mid-term (2041-2070) and v) end-term (2071-2100) using CMIP6 bias-corrected future climate datasets of 13 GCMs under 2 future climate scenarios viz., SSP2-45 and SSP5-85. Soil and Water Assessment Tool (SWAT) has been setup for the study area and multi-site calibration and validation have been carried out for simulation of streamflow for the future time zones as well. Dry spell analysis and critical dry spells (CDS) characteristics have been evaluated blockwise for all the 14 districts alongwith the crop water requirements for all major crops grown in the study area during all five time zones. The supplemental irrigation requirement during CDS has been computed for all five time zones for the providing life-saving irrigation. Indicator-based approaches have been adopted for assessment of meteorological, agricultural and hydrological drought characteristics, desertification, assessment of climate change impacts, assessment of climate change vulnerability, desertification vulnerability and drought vulnerability.

During the present period, the maximum (MaxT) has increased at the rate of 1.05°C per 100-year whereas the minimum temperature (MinT) too has increased significantly. The very hot days (MaxT>40°C), hot days (MaxT>35°C), hot nights (MinT>20°C) have increased considerably and the increase is highest in districts bordering Rajasthan. The cold nights (MinT<10°C) have seen a decline, with the highest decrease of 10-20% in the districts bordering Rajasthan. Similarly, the extreme rainfall events including the 1-day maximum rainfall, extreme rainfall (P>200 mm/day) and very heavy rainfall (P>100 mm/day) events have increased in the entire study area. Widespread drought occurred in 1965, 1966, 1972, 1979 and 1989 during the baseline period and in 1992, 2000, 2002 and 2010 during the present period.

The average annual stream flow during are projected increase steadily in future under SSP2-45 and SSP5-85 scenarios for the major rivers, the largest increase being in the end-term (2071-2100). The high flows (5% and 10% dependable flows) are projected to increase significantly whereas the low flows (90% and 95% dependable flows) are projected to decrease. The average aridity based on aridity index (AI) is projected to decrease from semi-arid (0.20<AI<0.50) during the baseline present periods to dry sub-humid (0.50<AI<0.65) during the end-term.

The climate vulnerability is projected to increase in all districts, from moderate to high in districts of Guna, Rajgarh, Agar, Mandsaur, Neemuch, Ujjain, Shajapur, Sehore and Indore whereas it is projected to increase from low to moderate Ratlam, Dhar, Dewas, Vidisha and Bhopal districts. The average annual soil loss is projected to increase during all future time zones, the highest change being projected during the end-term. The desertification vulnerability is projected to decrease in all districts, from high to moderate in Rajgarh, Agar, Dhar, Indore and parts of Guna district, whereas it is projected to decrease from moderate to low in Sehore, Dewas, and parts of Indore, Dhar, Ujjain, Ratlam, Mandsaur, Neemuch and Rajgarh districts. The drought vulnerability is projected to increase from moderate to high in the districts of Dhar, Indore, Dewas, Sehore, Ujjain, and Neemuch districts. The integrated drought vulnerability based on the assimilation of vulnerability to climate change, desertification and drought, is projected to increase mostly in all districts, from moderate to high in Rajgarh, Agar, Shajapur, Sehore, Guna and Dewas districts whereas it is projected to increase from low to high in Neemuch, Mandsaur, Ratlam, Ujjain, Dhar, Indore, Vidisha and Bhopal.

It can be concluded that extreme events including the 1-day MaxT, 1-day MinT, very hot days, hot days and hot nights are projected to increase substantially, whereas the cold night are projected to decrease which may have implications on the consumptive use requirements, crop growth and water demands for other sectors as well. Even though there is a decrease in the desertification vulnerability, the increase in climate change vulnerability and drought vulnerability calls for adoption of appropriate measures in the identified districts including climate smart agriculture, soil conservation, drought-resistant crops, real-time weather forecasting and efficient use of available water resources. The study will be useful for planning and implementation purposes for the Water Resources Department, Agriculture Department, research community and decision makers.

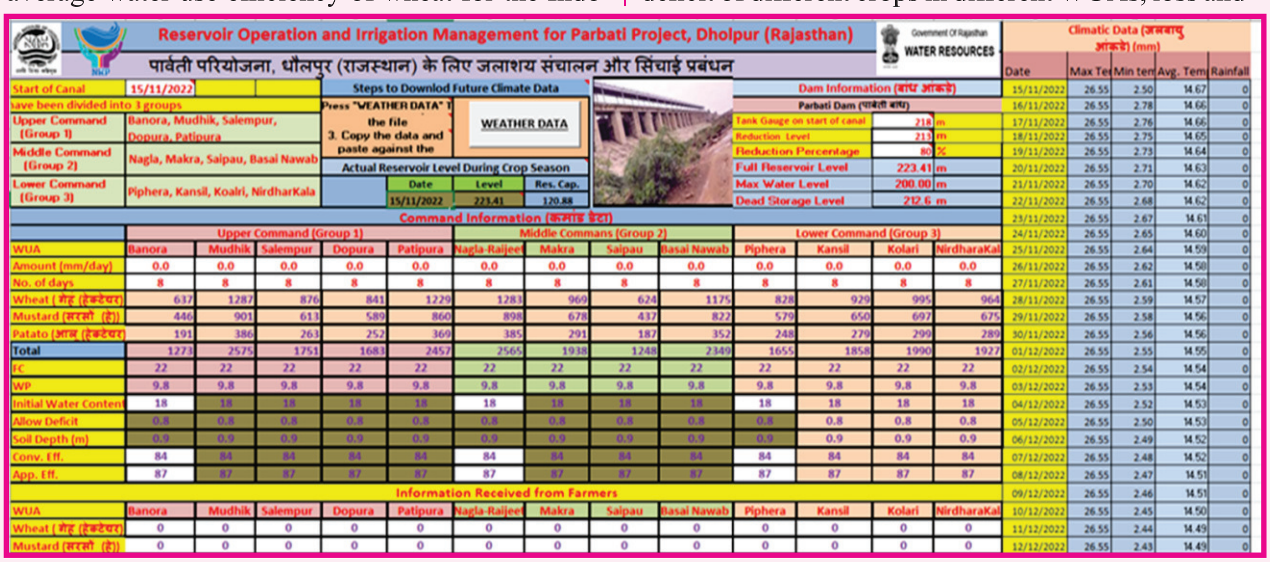


Comparison of integrated vulnerability during baseline and end-term (SSP5-85)

Development of Decision Tool for Efficient Utilization of Water Resource in Parbati Canal Project of Rajasthan

This PDS study has been taken with the objectives to assess the present efficiencies; scenarios based on demand-supply assessment under variable climatic, efficiencies, conjunctive use conditions; mobile-based data transfer, and decision support for optimal releases in the Parbati canal project of Rajasthan. The Parbati project is situated in the Dholpur district of Rajasthan having a dam with a gross storage capacity of 120.9 MCM and culturable command of 24667 hectares where mustard, wheat, and potato are the main crops. Different conventional and water use efficiencies were computed using computed data and modeling approaches. Reservoir efficiency, conveyance, and application efficiencies as conventional and economic water use index, gross production WUI, irrigation WUI, crop WUI, and irrigation economic WUI were computed for different years. From the analysis, it has been observed that prior to the lining of the canal, 60–70% of the area was irrigated, even in the flood year 2012-13.The conveyance efficiency before the canal lining was 45-60% and after the canal lining in 2017, the convection efficiency increased to 80-84%. Irrigation water use efficiency (IWUI) for wheat is in the range of 2.23 to 3.03 Kg/m^3 which is close to the average water use efficiency of wheat for the Indo-Gangetic region (1.74-4.3 kg/m^3) found in literature.

The NAM model for catchment up to Parbati dam was set up using inflow data from reservoir water balance and climate data from IMD. The model was calibrated from the period 2005 to 2013 with a coefficient of determination of 0.79. The model was validated from 2014 to 2021 and achieved a coefficient of determination of 0.67. The soil testing on nine different sites was carried out for soil properties and found that the soil is loamy in the Parbati command. The MIKE HYDRO basin model for the Parbati project with 3 water user associations (WUAs) was developed where results of the soil testing and NAM model along with reservoir characteristics, crop details, and climatic data were used as inputs. The model was simulated from 2005-06 to 2021-22 and found that in average and dry years, the reservoir cannot fulfill all the demand and after canal lining in the year 2017, the reservoir is now able to meet all the demand in most of the years. The developed MIKE HYDRO Basin model was brought in DSS-PM for further planning and assessment of the impact of change in crops, efficiencies, climate, etc. An excel-based dashboard for the reservoir operation system in Parbati command was developed whereby providing simple information like crop areas in different WUAs, date of start of canal, etc. the results of demands and deficit of different crops in different WUAs, loss and



Water management model for Parbati reservoir and its command remaining water after the rabi season can be determined. A web/mobile-based application was developed to provide timely and useful information to farmers and get feedback from farmers regarding water availability in their fields. The background water management model (Fig.) developed in this study is capable of providing demand, supplies, and deficit and optimizing cropping patterns based on the availability of water and future climatic conditions. The study's results can be used for optimal water management to maximize crop production in the Parbati command.

Mobile Application User Interface for WRM in Parbati reservoir and its command

7.2 SPONSORED PROJECTS ON-GOING DURING 2022-23

Anaerobic co-digestion of organic fraction of municipal solid waste and Municipal sludge

This study addresses two very innovative aspects i.e. Improving the efficiency of anaerobic digestion by thermal pre-treatment of co-mixed feedstock (OFMSW+ sewage sludge) and use of conductive materials to mitigate the recalcitrant toxicity and enhance the AD process performance. The key objectives of the study are (i) optimization of best co-digestion conditions for OFMSW+ Sewage sludge, (ii) optimization of thermal pretreatment of mixed OFMSW-Sewage Sludge, (iii) effect of thermal pretreatment on biogas production: Batch and Semi-Continuous study, and (iv) conductive materials mediated AD of mixed feedstock to mitigate recalcitrant toxicity and enhanced biomethanation.

The long term study revealed that anaerobic digestion of OFMSW and SS at 80:20 mixing ratio and TS 10% was optimized as best co-digestion conditions. Highest biogas yield of 474 L/kgVS was obtained at $125^{\circ}C$, and 618 mL/gVS at $125^{\circ}C$-3g/L NaOH. 15 days HRT and 5.1 kg VS/m^3.d OLR were best to achieve highest methane yield of 445 L/kgVS for thermal-alkali pretreated substrate ($125^{\circ}C$-3g/L NaOH). Methane yield for thermal-alkali pretreated substrate was 10% and 43% higher over thermally pretreated ($125^{\circ}C$) and control digesters, respectively. VS removal for thermal-alkali pretreated substrate was 57% and 11% higher than control and thermal pretreated digester. Thermal pretreatment alone and with alkali at $150^{\circ}C$ onwards led to the formation of recalcitrant compounds, i.e., 5-HMF and furfurals. Carbon-based conductive materials, i.e., GAC and GBC addition shows enhanced biogas production and recalcitrant removal (5-HMF and furfurals). Fe^{3}+mediated thermal-alkali pretreatment of OFMSW-SS helps reduce the formation of refractory compound and enhance biogas production by improving the degradability of pretreated substrate.

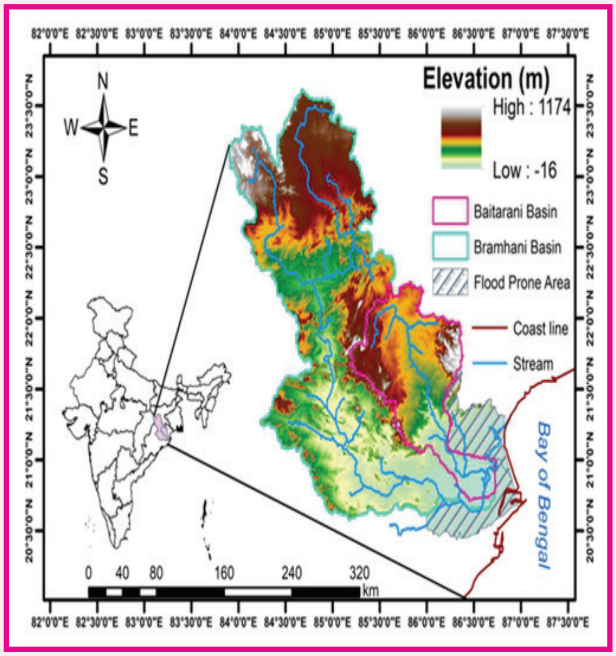
State Specific Action Plan (SSAP) for Water Sector for 16 States/UTs

The National Action Plan on Climate Change (NAPCC) identified the approach to be adopted to meet the challenges of impact of climate change through eight National Missions including National Water Mission (NWM). The main objective of NWM is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management".In order to achieve the objectives of NWM in a holistic manner, NWM envisages preparation of State Specific Action Plan (SSAP) for water sector of each State/UT aligning with the State Action Plans on Climate Change already prepared by the States/UTs with support from the Ministry of Environment, Forests and Climate Change. The water resources situation, its development, management and availability vary considerably from State to State. Many of the identified strategies/actions to achieve the goals of the NWM are required to be taken by the State Governments/Union Territories. The State specific Action Plans would essentially consist of (a) Present situation of water resources development and management, water governance, Institutional arrangements, water related policies, cross-boundary issues, agreements etc. This would constitute the Status Report on the State/Union Territory. The document should also define problems/issues related to all the aspects of water resources specific to the State, (b) Identifying a set of probable solutions to address the key issues/problem areas giving pros and cons of the solutions, and (c) Preparation of detailed Action Plan for each of the Strategy/activity identified in the NWM to be implemented by the State/Union Territory.

To achieve the above targets NWM has engaged National Institute of Hydrology, Roorkee (NIH) to act as the Nodal Agency (for NWM) to get the State Specific action plan for water sector prepared from 16 States and Union Territories (UTs) as per the Memorandum of Understanding (MOU) and Term of Reference (TOR). Accordingly, the NIH also entered into agreements with the respective State/UT for preparation of SSAPs and signed MOUs with various States/UTs to get the SSAP prepared from State Nodal Departments nominated by States/UTs for this purpose. In this process NIH is coordinating and guiding the nominated States/UTs departments in the preparation of SSAP document. To this end NIH is organizing various SSAP inception workshops for the benefits of States/UTs officials to meet the physical and financial targets to be achieved by the States/UTs. NIH is also helping States/UTs in close coordination so that deliverables envisaged are provided to DoWR RD & GR, Ministry of Jal Shakti as per schedule and would assist the various committees (Monitoring, Technical and Steering) as may be required by NWM from time to time. NIH is also providing financial assistance as a grant to States/UTs for the formulation of SSAP after getting these grants from NWM, DoWR, RD & GR, Ministry of Jal Shakti.

Operational coastal flood management through short-to-medium range (real-time) flood vulnerability mapping in the Brahmani-Baitarani River Basin integrating human and climate-induced impacts

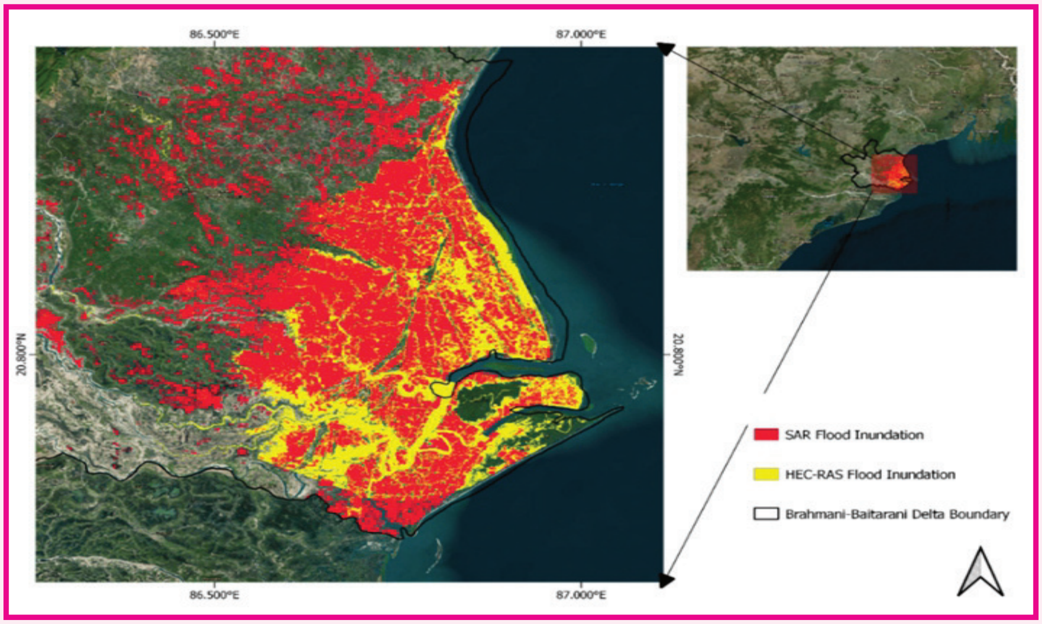
Flood hazard assessment in the coastal areas is very complex due to the presence of reservoirs in the river system that control the outflow during the flooding period and the presence of tidal backwaters in low-lying areas of the river system. The selected study area is the Brahmani and Baitarani River basins (Fig.), which extends over the states of Odisha, Jharkhand, and Chhattisgarh, having an area of 51,822 km^2 which is nearly 1.7% of the total geographical area of the country. This study undertaken with objectives: i) Assessment of historical flood inundation and sedimentation scenarios in the study area through field survey, secondary data, and remote sensing approaches ii) Detection of historical changes in land use and river cross-sections due to sedimentation and anthropogenic activities using survey data and satellite imageries iii) Forecasting of inflows into and releases from the Rengali/Mandira reservoirs in real-time up to 10-days lead-time accounting for the effects of urbanization, paddy land use, and river sedimentation iv) To forecast the tidal effect / sea-surges at the river-ocean confluence in the Bay of Bengal v) To simulate real-time 2-D flood inundation mapping in the deltaic river basin considering upstream streamflow forecasts, stream-aquifer exchange fluxes, and downstream tidal /sea-surge forecasts up to 10-days lead-time, and vi) To develop flood vulnerability maps in real-time (up to 10-days advance) for operational flood management using UNESCO-IHE guidelines.



Location and elevation map of Brahmani-Baitrani River basin

Data on all the historical floods from 1960-2021 were collected from various sources. Corresponding to the flooding events, satellite imageries were procured for the mapping of flood-inundated areas. Based on the Landsat satellite imageries, land use land cover maps of the study area were generated at five-year intervals to identify the land use change. It was observed that the Brahmani and Baitarani River basin has undergone major LULC changes. The dense forest has decreased up to 56% and the open forest has increased significantly up to 200%. Human interference can be seen clearly as the built-up area has increased substantially to 15%. Agricultural and barren lands have also experienced substantial changes of up to 150% and 50%, respectively. Similarly, Sentinel-1 satellite imageries were processed to prepare flood inundation maps over the delta region by change detection technique. An algorithm and computer codes were developed to process Sentinel-1 satellite imageries for the generation of an inundation map which is about to be communicated in scientific publications. It is evident that there is a frequent occurrence of floods in the coastal region of Brahmani and Baitarani Basin. In the last 5 years, three major floods have occurred in the coastal plains creating major damage to property and life.

The ehsB and SWAT-MODFLOW model setup is going on for stream-aquifer interaction modelling in the basin. For assessing the contribution of wave-current interaction to coastal flooding, a tightly coupled ADCIRC-SWAN (Surge-wave) model to compute water surface elevations as a combined effect of wind, astronomical tides, and waves was set-up in the part of Bay of Bengal Ocean. The surge-wave model was calibrated for tropical Cyclone Fani (SIM1), which made its landfall on 3rd May 2019. Another Cyclone Yaas (SIM2), which hit the Bay of Bengal on 24th May 2021, was used to validate the model. At (Brahmani-Baitarani Delta) BBD mouth, the ADCIRC-SWAN estimated temporal tide values serve as a downstream boundary condition in the 2D HEC-RAS model used for flood inundation mapping. The results of the flood inundation simulation in BBD are presented in Fig.



Flood inundation map of BBD generated based on HEC-RAS 2D simulation and SAR (Sentinel-1) extracted inundation extent

Further, flood forecasting plays a significant role in managing coastal flooding. In this study flood forecasting model is developed taking bias corrected Numerical weather prediction model forcings. The streamflow was simulated using the SWAT Pothole model and an error forecasting sub-model was implemented to minimize the error. The error-correction (forecasting) models are enlisted as: i) AutoRegressive (ARu); ii) AutoRegressive Moving Average with eXogenous inputs (ARMAXu), iii) Wavelet-based neural network (WNNu); iv) Dynamic wavelet-based Non-linear AutoRessive with eXogenous inputs (WNARXu). It was observed that using an error forecasting model to minimize the random error helped to improve the streamflow forecast at different lead-time. The NSE improved and falls in the range of 0.84 to 0.75 for a lead day of 1 to 5, respectively.The results of the study will be very useful to disaster management authorities engaged in the Brahmani-Baitrani River basin.

Integrated Management of Water Resources for Quantity and Quality in Upper Yamuna Basin upto Delhi

River Yamuna constitutes a major source of irrigation water for crop cultivation in large parts of rural north India and is an important source of drinking water supply for the urban population in Delhi. In recent years, several reaches of Yamuna river have experienced dry conditions and the contamination levels have increased especially near Delhi. The unprecedented increase in groundwater pumpage has led to declining groundwater levels in many areas despite the presence of the intensive canal network. In this context, it is very much pertinent to develop an insight into the changes in the hydrological processes occurring in the region and develop hydrological models for the basin. The study objectives include application and performance evaluation of selected hydrological models for the simulation of surface water, groundwater, and water quality in the Upper Yamuna Basin upto Delhi. The modeling studies broadly address the spatio-temporal variation in surface water and groundwater availability over the past decades on account of increasing water demands in the basin, contribution of snow and glacier melt on the surface water resources, conjunctive water use management of surface water and groundwater resources in canal commands, groundwater recharge, effect of anthropogenic activities on the quality of water resources, assessment of present and future water availability under alternate scenarios of climate change, and formulation of adaptation measures in the context of climate change.

The soil database providing the physical and hydraulic properties of soil in the study area has been developed based on field experiments and laboratory analysis of soil samples. Contribution of snow and glacier melt to surface water resources for the Himalayan basin including Tons river has been analysed using the hydrological model SWAT and WinSRM. Variations in snow cover extent have been analyzed using MODIS data. Maps of climate change indices have been generated for Himalayan and flat terrain using CMIP5 RCP 4.5 and 8.5 scenarios. Further, SWAT has been used to simulate streamflow, overland flow, groundwater recharge, evapotranspiration and total water yield in the flat terrain of Yamuna basin. Changes in baseflow contribution to River Yamuna have been assessed. In addition, WetSpass has been used to estimate the spatial variation in groundwater recharge in the basin, due to distributed land cover, soil texture, slope, meteorological conditions etc. In addition, groundwater samples have been collected from different districts and analyzed for trace metals. Hydrochemical analysis based on graphical analysis of IC, ICP-OES results has been performed. Further, the Qual2K model has been used to simulate and analyse water quality in Yamuna river, based on collected data from CPCB. The Water Accounting Plus (WA+) framework designed to provide explicit spatial information on water depletion and net withdrawal processes is being applied using satellite measurements. All the sheets of WA+ for Upper Yamuna Basin have been generated and results are being evaluated.

Enhancing Food and Water Security in Arid Region through Improved Understanding of Quantity, Quality and Management of Blue, Green and Grey Water

The nodal institution for the DST funded WATER IC Project is ICAR-Central Arid Zone Research Institute, Jodhpur. The National Institute of Hydrology, Roorkee, is one of the partner institutions. Other partner institutions include Indian Institute of Soil and Water Conservation, Dehradun; Central Sheep and Wool Research Institute, Bikaner; Central Institute for Arid Horticulture, Bikaner; National Institute of Agricultural Marketing, Jaipur. Major objectives of the project are: (1) To enhance water productivity in farming systems (districts Jodhpur, Jaisalmer, Barmer and Bikaner), (2) To develop improved methods for reusing industrial effluents in agriculture, (3) To analyse future demand and supply of water at regional and sub-regional level, and (4) To develop policy guidelines and capacity building of stakeholders.

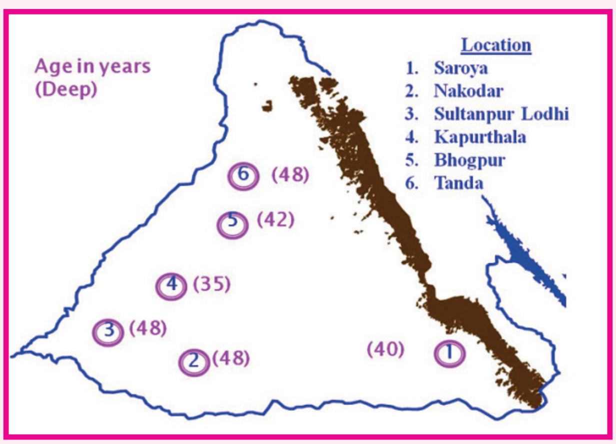
NIH has worked towards estimation of spatial and temporal variation in groundwater recharge in Indira Gandhi Nahar Project (IGNP) area using water balance model. Climate change indices have been generated for IGNP area based on CMIP6 SSP2-4.5 and SSP5-8.5 scenarios. In addition, field experiments were performed in CAZRI campus to study the impacts of different irrigation schedules on onion crop. Data collected from field experiments were used to numerically simulate flow in variably saturated porous media and study the impacts of different irrigation schedules on onion crop using HYDRUS software. The numerical simulations provided simulated soil moisture variation, and variation of moisture flux with days, in the respective scenarios for four different bed conditions 1) control flat-bed, 2) control raised bed, 3) mulched flat bed, and 4) mulched raised bed condition with three drip irrigation scenarios.

Groundwater fluctuations and Conductivity Monitoring in Punjab- Groundwater resilience in Punjab and adaptation to future changes in climate and water resource demands

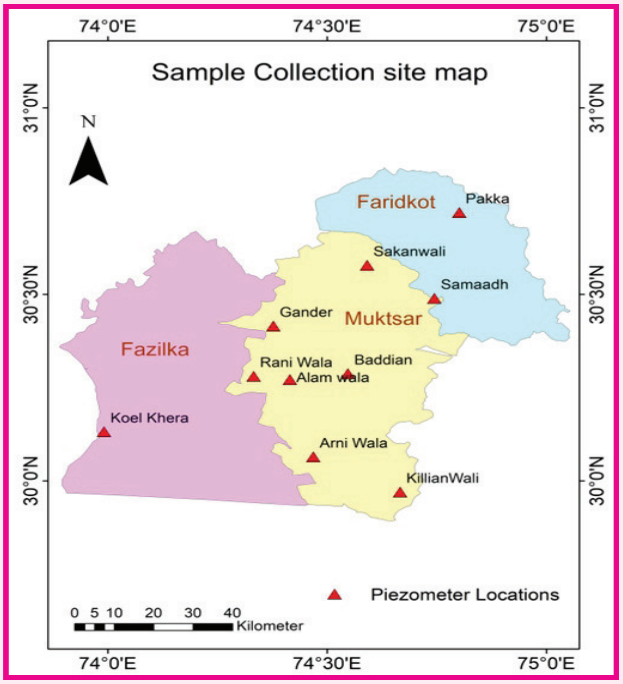
Punjab is underlain by the Indus Basin aquifer which has been rated as the second-most over stressed aquifer in the world. Among all the states of India, Punjab is drawing highest amount of groundwater resulting in its declination at an alarming rate. Bist-doab is one of the important regions of Punjab comprising of the districts of Hoshiarpur, Jalandhar, Kapurthala and SBS Nagar (Fig.). In recent years, a large volume of groundwater reported to be extracted in Hoshiarpur and Jalandhar districts. Agriculture is dependent on groundwater irrigation and concerns exist over the sustainability of current and future exploitation of groundwater; tracer data can help quantify groundwater renewal processes. In the joint study with BGS, UK high frequency water level and conductivity data is interpreted along with the analysis of water samples for a suite of tracers. In addition to the study in Bist-Doab, the study area has been extended to south-west (SW) Punjab where increasing demand of the irrigation water led to improper surface water irrigation policies resulting in water logging problems coupled with apprehension of saline zones formation by salinity ingression towards central Punjab due to excessive groundwater pumpage. To assess the inter-connection between aquifers sampling has been planned in Faridkot, Fazilka and Muktsar districts of Punjab.

In this study, groundwater level and conductivity data are monitored and high resolution field based observations are collected. For this loggers were installed in Saroya, Bhogpur and Sultanpur Lodhi in the month of May, 2019 (Fig.). In addition to these sites water level loggers were installed in Bhogpur, Tanda and Nakodar in October, 2019 (Fig.). The groundwater samples were collected for analysis of CFC, SF6 (at BGS, UK) for better understanding of the aquifer systems from 10 sites (Fig.) from the network of depth wise piezometers. Piezometers were developed in the depth range of 5 m-32 m and categorized as shallow (<10 m); intermediate 1^{st} (10-15 m); intermediate 2^{nd} (18-20 m) and deep (28-32m). The samples at BGS has been analysed for CFC, SF6 and other heavy metals. The data analysis and interpretation is in progress. Future plan includes downloading data from water level loggers and conductivity loggers, collection of new data from state department from nearby piezometers, and data analysis work with respect to various parameters like rainfall, land use etc. to observe the seasonal and spatial variation.

Average groundwater isotope values for shallow and deep groundwater sites are compared with amount weighted rainfall values and surface water end-members confirms the overall dominance of meteoric sources of groundwater recharge. Some of surface water samples show evidence of enrichment due to evaporative effects but average water isotope values for groundwater do not show any evidence of evaporative enrichment relative to the GMWL or LMWL. Groundwater stable isotope time-series and pairwise comparisons show that there are significant differences between deep and shallow groundwater isotope signatures at the same locations suggest long-term shift in the groundwater isotope values and salinity over the last 20 years based on groundwater residence time data for shallow groundwater in this region.Salinity variations are observed in the different aquifers in terms of average electrical conductivity in deeper aquifers (30 m) is 5050 μS/cm; in aquifer tapped at depth of 5-8 m it is 4068 μS/cm while in middle aquifers 10-20 m the electrical conductivity is 2794-3006 μS/cm.From the SF6 data, it is inferred that the piezometers tapped at the depth of 20-30 m are older (50 years) as compared to the other aquifers (~30-45 years). The evidence is widespread CFC contamination but the SF6 is fine. Hence, best 'age' or mixing estimates come from SF6 data alone. There are varied changes such as water gets younger with the depth in some cases. It is therefore most likely that this simultaneous change in isotope value in water samples in both deep and shallow sites is driven by changes in borehole pumping regimes that take place across the state.



Sites for installation of loggers in Bist Doab, Punjab

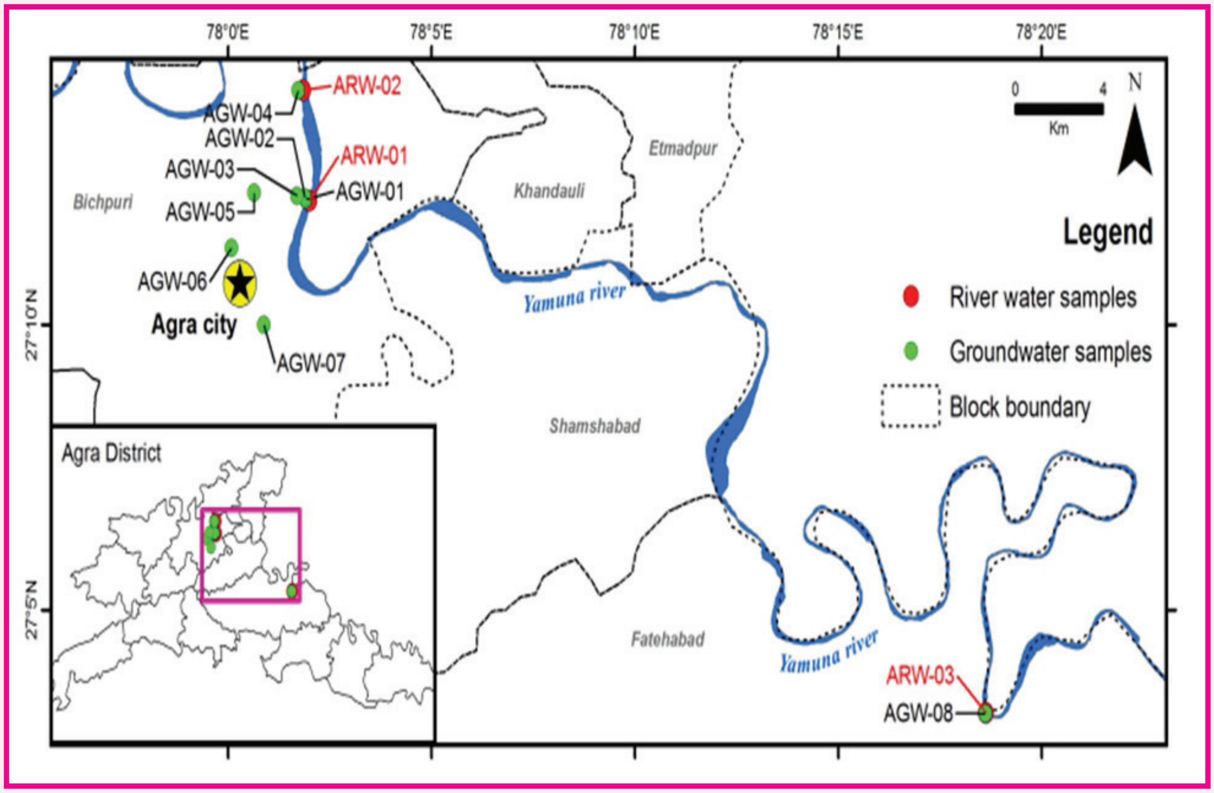


Sites for sample collection in south-west, Punjab

Expansion of the Indo-German Competence Centre for Riverbank Filtration – CCRBF

With the impending conclusion of project Pey Jal Suraksha (PJS) in 2018, NIH and HTWD, Germany endeavored to exploit the infrastructure created in PJS (pumping well), in a new collaborative project. None of the following were possible to investigate in the predecessor project PJS, viz. (1) Validation of RBF process, which includes-Possibility to investigate the upper limit of the purification capacity for RBF w.r.t. organic micropollutants and pathogens because the Yamuna river is one of the most polluted rivers worldwide, Comparison of RBF water quality with directly abstracted and conventionally treated surface water treated at the same location, Investigation of the effects of aquifer anisotropy (hydraulic conductivity changes in vertical/z-direction due to intermittent low and high conductivity layers) because the subsurface stratification found in the Yamuna floodplain in Agra is similar to many locations in the Ganga-Yamuna basin, Estimation of the portion of bank filtrate in pumped water from well and travel time of bank filtrate from river to well, (2) Demonstration of RBF scheme, which includes- Development of existing well into a demonstration site for RBF to show how a RBF site should be made and to display the benefits of RBF, Creation of infrastructure to monitor the RBF site by construction of at least 1 monitoring well, Demonstration of the purification capacity of RBF for conditions typical of extremely polluted rivers with complex subsurface geology, (3) Exploitation of above by development of a science-based masterplan for RBF water supply in India using above scientific results, Revision of existing guidelines on RBF into a second edition that will incorporate scientific / technical experiences of above, Investigate the inclusion of RBF as a "smart water infrastructure concept" within the "Smart City" project of the city of Agra.Additionally, and with reference to the progress report of CCRBF for the year 2021-2022, a potential RBF site in village Gagdhagara, near Talwan town by the Sutlej river in Punjab has been included in the project. This is in tune with the World Bank report (2020) on “Managing Rural Drinking Water Quality in Punjab”, wherein the following have been recommended including (i) Establishment of RBF systems in Punjab as a safe long-term solution, (ii) and systematic inventory of existing sites and exploration of new sites for development of RBF systems along major rivers.

Consequently, the quality of the Sutlej river water and groundwater from a vertical well used for rural water supply and located ~200 m from the riverbank in Gagdhagara, were investigated within the CCRBF project in June 2022 with the following key results and conclusions: (a) current investigations in Gagdhagara by NIH & German partners HTWD and TUD reaffirm recommendations of World Bank report-2022, (b) inorganic water quality of well within IS 10500 limits for drinking water, (c) little to no removal of atrazine and carbamazepine during subsurface passage indicates river-aquifer hydraulic connection, (d) potential for RBF at existing site exists, however further geohydraulic investigations and water quality monitoring needed, (e) good example of RBF as a sustainable source in Jal Jeevan Mission.



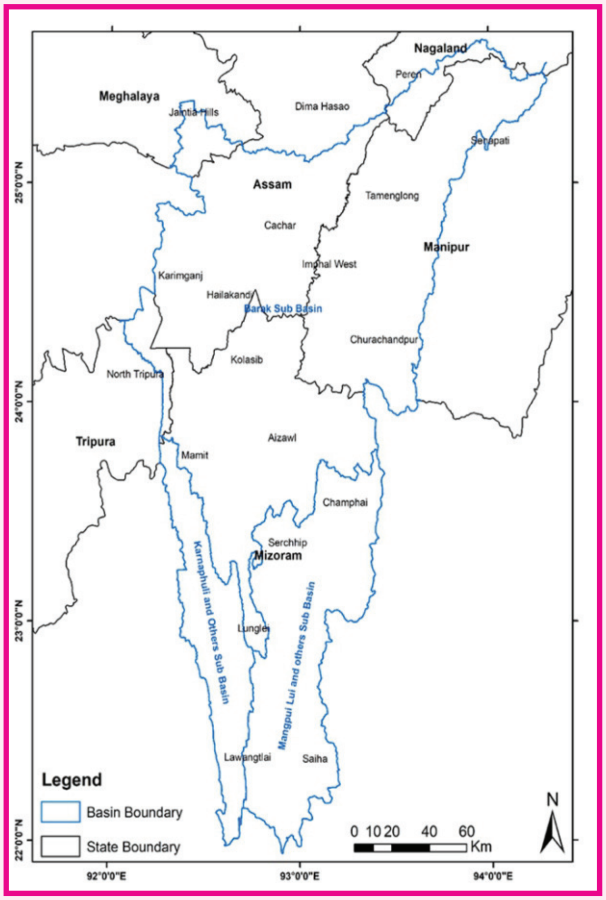
Location map of study area in Yamuna River catchment

Partitioning Evapotranspiration into Evaporation and Transpiration fluxes using Stable Isotopes of Oxygen and Hydrogen

Agriculture is the single largest user of freshwater in India. A significant portion of the applied irrigation water eventually evapotranspires. The transpiration (T) component of the evapotranspiration (ET) is associated with crop productivity, while the undesirable soil evaporation (E) component represents losses. The knowledge of the relative magnitudes of E and T fluxes is therefore essential for designing efficient irrigation techniques and understanding energy and moisture transfer in the soil-plant atmosphere continuum. In this direction, the institute has developed methodologies for collection of air moisture samples, soil evaporation and evapotranspiration samples, transpiration samples. Wherever possible, instruments are designed and fabricated inhouse to suit the local conditions and give reliable data at a low cost. For experimentation in the field, two sites are selected in Kanpur to study ET partitioning at plot and field scales. The sites are instrumented for measuring ET fluxes using hydrometric and isotopic methods. During the year, the following components have been carried out (a) Collection of Atmospheric moisture samples, (b) Collection of Plant transpiration samples, (c) Model development to collect Soil evaporation samples.

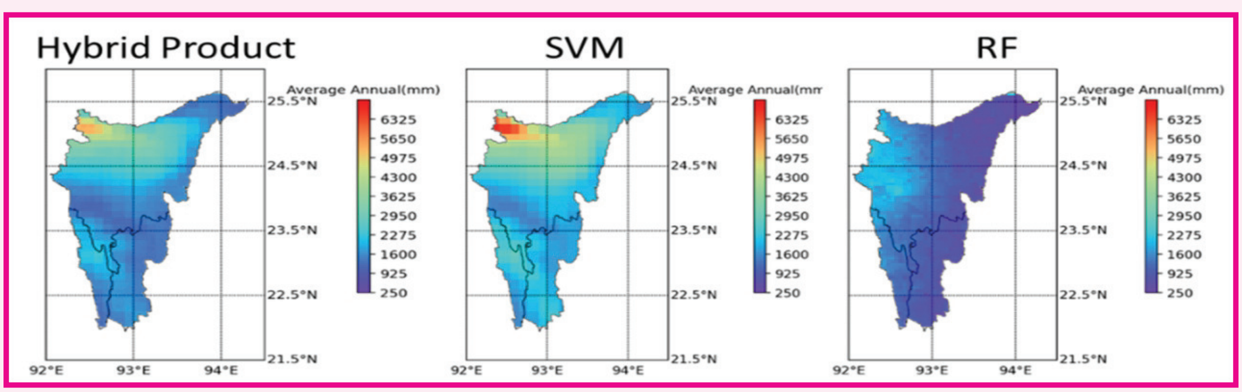
Long term hydrological assessment for the development of water security plan into three sub-basins namely Barak, Minor rivers draining into Bangladesh and Minor rivers draining into Myanmar subbasins in the state of Mizoram

The major objective of this study is to apply the advance modeling framework for Barak, Minor rivers draining into Bangladesh (MRD-BAN) and Minor rivers draining into Myanmar (MRD-MYA) subbasins in the state of Mizoram for water security plan. This will generate useful base data to help development of proper water management strategies and decision processes.



Study area map of Mizoram state

The major objectives of the study are to collect, prepare and evaluate various thematic datasets such as digital elevation model, land use/Land cover (LULC) map, soil map, population data (census) and hydro-meteorological data-sets such as precipitation, temperature, discharge etc. The long-term rainfall trend analysis based on rainfall frequencies and intensities to analyse the effect of climate change as per the standard guidelines. Then the hydrological modelling, calibration and parameterization over Barak, Minor rivers draining into Bangladesh and Minor rivers draining into Myanmar subbasins in the state of Mizoram for the assessment of watershed components (including surface and groundwater) and water availability using SWAT and SWATCUP models (Arnold et al., 2012). Analyzing the effect of LULC changes on the hydrological scenarios such as water availability (or water yield) at sub-catchments scale and discharge at the outlets. Analyzing the effect of climate changes on the hydrological systems, with possible thresholds for resilience under different conditions and combinations anticipated. To setup WEAP model (Levite et al., 2003) for calculating water demand of Mizoram state subject to mid-term water availability (say up to 2050) to increase water use efficiency and maintaining the adequate water supply sustainable development. To prepare the detailed report for study basins/sub-basins in Mizoram state as per the mid-term hydrological assessment with the guidelines of water security plan with particular reference to demand points (domestic, irrigation or others) identified by the Water Resources Department, Government of Mizoram.To impart training on "hydrological modelling" to the state officials of Water Resources, Agricultural and other related Deptt., as well as officers from other implementing agencies of the National Hydrology Project. Selection of dam sites with suggested capacity to meet the growing demand of water in the state.



Showing averaged annual rainfall as per Hybrid product (i.e. Assimilated) and Predicted (e.g. SVM & RF)

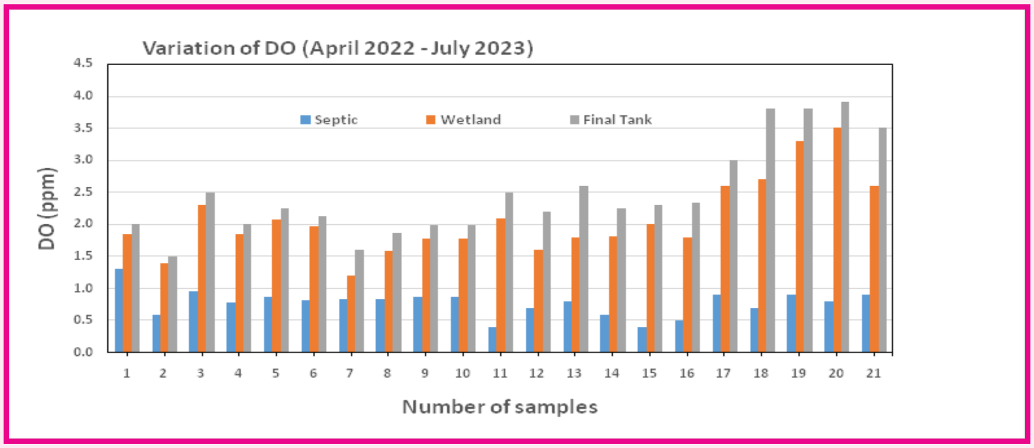
Development of Water Accounts for the different sub-basins in the state of Nagaland using Water Accounting Plus (WA+) Framework

The study has been awarded in the 1st week of June, 2021 as a Special Study under National Hydrology Project (NHP). The major objective of this study is to apply the newly developed Water Accounting Plus (WA+) framework for the selected sub-basins of Brahmaputra, Barak and Irrawady-Chindwin basins in the state of Nagaland for estimating the status of the water resources. This will generate useful base data to help development of proper water management strategies and decision processes. The specific objectives include: (i) To set-up WA+ Framework for the selected study basins/sub-basins; (ii) To estimate ET consumption patterns for the selected basins/sub-basins; (iii) To estimate land and water productivity for the selected basins/sub-basins; (iv) To develop Resource Base (Surface water & Groundwater) for the selected basins/sub-basins; and (v) To develop capacity on WA+ to the State Govt. officials from WRD, Nagaland through training programmes. As per the approved work schedules, open access data downloading and processing work is completed. Rainfall data from CHIRPS and Evapotranspiration from SSEBop have been analyzed to estimate the yield for the periods from 2001 to 2020. Also GIS database and generation of different thematic maps is completed. WA+ based land use/land cover (LULC) map has been developed and validated with the NRSC land use map (Fig.). Sheet 2 comprising of total ET, separation of ET into evaporation, transpiration and interception losses have been generated on monthly and annual basis. Water consumption patterns and estimates of water and land productivity (Sheet 3) have been completed. The 'Waterpix' model has been set-up and initial run of Sheet 4 (Utilized flow) and Sheet 6 (Groundwater) is under progress. A capacity building programme on “Application of Water Accounting Plus (WA+) Tool for Water Resources Management” has also been conducted during 28 Nov.-02 Dec., 2022 at Kohima, Nagaland for the officials from WRD, Nagaland. WA+ Framework is quick, reliable, and provide unbiased measure of water resources using Open access data. It is useful for inaccessible data scare region. WA+ provides information on consumptive water use, land and water productivity, available water; utilizable flow; non-utilizable flow, etc. which is helpful in water resource measurement, management and policy making.

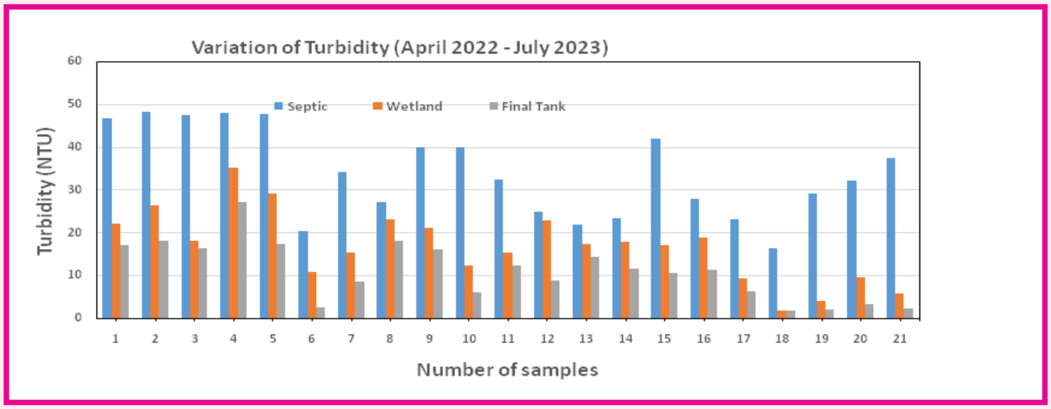
Water accounting-based landuse categorization for management of water resources

High Performance Advanced Septic System for Villages and Roadside Restaurants

The HPAS wastewater treatment system is a treatment that incorporates four discrete components – a conventional septic tank, a multi-soil layering system ('MSL unit'), a constructed wetland, and a stabilization pond (i.e. water holding tank). Design of the septic tank was completed in accordance with the Indian Standard - Code of Practice for Installation of Septic Tanks (Part 1 Design Criteria and Construction – IS: 2470). The MSL unit was designed based on hydraulic loading rates recommended in literature. The constructed wetland and stabilization pond were designed in proportion to the septic tank and MSL unit tanks. Four tanks (Septic tank, Multi-soil layering system, Constructed wetland, Stabilization pond) were constructed on JNTUK campus. Materials required for the soil mixture blocks (SMB) of the MSL unit include: sand, clay, sawdust, iron filings, and charcoal. Additionally, a mineral-based gravel material, namely zeolite, was specifically required to provide enhanced ammonia treatment and acts as the permeable material surrounding the SMB in the MSL unit. Additional items used for HPAS include: air blower, contaminant and nutrient 'test strips', gravel, soil, and pipes for conveyance of wastewater and air through the system.The HPAS average performance of sewage water into final treatment (Final Tank) in terms of DO, BOD, Turbidity, NO_3, PO_4 and TDS are 241%, 64%, 67%, 37%, 74% and 7% respectively. Initial results indicated that significant percentage of contaminants were removed from the raw sewage water using HPAS. However, the DO and Turbidity plots of raw sewage water (Septic), treated water into MSL (Wetland) and treated water from wetland (Final Tank) are given below in the Figures.The study is under progress.



Variation of DO (April 2022-July 2023)



Variation of Turbidity (April 2022-July 2023)

Modeling and management of erosion and sedimentation processes in Gandak river using morphodynamic modeling

The problem of erosion and siltation in a river reach are equally disastrous and need engineering interventions at critical locations. For providing dependable protection, scientific approach is required to understand the river morphodynamic and to estimate the suitable hydraulic design parameters for anti-erosion works and silt management measures. The 2D morphodynamic models are better replica of flow conditions and velocity distribution in alluvial river to understand the river regime and flow characteristics. The study is proposed with following objectives: (i) satellite image based river shifting/ meandering analysis, (ii) to develop the flow field and carry out flood studies of river channels and adjacent floodplains using a curvilinear grids that follow the bank lines to compute the flow characteristics like maximum flood level, flow velocity, flow direction, etc., (iii) to forecast of morphological changes over 2-3 years in the mobile braided river, (iv) to prepare design criteria for river training works in terms of flow velocities, flow depths, scour depths, bank line retreat rates, shoaling, etc., (v) to analyze sediment deposition (and erosion) in the study stretch, particularly at the meandering portion, bifurcations, confluences etc. and prediction of required annual volume of silt for dredging and sand mining etc. The river stretch for the study has been finalized in consultation with WRD, Bihar. It is situated around Rewaghat on Gandak river, about 45 km stretch upstream of Hajipur Bridge on the Gandak River. The study reach for detailed analysis is from Fatehabad/ Kunwari village to Baligaon village in a stretch of about 20 km.

The numerical models for river flow simulation and sediment transport are divided into three main categories: one-dimensional (1D), two-dimensional (2D) and three-dimensional (3D). One-dimensional models, although simple to use, fail to provide detailed information regarding the flow field while data requirement for 3D models are extensive and almost impracticable for field applications. However, two-dimensional modelling has the advantage of simulation of flow propagation with greater accuracy. In the study use of MIKE 21C model is proposed. The main advantage of MIKE 21C model is that it is based on a curvilinear (boundary-fitted) grid where the grid lines follow the bank lines. The curvilinear grid makes the MIKE 21C model a suitable tool for fast and detailed simulation of river hydraulics and sediment transport. The morphodynamic model is able to describe the variation in hydrodynamic characteristics i.e. water level, flow velocity and morphological characteristics such as helical flow, sediment transport, scour and deposition, bank erosion and plan form change of a river etc. During the year, daily hydrological data for water level, discharge and sediment concentration are collected at Baligaon site during 15 Jun to 15 Oct 2022. For measurement of the flow velocity and discharge, echo-sounder and current meter are used. Further, radar based automated water level recorders (AWLR) have been installed at two sites.

The forecast of morphological changes in the study stretch over short and long term period are useful in connection with planning and execution of river training works if required based on identification of sediment and erosion prone areas. Further the analysis useful in preparation of design criteria for river training works in terms of flow velocities, flow depths, scour depths, bank line retreat rates, shoaling, etc.

Field Investigations for requisite data Collection at Gandak River

Permafrost mapping and characterization of Western Himalayan Region

The cold-arid region of Ladakh has reported sporadic occurrence of permafrost and associated landforms with sorted patterned ground and other periglacial landforms such as ice-cored moraines. Catchment scale studies suggest that ground ice melt component may be a critical water source during dry years in the cold-arid regions of Ladakh (Thayyen et al., 2015). Ladakh has large areas of high altitude wetlands and lakes and the studies indicated phases of permafrost growth during low lake levels, especially after 5 kyr BP. Continuous development of permafrost mounds and thermokarst features are also inferred during the last 60 years as well. These studies have firmly established significant permafrost coverage in the high mountain areas of IHR. As glaciers and snow cover is shrinking in the most part of the IHR in response to changing climate, the permafrost areas are also expected to respond in a comparable manner as evident from other similar cryospheric areas globally.

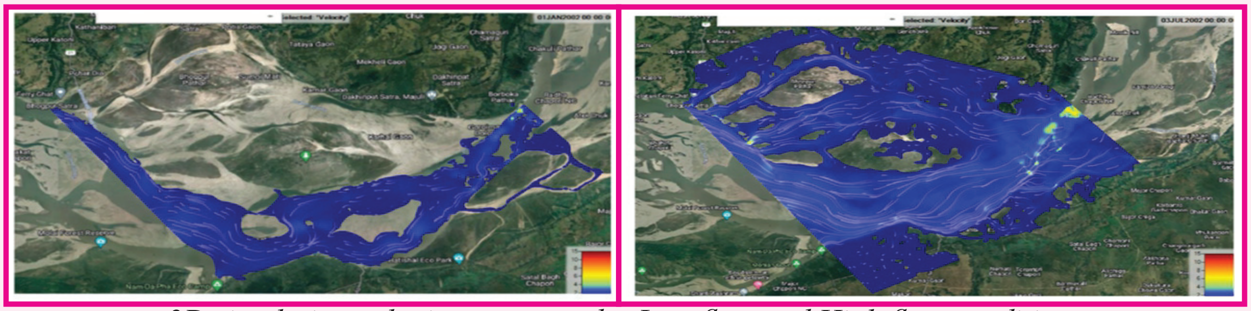
Thirty-five (35) sites were identified during the first field expedition. At these sites, the miniature temperature data loggers were installed. Further, the collection of different water samples, permafrost leachates and soil sampling was carried out by the partner institutes. Input data for the GEOtop model, which will be used for the modelling of permafrost at the selected sites was prepared. Permafrost thawed water samples and soil samples were collected from 30 sampling locations in Ladakh. Surface water and groundwater samples also collected from different sources like permafrost, active layer melt, glaciers, snow, surface for hydrochemistry and isotopic analysis. Model developed based on remote sensing products for the mapping of spatial distribution of permafrost in the Tso Kar basin. Using the Landsat imagery, different environmental predictors were prepared for further analysis and use. SRTM digital elevation model (DEM) at a resolution of 30 m, was used for the catchment delineation and calculation of other layers. Parameters like Temperature, pH, and EC of the thawed samples were analysed on the spot using potable handheld multiparameter analyser. Topographic Wetness Index (TWI) map, Emissivity map, PISR map, LST map, etc. were also prepared. Quality assessment of water and thawed active layer samples has been carried out through three-time sampling during the year 2020 and 2021, in terms of general water and soil quality parameters along with total and dissolved organic & inorganic carbon and nitrogen for Leh district, Ladakh. Modelling exercise for the estimation of permafrost characteristics is under process.

Data collection from miniature temperature data loggers (MTDs) during the field expedition to Leh, Ladakh

A Coupled Hydrodynamic and Bank Dynamic Modeling Approach for Forensic Analysis of Bankline Erosion Process Along Majuli Island- the Largest Inhabited River Island in the World

Majuli, an island district in the state of Assam has been suffering from acute erosion problem by the river Brahmaputra on its south. The drastic change in channel configuration in erosion-prone areas along its bank is a clear indication of the dynamic nature of river morphology of the Brahmaputra and the intensity of erosion caused by it. So this study has been taken up for a reach along Brahmaputra taking into consideration its dynamic behavior since last five/six decades. The objectives of the study are: (i) To study the erosion/deposition and bankline migration process of the acute erosion-prone reach of the Brahmaputra along Majuli and to estimate the rate of riverbank erosion since the last five decades, (ii) To develop the river's historical flow scenario using hydrological modeling to understand the change in flow pattern within the reach and (iii) To develop a coupled hydrodynamic and bank dynamic modeling approach to estimate the role of fluvial erosion and pore water pressure on the bank erosion process. The methodology adopted for this study involves the integration of three different modeling approaches, hydrological, hydrodynamic, and bank dynamic to understand the interactive bank erosion processes in the selected reach of Majuli island. A hydrological model was developed using the Soil and Water Assessment Tool (SWAT). The model was calibrated and validated at four locations using the SUFI-2 algorithm to estimate daily streamflow upstream of the study area. The generated streamflow is calibrated at subbasin outlets, Passighat, Chenimari, and Sibsagar, and then validated at Bessamora. The model is further calibrated using the Particle Swarm Optimization (PSO) algorithm to accurately represent the watershed.

For the hydrodynamic simulations, an event-wise approach is considered. To select the events for analysis, annual erosion from 1971 to 2014 at the six points where soil samples were collected, was estimated from satellite imagery. The ten events corresponding to the highest erosion were considered for the hydrodynamic simulations. The terrain data for each event was prepared using the Normalized Difference Vegetation Index (NDVI) of the Landsat images and SRTM elevation data. Land Use/Land Cover maps corresponding to each year were also prepared using supervised classification technique. 1D simulations are performed to estimate the optimal Manning's n value for each event, followed by 2D simulations to estimate shear stresses at the six points.Field visit was also made to collect soil samples from different locations and the samples were then analyzed for different engineering properties.From the SWAT simulation, a significant improvement in the statistical parameters is seen after initial calibration by the SUFI-2 algorithm. However, only a slight improvement over the SUFI-2 calibration results could be made by further calibrating with the PSO algorithm.The reach considered for the 1D simulations in HEC-RAS with the cross-sections in green is shown in Fig.The 2D simulation outputs in the low flow and high conditions are shown in Fig. The value of shear stresses were obtained from the simulation at 6 different locations along the reach. The samples collected from the field were analyzed for the engineering properties at AWRMI, Guwahati and IIT Guwahati. The soil is tested to be SM/SP or SC type, while SM and SP are predominant soil types. Dry density ranges from 1.499 to 1.589 gm/cc, cohesion ranges from 0.01 to 0.19 t/m^2, permeability ranges from 4.8 x 10-5 -19.7 x 10-5 cm/sec.



2D simulation velocity output under Low flow and High flow conditions

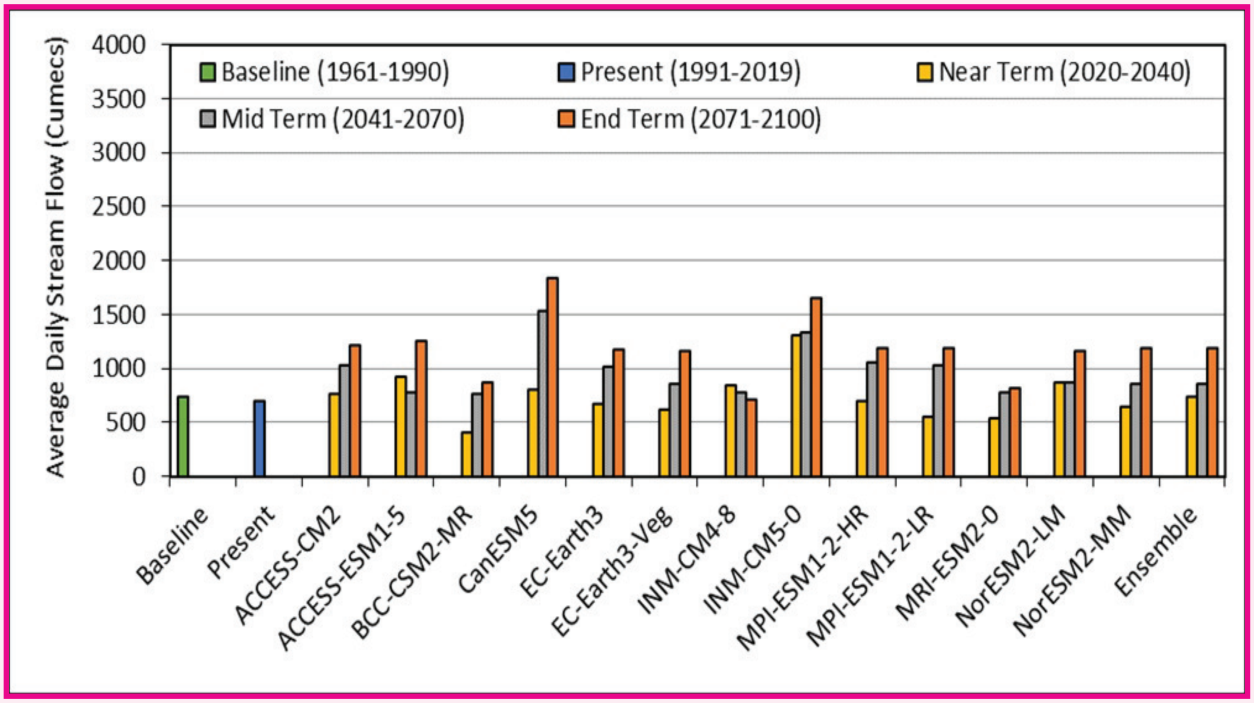
Integrated Assessment of the Impacts of Climate Change and Land-use Change on the Hydrology of the Narmada basin through Hydrological Modelling Approaches.

The foot prints of climate change are clearly visible with India experiencing a warming climate with increased frequency of extreme rainfall events, heat waves, floods and droughts which will have significant impacts on the agriculture and food security of the country. Climate change is as such is expected to have major impacts on future water quantity and quality. The water resources development is taking place at a brisk pace in Narmada basin in Central India. The study focusses on the application and performance evaluation of select hydrological models for simulation of surface water and groundwater flow, climate change impact assessment, water allocation planning and management and formulation of adaptation measures.

The models applied include Soil and Water Assessment Tool (SWAT), Variable Infiltration Capacity model (VIC), Hydrologic Engineering Center – Hydrologic Modelling System (HEC-HMS), Nedbor-Afstromings Model (NAM), Water Evaluation and Planning (WEAP), Water and Energy Transfer between Soil, Plants and Atmosphere under quassi-Steady State (WetSpass), MODular three dimensional finite difference groundwater FLOW model (MODFLOW) and NIH Reservoir Systems Package (NIH_ReSyp). These models have been set-up, calibrated and validated using the observed meteorological and hydrological datasets. The daily discharge data at various gauging sites have been used for multi-site calibration and validation of surface water models, whereas quarterly groundwater levels have been used to calibrate and validate the groundwater flow model. For climate change impact assessments, the high-resolution IMD precipitation and temperature data have been used for two time zones viz., i) baseline (1961-1990) and ii) present period (1991-2019). The bias-corrected downscaled high-resolution CMIP6 future climate data of 13 GCMs under two future scenarios i.e. SSP2-45 and SSP5-85 have been used for three future time periods viz., i) near-term (2020-2040), ii) mid-term (2041-2070) and iii) end-term (2071-2100).

The surface water models have been setup for Upper Narmada basin up to Hoshangabad and was further calibrated and validated. The comparison of observed and simulated average daily stream flows at Hoshangabad using VIC model during the baseline, present and future time zones is given in Fig. The spatial and temporal variation in groundwater recharge during baseline, present and three future time zones have been computed using WetSpass. MODLOW has been used to simulate the transient flow condition in Narsinghpur district falling in the Upper Narmada basin during all time zones. Water allocation planning including the water demands, supplies, unmet demand etc. for the present and future times zones have been carried out using WEAP. NIH-Resyp model has been applied for the conservation operation of Bargi Multipurpose Reservoir and Barna Irrigation Projects.

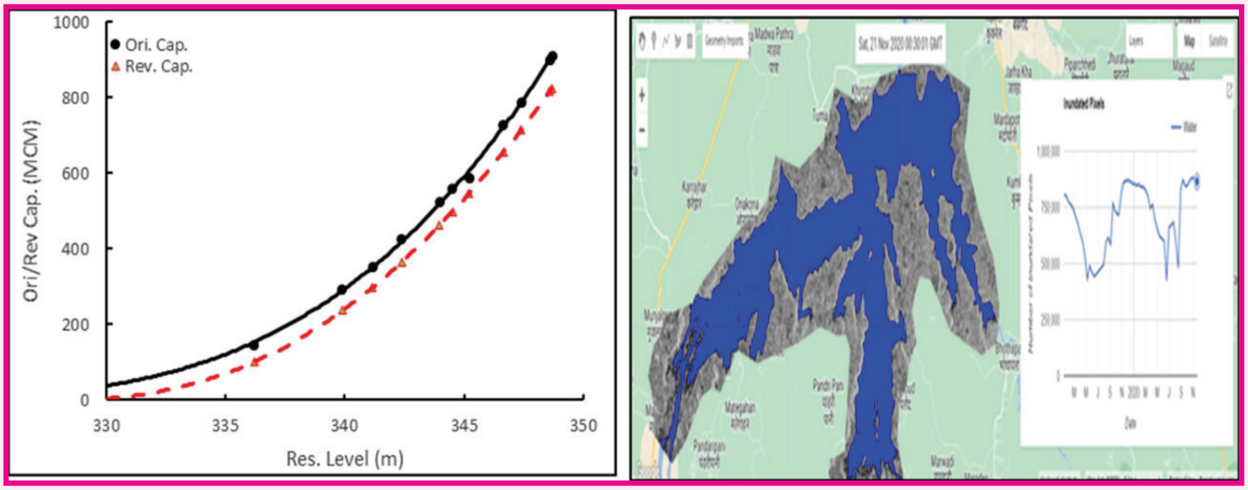
The 1-day maximum temperature is projected to increase from 43.3°C during the baseline period to 46.9°C under SSP5-85 scenario towards the end-term. Similarly, the 1-day minimum temperature is projected to increase from 28.9°C to 33.0°C under SSP5-85 scenario towards the end-term. The cold nights (MinT<10°C) is projected to decrease from 31 days to 09 days under SSP2-45 scenario and 02 days under SSP5-85 scenario. The high flows are projected to increase substantially in the head water catchments as well as in the main river basin during all future time zones, with the highest increase projected during the end-term. Droughts events including the severity and duration are projected to increase in all future time zones. Understanding the impacts of climate change vis-à-vis water availability, extreme meteorological and hydrologic events, droughts and supply-demand analysis under the changed scenario may be useful to the decision makers of Water Resources Department, Govt. of MP to plan for adaptation and mitigation measures for the water and food security of the region.



Comparison of average daily stream flow during baseline, present and future time zones under SSP2-45 at Hoshangabad G/D site using VIC model

Integrated Reservoir Operation Study for Mahanadi Reservoir Project Complex in Chhattisgarh

Most reservoir projects have multiple purposes and objectives, such as domestic and industrial water supply, irrigation supply, and hydropower generation. Many optimization techniques are available to optimize such complex reservoir systems. The Study (PDS) envisages developing a multi-reservoir operation rule using optimization techniques for a complex reservoir system in MRP. The Mahanadi Reservoir Project (MRP) complex comprising of four reservoirs in the Mahanadi basin, namely Ravishankar Sagar, Dudhawa, Maramsilli reservoirs, and Sondur reservoir in the Pairi basin. There is an inter-basin transfer of water from the Pairi basin to the Mahanadi basin through a feeder canal. The major demands include municipal, industrial, irrigation, and hydro-power from the feeder canal and Mahanadi main canal. During this period, the revised capacities of Ravishankar Sagar, Maramsilli, Sondure, and Dudhawa reservoirs were computed using the Otsu technique for the identification of water pixels from the rest of the image. A code in Google Earth Engine was developed where revised water spread can be computed for any reservoir in the world. The computed revised capacities of these reservoirs were compared with the bathymetric surveys conducted during the same period. The analysis suggested that 9.25% of gross storage (85.26 MCM from 910.52 MCM) of Ravi Shankar Sagar (Fig.), 10.3% of Muramsilli, 13.1% of Sondure, and 12.4% of Dudhawa reservoirs have been lost. The empirical area reduction method was used to extend the distribution of sediment during different periods. The Markov chain algorithm was used in TerrSet 2020 software to predict the 2005 and 2021 LULC maps using the 1985 and 1995 maps for catchments and commands of different reservoirs. The status report was prepared for the study.



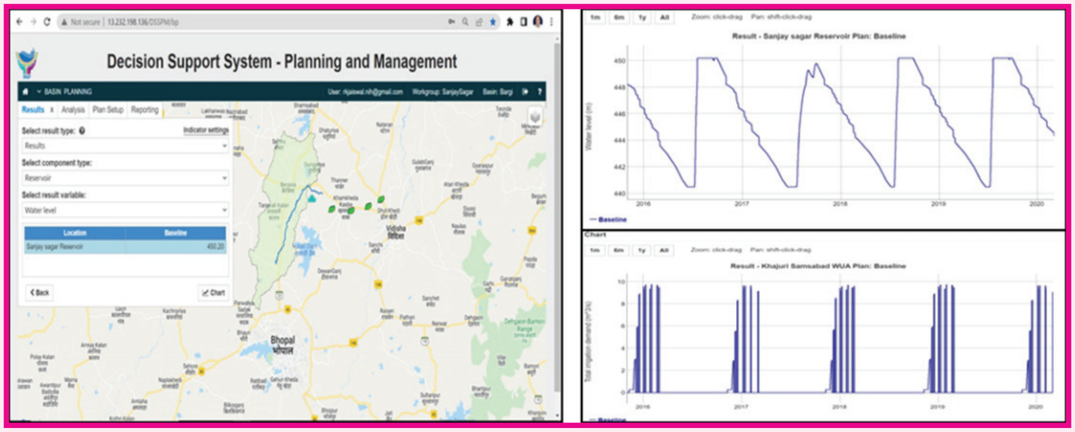
Google Earth Engine based assessment of revised water spread and original /Revised capacities of Ravi Shankar Sagar reservoir

Hydrological Modelling for Evaluation of Return Flow and Irrigation Planning for Optimal Utilization of Water Resource in the Command of Sanjay Sagar Project in Madhya Pradesh

Irrigation return flow (IRF) is defined as the excess of irrigation water that is not used in evapotranspiration rather than evacuated by direct surface drainage, and which returns to an aquifer vary by more than 50% for rice cultivation using standing water irrigation, 15% for wheat to 0% in the case of drip irrigation technique. The return flow is an important component of hydrology in the command and depends on canal conditions, type of crops, irrigation methods, geology, operation policies, etc. In Madhya Pradesh state, a fixed 10% of water storage is used as regenerated flow from the command which needs to be verified using scientific assessment for optimal utilization. The present PDS proposal has been formulated to address the issue of computation of irrigation return flow from the command of the Sanjay Sagar irrigation project (Vidisha, MP) for optimal irrigation water management. During the period, detailed soil analysis of command for soil moisture, texture, and soil water retention was carried out on twelve different sites. The soil in the command is mainly silty loam that can retain water from 19.67 (Permanent wilting point) to 35.77% (field capacity). The soil samples collected from the field were analyzed for soil moisture and compared with remote sensing-based Soil Moisture Active Passive (SMAP) data. Evapotranspiration for the crop in the Sanjay Sagar command was computed using RS data through the SEBAL model and compared with Hargreaves and Penman Montieth equation. The results of the analysis can be used to assess water allocation in different WUAs. NAM model was applied for rainfall-runoff modeling at the Bah G/D site situated in the mid part of the command. The virgin data of the Bah G/D site from 1991 to 2003 was used for calibration and from 2006 to 2013 for validation of the model. The coefficient of determination (R^2) was worked out as 0.70 and 0.64 during calibration and validation respectively.

The developed NAM model and soil testing results were used in the MIKE HYDRO-based water management model for irrigation planning. In the MIKE HYDRO model, the catchment of Sanjay Sagar dam, reservoir, and four water user associations as irrigation water users were assigned, and requisite data and information on soils, crops, reservoir, and climate were given to the model. The model was simulated for 2015-16 to 2021-22 and demand, the deficit of each WUA and reservoir levels, etc. were computed. The same model was imported in DSS-PM developed by DHI under National Hydrology Project. An excel-based irrigation management model for the Sanjay Sagar project was developed giving information on crop areas, the start of the canal, and reservoir operation rules, the demand and deficit in different WUAs can automatically compute based on crop water requirement, reservoir water availability, future forecast climate, etc. The developed excel model is easy to use for water resource managers and policymakers. The study is in progress.

Field soil testing and sampling in Sanjay Sagar command

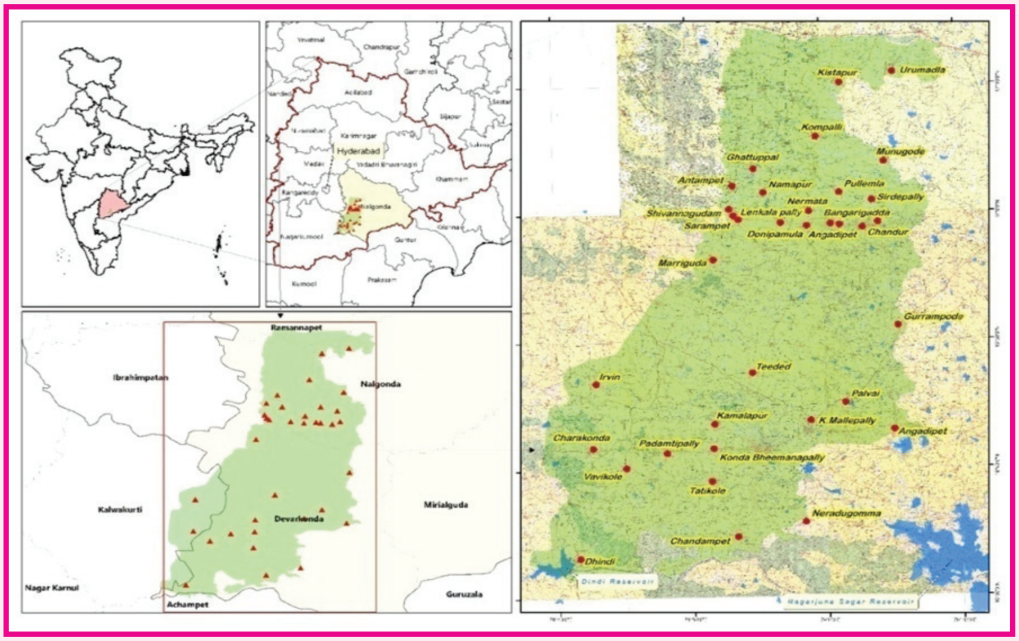


DSS-PM for Sanjay Sagar command

Groundwater Model Development in Micro Basin of Hard Rock inKrishna and Godavari River Basins of Telangana

Field investigations were conducted at the Nizamabad district Cheppur micro-basin along with the GWD officials. The field test locations were been selected based on different geomorphological, soil, and Land use conditions (agricultural, barren, open land, tank u/s, d/s, canal influence, flood plains, and river banks). Field tests have been successfully conducted at 17 well-spatial distributed points in Cheppur study area. The objective of the field study was to conduct infiltration and hydraulic conductivity tests using a Disc permeameter and Tension Infiltrometer. Core soil sampling using an auger and geophysical survey (VES) is being carried out to estimate various groundwater modeling parameters. Soil samples are been tested for moisture content, bulk density, and sieve analysis in the lab for analyzing the infiltration rate, sorptivity, and hydraulic conductivity of soil based on the disc permeameter. Geophysical surveys were been carried out in the Cheppur study area using vertical resistivity survey (Wenner configuration). The average depth of investigation was 60 meters as per the geological condition and finding of hard rock. The test results would be used to determine the detailed stratigraphy (different layers with depth and types) of the study area for improving the conceptualized groundwater model.

The MODFLOW groundwater model which is prepared would be updated with parameters obtained from field investigations. The detailed data of well inventory for different mandals will be used to determine the groundwater usage and draft from the controlled system taking constant values at a time of different boundary conditions like rainfall recharge, Evapotranspiration, River, and lake influence on groundwater. The simulated outcome will be calibrated for Hydraulic conductivity values and storage values and the PEST module will also be used to validate the hydraulic conductivity obtained from the simulated outcome and field investigations. The steady-state model in different stress periods will be used to calibrate and validate all boundary conditions and Hydro-geological parameters. Additional secondary data were collected such as rainfall data, tank de-siltation, specific well observation location, and data related to Mission Kakatiya tanks, GEC reports, check dam details and soil testing report from WRD, and additional BDR and VES data in the region.



Index map of Dindi micro-basin in Krishna catchment

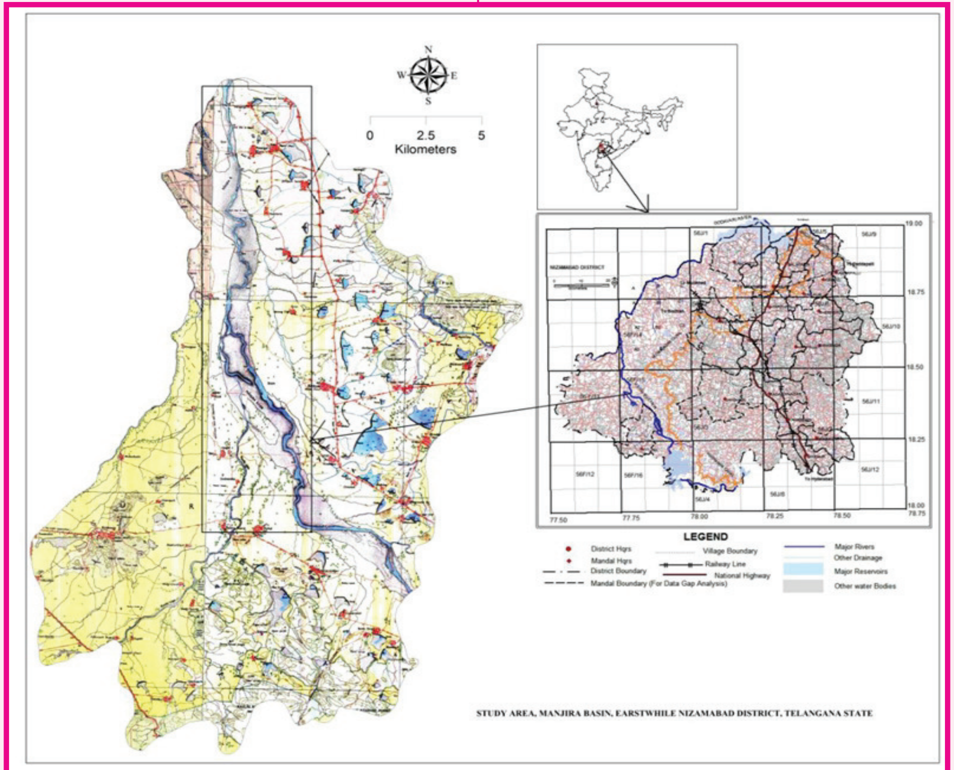
Comprehensive Assessment of Water Availability, Use and Issues for Goa State

The state of Goa receives rainfall of the order of > 4000 mm annually. More than 80% of rainfall is received during monsoon months. However, there are not many water resources projects to capture the rainfall and store water for rest of the year. In the last decade are so, there are many industries are being established in the state and state has witnessed a steady rise in the population. To cater to these activities and a huge floating population during the tourist season, there is a need for an efficient mechanism to manage the water resources of the state. Therefore, a study on comprehensive assessment of water resources in each of the catchment is initiated with following objectives, viz.;, (i) Development of methodology (including mathematic models) to estimate the availability of water resources; (ii) Assessment of present water demand and water use pattern for various sectors in these river basins and forecast the future demands and use pattern; (iii) Assessment of water availability under the climate change scenarios for future period; (iv) Assessing the hydrological extreme events in the future and possible mitigation measures; (v) Assessing Surplus and Deficit catchments and possible augmentation of water resources, possibilities inter-basin and intra-basin water sharing; (vi) Formulating the policy framework for strategic management and optimal utilization of water resources considering the future demand and water availability.

In order to achieve all the objectives, following analysis has been carried out and completed some of the task such as; (i) identification of best satellite product for the study area so as to use the satellite product in places where there are no point observation; (ii) developed stage-discharge curve for converting the hourly water levels into the discharges and to compute the daily discharge for all the stations; and (iii) set-up rainfall – runoff model for river basins of Goa.

Impact of Sand Mining on Groundwater Regime in Parts of Manjira River Basin, Telangana State

The study has been taken up as an in-house study by the Ground Water Department, Telangana State under the National Hydrology Project (NHP), with NRSC, Hyderabad and Regional Centre, NIH, Belgaum as Partner Institutions. The objectives of the study are; To study the river dynamics on 1:10000 scale using remote sensing techniques to understand sand depositional pattern; To study very high resolution RS data for preparing pre and post monsoon thematic layers to understand the impact of sand mining on geomorphology, drainage and land use pattern; Investigate thickness of saturated sand along the river; To study temporal changes in GW levels along river Manjira in response to rainfall , GW draft and sand mining; To study hydrogeological conditions and to understand the interaction between river and adjoining aquifer system under various stress conditions; To understand impact of sand mining on GW system and Simulation of GW flow under various stress conditions.



Study area showing Manjira River Basin, Telangana State

The aquifer modelling methodology has been proposed to assess the impact of sand mining on groundwater. Data concerning ground water levels, water quality, rainfall, stage-discharge as well as hydrogeological parameters are to be collected to facilitate simulation of aquifer system for various stress conditions and sand removal options. The study will employ a methodology consisting of field investigation methods, laboratory analyses of water samples and aquifer modelling. The interaction characteristics of river-aquifer will be analyzed. Simulations can be carried out based upon the river profile conditions due to sand extraction as well as groundwater levels to ascertain the aspects or impact. The data requirements are; aquifer parameters (e.g. K, Sy, Ss, T, water levels, lithology/ hydrogeological information, aquifer delineation/ layer etc.); river data (e.g. stage/ discharge, river cross sections, river morphology, sediment/ bed material transport, etc.); groundwater well information/ water level; groundwater draft / groundwater utilization pattern in the study area; conjunctive use information; existing sand removal practices and quantities; information on structures over river/ installations near river banks, land use & soil maps; sediment/ bed load samplings at selected locations; rainfall and aquifer recharge data.

Dam Break Studies of Somasila, Kandaleru and Pulichintala Dams in Andhra Pradesh State

Dam break flood analysis of Kandaleru dam has been investigated which is located in Andhra Pradesh. Kandaleru dam is built for a purpose of irrigation and comes under Telugu Ganga project which supplies drinking water to Chennai city from the Srisailam reservoir in Krishna River. Kandaleru dam is an earthen dam of 10.752 Km length with a height 49.00m. The gross storage capacity of reservoir at Full Reservoir Level (FRL) is 68.03TMC with a FRL value 85.00m and Top Bund Level (TBL) of dam is 89.00m. One-dimensional HEC-RAS model has been used for dam break analysis. For this analysis, breach is selected as trapezoidal shape at the spillway location with overtopping failure. It may be noted that maximum flow at dam site is 59,209.70m^3/sec and 10km away from dam the value of flow is 56,175.51m^3/sec. For better understanding of dam break results, different sensitivity analyses are performed with the help of Froehlich equations. It is found that as breach width increases flow value increases but in case of breach formation time the flow decreases. The Manning's roughness of main river reach has more impact on flood values rather than flood plain roughness values.

Innovation Centre for Eco-Prudent Wastewater Solutions (IC-EcoWS)

This project has been funded by Department of Science & Technology (DST), Government of India. The National Institute of Hydrology (NIH) Roorkee is the leading institute for implementation of this project, in collaboration with the project partners from Indian Institute of Technology Bombay (IITB), Malaviya National Institute of Technology (MNIT), Jaipur and Institute of Rural Management Anand (IRMA), Ahmedabad. The objectives of the project are (i) establishment of a state-of-art Centre for Eco-Prudent Wastewater Solutions (IC-EcoWS) to harness the potential Natural Treatment Systems (NTS) and other eco-prudent resource recovery technologies for water security and sustainability in India, (ii) development of a Decision Support Tool (DST) based on Life Cycle Assessment (LCA) and Multiple Criteria Decision Making (MCDM) approach for selection of appropriate "Technology Packages" for resource recovery oriented wastewater treatment infrastructure, (iii) establishment of few pilot study sites ("Live Laboratories") for detailed assessment of selected NTS in urban, peri-urban and rural settings, for both secondary and tertiary treatment requirements as per new CPCB norms as well as for select emerging pollutants, (iv) to explore innovative ideas on the development (e.g. use of pre-fabricated structures, efficient structures for control of solid waste in sullage) and application (e.g. retrofitting of existing village ponds, drains, linkage to livelihood options) of NTS for wastewater treatment and (v) to organize capacity building, awareness creation, documentation and dissemination activities, and preparation of a TOT

Module on NTS applications and an Indian handbook for promotion and propagation of NTS for resource recovery and wastewater treatment in India.

During 2022-23, two online in-situ monitoring systems were established at NIH Roorkee (Horizontal sub-surface flow constructed wetlands, HSSF-CW) and MNIT Jaipur (vertical flow constructed wetlands, VF-CW). Under Innovative Ideas for wastewater treatment using natural treatment systems, two field experiments, viz. pesticide removal from synthetic wastewater and biogas Generation Potential from Canna indica (Resource Recovery) were also in progress. The First Version of the Decision Support Tool (DST) based on NTS suitability and life cycle costing has been prepared including the tools such as Multi-criteria Decision making of NTS, Life-Cycle costing tool, and NTS Technology selection tool. Furthermore, Social Cost and Benefit analysis of various NTS technologies including constructed wetlands were also performed based on 18 NTS technology for business model development. More details of project activities are provided in IC-EcoWS Centre's Portal

(http://117.252.14.242/rmod_dst/Default.aspx).

HSSF-CW for natural treatment of doestic wastewater (NIH Residential Colony)

HSSF-CW for pesticide removal from synthetic wastewater (NIH Campus)

8 Initiatives for the North-East Region

To cater to the hydrological needs of the North Eastern Region, Sikkim and northern part of West Bengal (Teestha Basin), National Institute of Hydrology established a regional Center at Guwahati in August 1988, which was renamed as NIH Centre for Flood Management Studies for the Brahmaputra Basin (NIH-CFMS) in September 2001. The Centre has been renamed to North Eastern Regional Centre, NIH Guwahati recently.Since its inception, the Centre has been actively interacting with various State, Central and Academic organizations working in the areas of northeastern water resources e.g. Brahmaputra Board, Central Water Commission, Central Ground Water Board, India Meteorological Department, North Eastern Regional Institute of Water and Land Management (NERIWALM), Water Resources Departments, State Pollution Control Boards, Guwahati University, Indian Institute of Technology Guwahati and Assam Engineering College etc. for active research work. As per the action plan, thrust areas for research and studies of the Ventre are (i) Flood estimation and routing; (ii) Structural/non-structural measures for flood management; (iii) Integrated watershed management for flood control; (iv) Hydrological data base management system; (v) Drainage congestion and erosion problems; (vi) Water quality problems; (vii) Socio-economic aspect of flood disaster; (viii) Springshed management; and (ix) Technology transfer through trainings and awareness programs etc.

The Centre is actively involved in conducting field-based studies for many years. Presently, the centre is engaged in five Institute funded R & D Studies i.e. i) Linear Hydrological routing using Satellite precipitation datasets for flood forecasting in parts of Brahmaputra Basin; ii) Hydrological behavior of two mid-sized mountainous catchments under the influence of climate change; and v) Rainfall Induced Flood Hazard Risk Vulnerability Assessment in East Jaintia Hills, Meghalaya vi) Impact of Climate Change on Flood Inundation in Beki River Basin and Drought characterization and vulnerability assessment in Assam. The centre is involved in two Sponsored Projects funded by NHP i.e. i) Study on Behaviors of Flooding and Unexpected Drought like Situation in Garo Hills District of Meghalaya and ii) River basin planning studies in Teesta basin up to the confluence with Rangit River in Sikkim, and one project funded by DST entitled 'A coupled hydrodynamic and bank dynamic modeling approach for forensic analysis of bankline erosion process along Majuli Island- the largest inhabited river island in the world'.

One DST-SERB funded project titled “A Coupled Hydrodynamic and Bank Dynamic Modeling Approach for Forensic Analysis of Bankline Erosion Process Along Majuli Island-The Largest Inhabited River Island in the World”is going on in the North Eastern Regional Centre, Guwahati. Majuli, a district in the north-eastern state of Assam is the world's largest inhabited riverine island. It is bounded by the river Brahmaputra on its south and on the north by river Subansiri which itself is one of the major tributaries of Brahmaputra. The very existence of the islandis in danger due to erosion caused by the bounding rivers. The erosion was known to be initiated to a large extent by the great Assam earthquake of 1950 of magnitude 8.7 Richter scale. The severity is evidenced by the fact that an area of 1246 km^2 in 1950 of Majuli was reduced to

925 km^2 in 1971. The acute erosion problem around Majuli, especially on its southern bank, is a clear indication of the erratic behavior of the river Brahmaputra. For the present study, a vulnerable reach along the south bank of Majulihas been considered to understand the combined effect of interacting bank erosion processes by coupling a hydrodynamic and a bank dynamic model.

Field investigations in Majuli island

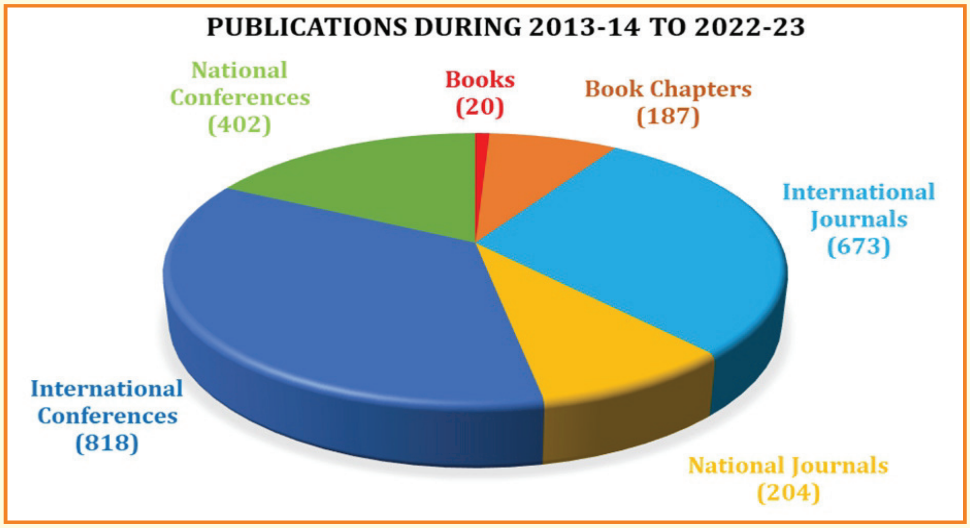
Training Program on Hydrological Modelling using SWAT was organized at NERC, NIH Guwahati on December 5 – 9, 2022.

Training Program organized at NERC, NIH Guwhati during December 5-9, 2022 on Hydrological modelling using SWAT

9 Publications

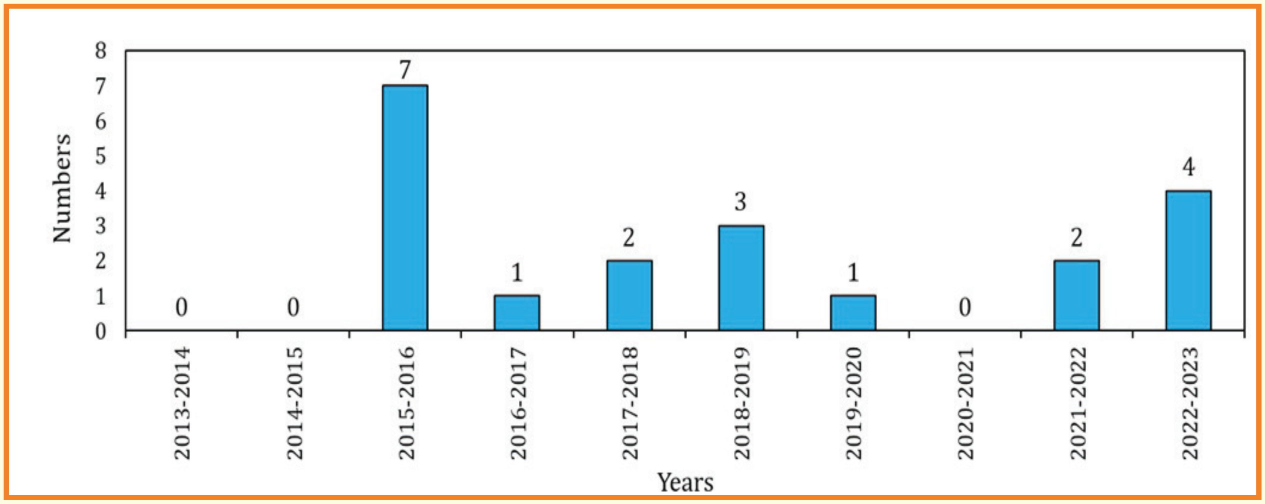
National Institute of Hydrology publishes its research output in the form of various type of reports, books, chapters in books, research papers in peer reviewed International and National Journals; and in International and National conferences/ symposia, seminars, workshops, etc.

During the last ten years from 2013-14 to 2022-23, the Institute has published total 2304 publications including 264 publications during 2022-23.

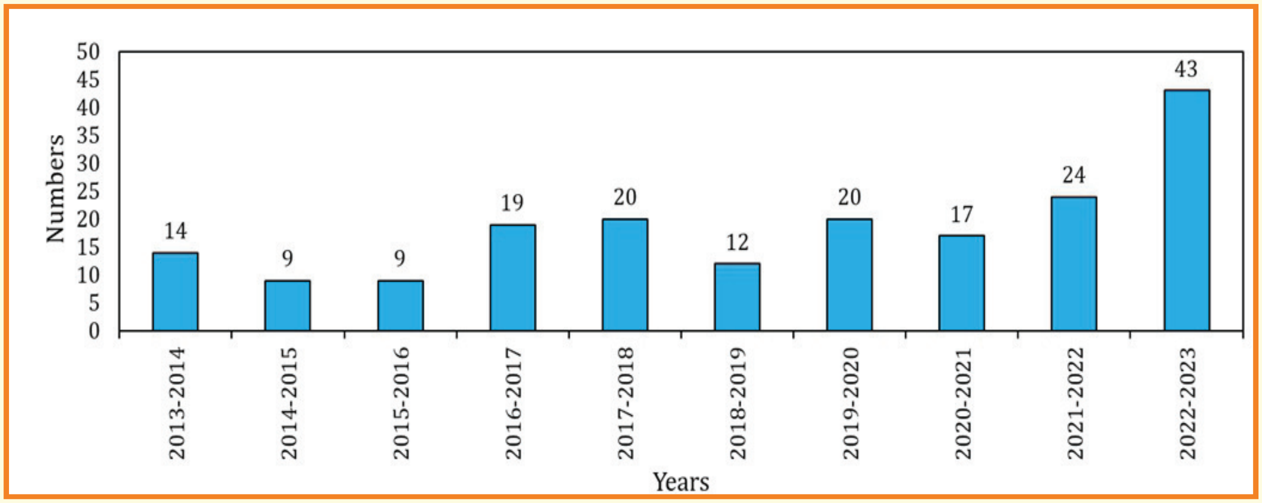


Total publications of NIH during 2013-14 to 2023-23

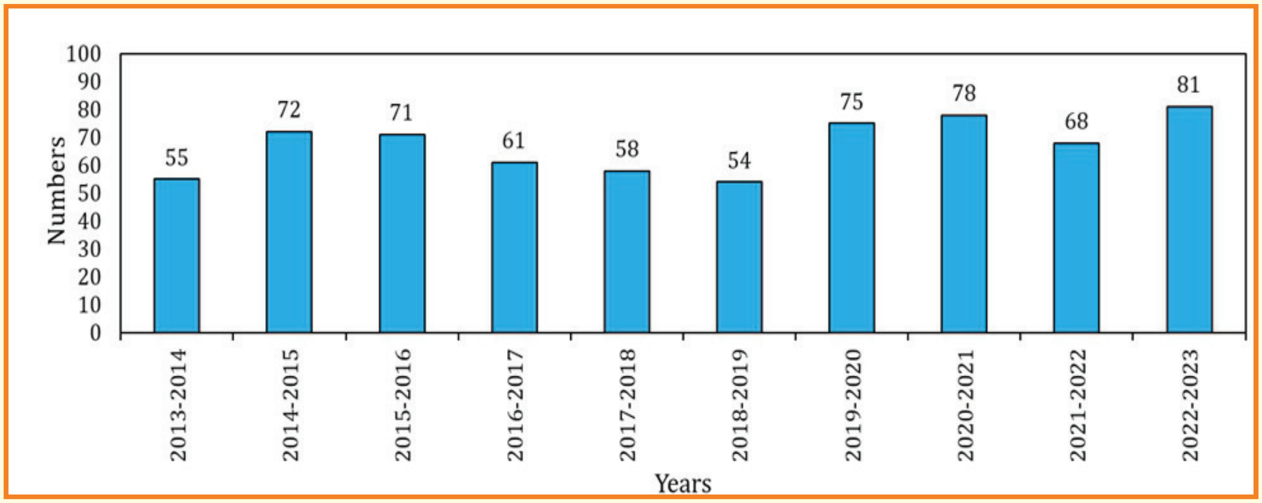
Category wise Publications during the last decade (2013-14 to 2022-23) are shown below:



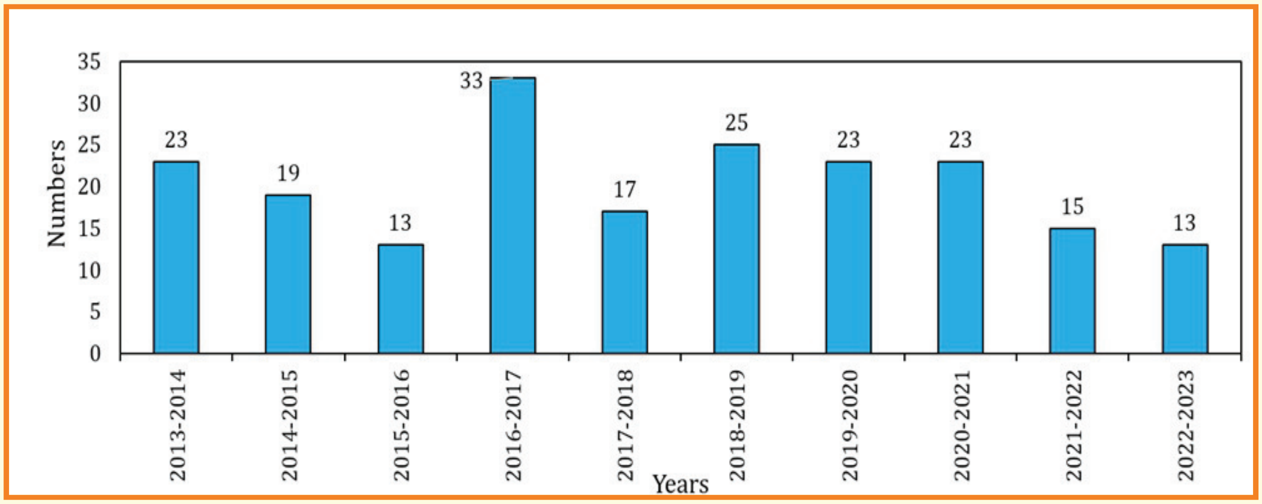
Books published during 2013-14 to 2022-23



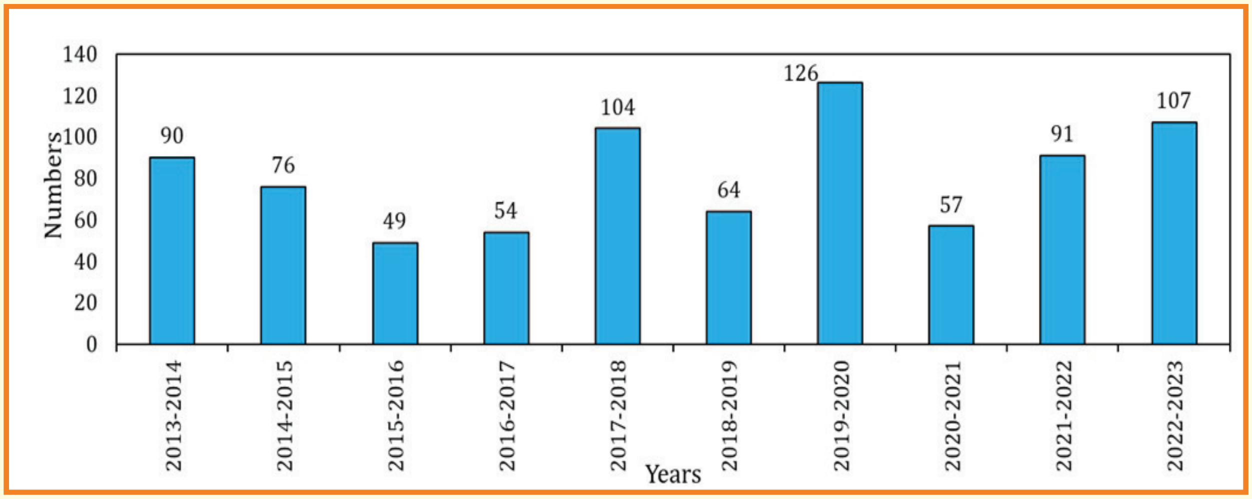
Chapters in Books published during2013-14 to 2022-23



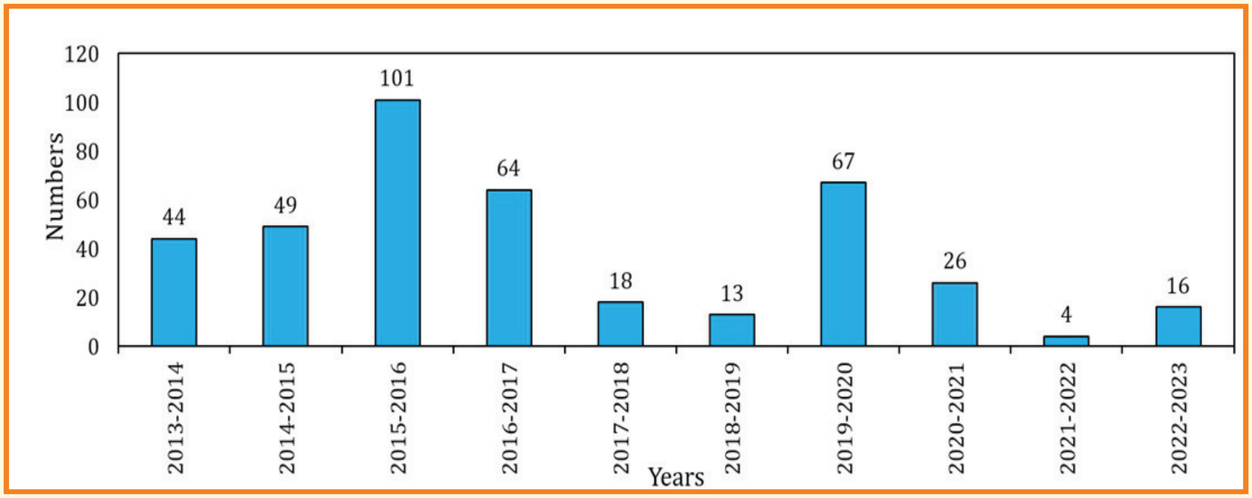
Publications in International journals during 2013-14 to 2022-23



Publications in National journals during 2013-14 to 2022-23



Publications in International conferences during 2013-14 to 2022-23



Publications in National conferences during 2013-14 to 2022-23

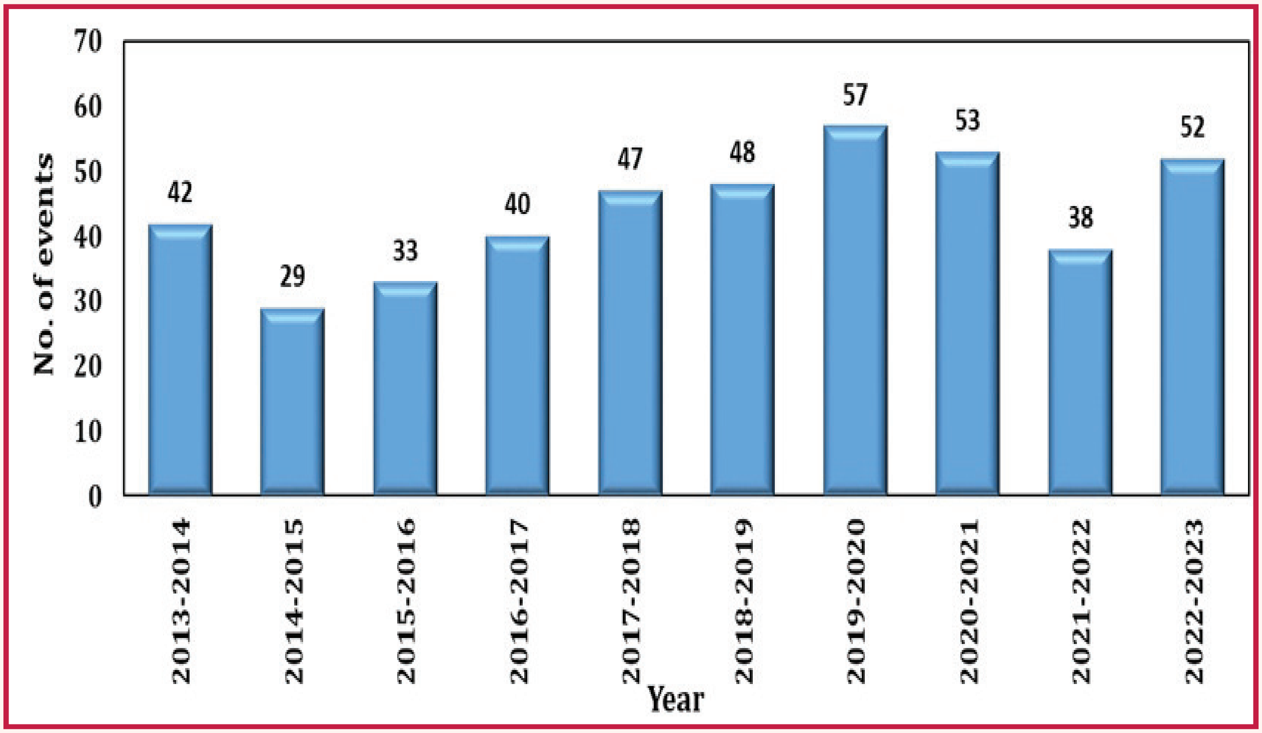
The publications of the Institute during 2022-2023

S.No.	Item	Published
1.	Books	4
2.	Chapters in Books	43
3.	International Journal	81
4.	National Journal	13
5.	International Conference/ Seminar/ Symposium	107
6.	National Conference/ Seminar/ Symposium	16
Total		**264**

The detailed list of publications during 2022-23 is given in Appendix-X.

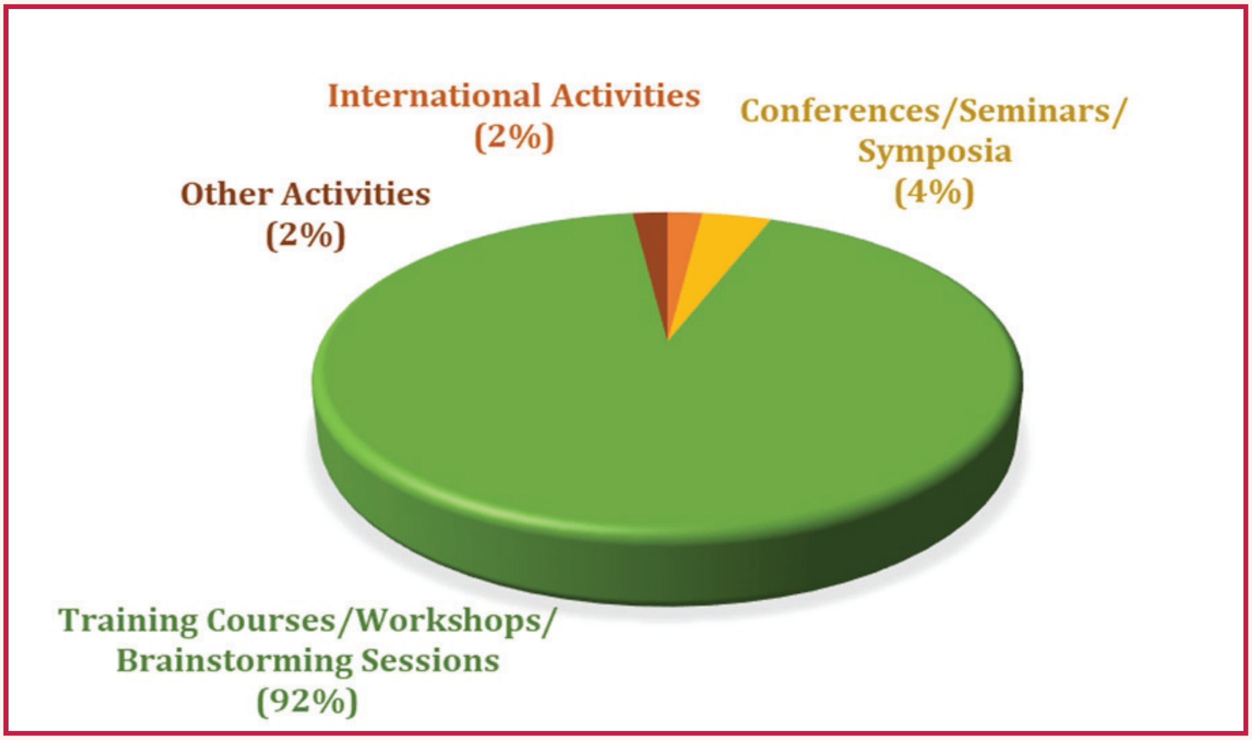
Technology Transfer 10

Technology transfer activities form an important component of the Institute's activities besides publication and circulation of reports of studies and research. The Institute has been organizing International and National level conferences/ seminar and short duration workshops/ brainstormings/training courses etc. dealing with specialized areas in hydrology for transfer of relevant theoretical knowledge as well as methodologies, including computer programmes, to the field engineers of Central and State Government organisations in the country, academicians, students and practitioners. In the last 10 years (2013-14 to 2022-23), the Institute has organized total 439 International/National activities in the form of Seminars, Symposia, Conferences, Training Courses, Workshops, Brain Storming Sessions, etc. as given in the figure below:



Technology transfer activities organised by the Institute during last 10 years from 2013-2014 to 2022-2023

During the year 2022-23, the Institute organized a total of 52number of activities, which included 1 International activity and 51 National Level activities. The National Level activities includes2 symposia/seminar/conferences, 48 training courses/workshops/brainstormingsessionsand 1 other activity at various locations throughout India. The technology transfer activities were attended by a number of field engineers, researchers, academicians, administrators etc.



Technology transfer activities organised by the Institute during 2022-2023

Detailed list of technology transfer activities carried out by NIH during 2022-23 is given at Appendix-XI.

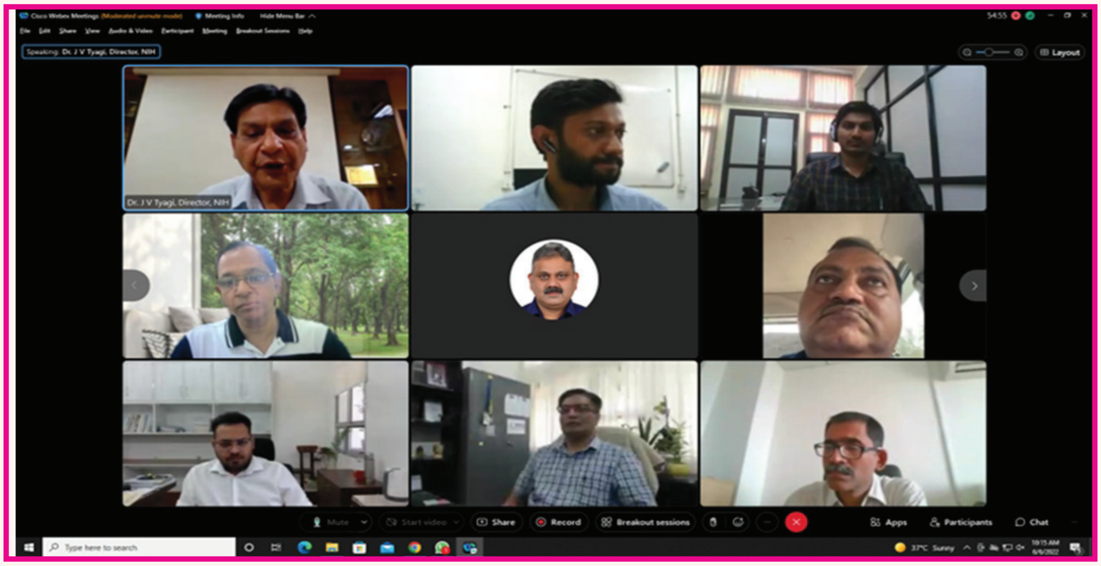
Brainstorming Session on "Water Security in a Changing Environment- Focus on Indian Himalayan Region" under INC-IHP during Uttarakhand State Science and Technology Congress at Graphic Era (Deemed to be University), Dehradun on22 June 2022

Training Course on 'Water Quality Monitoring & Management', February13-17, 2023at NIH, Roorkee

SERB Sponsored High-End Workshop on "Challenges in Water-Related Disasters Risk Reduction: Vulnerability, Adaptation and Resilience Techniques", 16-21Jan. 2023 at NIH, Roorkee

Training Course on "Application of Water Accounting Plus (WA+) Tool for Water Resources Management", 28 Nov-02 Dec, 2022, Kohima, Nagaland

Special Session for Young Professionals on "Water Security for Sustainable Development with Equity" in 7th India Water Week-2022 (03.11.2022) at IEC, Greater Noida



Online training on "Approaches for Management of Groundwater Quantity and Quality with special focus on MAR", 06-10 June, 2022, jointly organized by NIH and IIT Roorkee

Training Course on Analyzing Hydro-Meteorological Data Using R Programming Language, March 17, 2023 at RC, Jammu

Training programme on "Life cycle approach for rejuvenation of ponds and lakes using nature based solutions", under NWM, 13-17 March 2023 at RC, Kakinada

11 Important Meetings and Visits

Activities of the National Institute of Hydrology are managed by various committees. A number of meetings of these committees are held every year. The Institute is also actively involved in various National and Regional committees constituted by various Ministries and Departments. A number of scientists of the Institute have representation in many such national and state-level committees. A number of national and international dignitaries and experts visit the Institute every year for various technical and official purposes. Similarly, scientists of the Institutes also visit abroad for various technical purposes. The status of important meetings held, representation of NIH in national and regional committees, dignitaries who visited NIH and visits abroad by NIH scientists for the year 2022-23 are given below:

Important Meetings Held

Following important meetings were organized by NIH and its regional centres during the year 2022-23:

Important Meetings Held during 1 April 2022 – 31 March 2023

Sl. No.	Date	Meeting	Venue
1.	April 12-13, 2022	52nd Working Group meeting of NIH	NIH, Roorkee
2.	April18, 2022	Online Review meeting to discuss Budget for current year followed by the discussions on "Vision 2047" under the Chairmanship of Secretary, DoWR, RD & GR	DoWR, RD & GR Through Virtual Mode
3.	April 21-22, 2022	Assessment Promotion Board meeting for assessment promotion of NIH Scientist D to Sc.E, Sc. E to Sc.F& Sc. F to Sc. G under the Chairmanship of Chairman, CWC	CWC, New Delhi
4	April 25, 2022	Online meeting for holding discussion by JS(A, IC & GW), DoWR, RD & GR on setting up of cryosphere centre and NIH-North West India Hydrology Cetnre at Jodhpur	
5.	April 26, 2022	•Meeting under the Chairmanship of JS(A&Parl) to review the arrangements for the Study-Visit of the Standing Committee on Water Resources to Rishikesh, Auli (Badrinath) and Guptkashi (Kedarnath) during 19-23 May 2022. •Online Meeting regarding Release of funds to the Autonomous / Statutory Bodies, etc. through TSA. •Online meeting for technical Committee on the revised DSR of Bihar (SSAP).	Virtual mode DoWR, RD & GR, New Delhi

6.	April 27-28, 2022	Chaired Thirteenth R&D Session on PDS through virtual platform	NIH Roorkee
7.	May4-5, 2022	Chaired 21^{st} Regional Coordination Committee meeting of NIH-CFMS, Patna	NIH-CFMS, Patna
8.	May 8-11, 2022	Chaired Regional Coordination Committee meeting of CIH RC, NIH, Bhopal Discussion with Scientists and staff of CIHRC, Bhopal on various issues क्षेत्रीय केंद्र, भोपाल और जल संसाधन विभाग, मध्य प्रदेश में परस्पर सहयोग और सहभागिता बढ़ाने एवं संभावित अध्ययनों के बारे में जल संसाधन विभाग के अधिकारियों के साथ चर्चा कोलार डैम की विजिट तथा कोलार डैम के कमांड एरिया में संस्थान द्वारा किए जा रहे अध्ययनों पर डैम के अधिकारियों से चर्चा	CIHRC, Bhopal
9.	May 19, 2022	To make presentation on 'Inventorization and Revival of Springs' in the Workshop -cum-Orientation Program under Jal Shakti Abhiyan: Catch the Rain-2022 Campaign	Bhim Auditorium, Dr.Ambedkar Int. Centre, N Delhi
10.	May 25-27, 2022	Module wise DSS (PM) meetings on the current status of model development	Hybrid Mode
11.	May 27, 2022	26^{th} Regional Coordination Committee (RCC) of Western Himalayan Regional Centre, Jammu, NIH	WHRC, Jammu
12.	May 3, 2022	Meeting to discuss the issues related with 'Hydrological Studies in BadrinathDham' under the Chairmanship of Secretary, DoWR, RD & GR	DoWR, New Delhi
13.	June 3-4, 2022	5^{th} World Bank Mission / Review Implementation Support under NHP – zone wise	
14.	June 6, 2022	Inaugurated the training program on "Approaches for management of Groundwater Quantity and Quality with special focus on MAR (6-10 June 2022) as Chief Guest and addressed the function of inaugural session on 6 June 2022	Jointly by NIH & IIT Roorkee
15.	June 7, 2022	The Soil Moisture India Network (SMIN) Steering Committee meeting	NPMU-NHP, New Delhi
16.	June 9-16, 2022	• Chaired 32^{nd} Regional Coordination Committee meeting of Hard Rock Regional Centre, Belagavi (10.6.2022) • Meeting with Chief Engineer, HerangiIrrig. Project; • Visit Krishna NagarjunaSagar Dam, Mysore • 1^{st} Review meeting of the Expert Committee for	CGWB, Bangalore NCESS, Thiruvananthapuram

		implementation of the R&D program on "SGD-Phase-II"	
17.	June 23-25, 2022	Chaired 17th meeting of Regional Coordination Committee (RCC) of NIH-NERC, Guwahati	NERC, Guwahati
18.	June 27, 2022	Meeting on establishment of Centre for Cryosphere and Climate Change studies in NIH, Roorkee under the Chairmanship of JS&FA, DoWR, RD & GR	S S Bhawan, New Delhi
19.	June 28, 2022	Online Meeting on GLIS Portal under the Chairmanship of Secretary, DoWR, RD & GR	Virtual mode
20.	July 5, 2022	31st Regional Coordination Committee meeting of DRC, Kakinada	DRC, NIH, Kakinada
21.	July 5, 2022	4th meeting of National Level Steering Committee of NHP and Wrap-up of 5th World Bank Mission meeting	New Delhi
22.	July 7, 2022	Meeting to discuss on draft model bill on Integrated Water Resources Management under the Chairmanship of Secretary, DoWR, RD & GR	Shram Shakti Bhawan, N Delhi
23.	July 11, 2022	Technical Committee meeting for SSAP, Uttar Pradesh	
24.	July 13, 2022	Fourth six monthly review meeting of PEG of AICRP-14 of ICFRE Technical Committee meeting for SSAP, Rajasthan State	ICFRE In Virtual mode Virtual mode
25.	July 18, 2022	Meeting taken by Joint Secretary (A, IC & GW), DoWR, RD & GR, MoJS to discuss the establishment of proposed regional centre of NIH named "North West India Hydrology Regional Centre" at Jodhpur	Shram Shakti Bhawan, New Delhi
26.	July 25, 2022	2nd meeting of the National Review Committee of SGD Phase-II project	Virtual mode
27.	July 27, 2022	Review meeting with DHI-India on DSS (PM) modules	Hybrid Mode
28.	Aug. 5, 2022	To present the draft books before Hon"ble Union Minister of Jal Shakti, Govt. of India prepared by NIH on "A Resurgent Bharat during Freedom Struggle: The Water Story (1800-1947)" and "Hydrological Knowledge in Ancient India"	Shram Shakti Bhawan, N. Delhi
29.	Aug. 25, 2022	Review meeting reg. position of vacancies and action being taken to fill up the vacant posts in NIH under the Chairmanship of Secretary (WR)	Chamber, Secy. DoWR, RD & GR, New Delhi
30.	Aug. 29, 2022	76th Technical Advisory Committee meeting	NIH, Roorkee

Important Meetings by Dr.Sudhir Kumar (Director) during 2022-23

Sl. No.	Date	Meeting	Venue
1.	Aug. 30, 2022	• 21st Meeting of the "Sub Committees on System Studies for identification of most appropriate alternative plan" • Online meeting of Steering Committee of SSAP for the States of Bihar, Madhya Pradesh and Chandigarh under the Chairpersonship of Additional Secretary & Mission Director, NWM, DoWR, RD & GR	NIH, Roorkee Virtual mode
2.	Sep. 1, 2022	G-20 meeting under the Chairmanship of Secretary, DoWR, RD & GR, Ministry of Jal Shakti	New Delhi
3.	Sep. 6, 2022	Online meeting to review the progress of Capital expenditure taken by JS & FA, DoWR, RD & GR	Virtual
4.	Sep. 13, 2022	Meeting on Special Campaign 2.0 under the Chairmanship of Secretary, DoWR, RD & GR and 4th meeting to review & finalize the activities to be undertaken in DoWR, RD & GR during India"s G-20 Presidency under the Chairpersonship of Additional Secretary, DoWR, RD & GR	New Delhi AS (WR) Chamber, DoWR, New Delhi
5.	Sep. 14, 2022	Meeting convened with NHP officials	NIH, Roorkee
6.	Sep. 15, 2022	Online Review meeting regarding expenditure under the Chairmanship of Secretary, DoWR, RD & GR	Virtual
7.	Sep. 16, 2022	Online meeting with High Court officials	Virtual
8.	Sep. 19, 2022	Chaired Plenary Session-III of International Conference on Climate and Weather-related Extremes (ICCWE)-2022	IIT Roorkee
9.	Sep. 20, 2022	5th meeting of Scientific Committee of 7th India Water Week (IWW 2022) under the Chairmanship of Chairman, CWC	CWC, New Delhi
10.	Sep. 21, 2022	Online meeting on Special Campaign 2.0 under the Chairmanship of Secretary, DoWR, RD & GR	Virtual
11.	Sep. 24-28, 2022	Visit to project site regarding Hydrological study of BadrinathDham	Badrinath
12.	Sep. 29, 2022	Online meeting to review the budgewt allocation vis-à-vis progress of expenditure by NWM and R&D under the Chaipersonship of AS & MD, NWM	Virtual
13.	Sep. 30, 2022	84th meeting of Official Language Implementation Committee	NIH, Roorkee

14.	Oct. 10, 2022	22nd meeting of Reservoir & Lakes Sectional Committee, WRD-10 Pursue NIH cases at DoWR, RD & GR	White Room, BIS HQ, New Delhi DoWR, New Delhi
15.	Oct. 11, 2022	Review meeting on online mode taken by Secretary, DoWR, RD & GR to discuss on the issues e.g. a) Expenditure Review, b) Pending PMO/VIP References, c) Public Grievances cases, d) Parliament assurance & e) Discussion on key issues that emerged out in Council of Ministers held on 29.9.2022.	DoWR, RD & GR
16.	Oct. 15-17, 2022	Discussion with officials of Irrig. Dept. reg. project entitled "Changing the fate of Hindon river by welweting the impact of agriculture on the water balance: developing for a cleaner Ganga River" Finalization of G&D sites of River Hindon along with Irrigation Deptt. Officers and discussion with cGanga officials at New Delhi	Jani Escape, Mohan Nagar
17.	Oct. 19, 2022	Review meeting of 7th India Water Week (IWW 2022) under the Chairpersonship of Additional Secretary, DoWR, RD & GR, Ministry of Jal Shakti	DoWR, RD & GR, New Delhi
18.	Oct. 20, 2022	Meeting with DHI-India, IIT, Hyderabad and Vassar Lab IT team on usage of APIs in DSS (PM) software	Virtual Mode
19.	Oct. 27, 2022	Meeting on Campaign 2.0 under the Chairmanship of Secretary, DoWR, RD & GR	Virtual mode
20.	Oct. 29, 2022	83rd meeting of Governing Body of NIH chaired by Secretary, DoWR, RD & GR	New Delhi
21.	Nov. 1, 2022	Activities under India Water Week (IWW 2022) at Greater Noida	Greater Noida
22.	Nov. 2, 2022	• Panellist in India Water Week 2022 • CED 56-Hill Area Dev. Engineering, BIS meeting	Greater Noida/ ManakBhawan, New Delhi
23.	Nov. 3, 2022	Chaired Special Session for Young Professionals under India Water Week 2022 Chief Guest for Prize Distribution under India Water Week 2022	Greater Noida
24.	Nov. 4, 2022	Online meeting on Badrinath Project	Virtual
25.	Nov. 04, 2022	Chief Guest of IGWC Working Group at IIT Roorkee	IIT Roorkee
26.	Nov. 7, 2022	Valedictory function of Vigilance Awareness Week (VAW) organized by NIH	NIH, Roorkee
27.	8.11.2022	Meeting with UK Tourism officials regarding Badrinath Project	NIH, Roorkee

28.	Nov. 11, 2022	5th Meeting regarding G-20 under the Chairpersonship of Special Secretary, DoWR, RD & GR Meeting reg. Tibet Glacier under the Chairmanship of Secretary, DoWR, RD & GR	DoWR, RD & GR, New Delhi -do-
29.	Nov. 14, 2022	DPC meeting for promotion to the post of Scientist B at NIH	NIH, Roorkee
30.	Nov. 17-20, 2022	Panellist in the Plenary Session on "Springshed Management" at Tezpur to ensure water security in Indian Himalayan Region" and Workshop on Springshed Management, jointly organized by NIH with NERIWALM	NERIWALM, Tezpur
31.	Nov. 23, 2022	Online meeting the Committee reg. NIQUM Meeting reg. DST NWO project on River Hindon with the officials of The Netherlands and IIT Kanpur	Virtual NIH, Roorkee
32.	Nov. 24, 2022	Meeting with the official of CPWD reg. Settlement of advance Valedictory function of SDC activity	NIH, Roorkee
33.	Nov. 25, 2022	Pledge of Constitution Day was administered to all employees of NIH, Roorkee Departmental Promotion Committee meeting for promotion to the post of Assistant	NIH, Roorkee In Hybrid mode
34.	Nov. 29, 2022	Online meeting of Ground Water Resource Estimation Committee to review and revise Ground Water Estimation Methodology 2015 (GEC 2015)	Virtual
35.	Nov. 30, 2022	Online meeting on SSAP under the Chairpersonship of Special Secretary, DoWR, RD & GR	Virtual
36.	Dec. 1, 2022	• 4th Steering Committee meeting of Soil Moisture India Network and Stakeholders meeting • Meeting to review the VIP/PMO references, Public Grievances, Parliamentary assurances and expenditure	DoWR, RD & GR, New Delhi NPMU Committee room, N Delhi
37.	Dec. 14, 2022	Meeting of the Committee on NAQUIM 2.0 in online mode	CGWB
38.	Dec. 16, 2022	45th Foundation Day Celebrations and Technical Sessions	NIH, Roorkee
39.	Dec. 19-20, 2022	Modellers Meet under NHP	BY NIH with NPMUat New Delhi
40.	Dec. 21. 2022	Online meeting on Western Ghats	DoWR, RD & GR, New Delhi

41.	Dec. 22, 2022	Training course organized on "SCIENTIFIC DATA COLLECTION AND PROCESSING TECHNIQUES FOR Springshed Management And Rejuvenation" during 19 to 22 Dec., 2022 at Irrigation Research Institute (IRI), Roorkee under NHP.	IRI, Roorkee
42.	Jan. 5-6, 2023	'1st All India Annual State Ministers Conference on Water' with the theme 'Water Vision"2047' organized by National Water Mission, Ministry of Jal Shakti	Jahangirabad, Bhopal
43.	Jan. 30, 2023	Meeting to review progress of draft model bill on Integrated Water Resources Management under the Chairmanship of Secretary (WR, RD & GR) Inception Workshop for the project Built Water Storage in South Asia	DoWR, RD & GR, New Delhi Hotel Taj Palace, New Delhi
44.	Jan. 31, 2023	• Meeting to review the status of pavilion to be installed at Mahatma Mandir Convention & Exhibition Centre during 2nd G20 Environment & Climate Sustainability Working Group (ECSWG) meeting in Gandhinagar (held during 27-29.3.2023) and finalize the draft communique under the Chairpersonship of Special Secretary, DoWR, RD & GR • 1st meeting of the Committee constituted for Spring-shed mapping of Indian Himalayan Region including mountainous regions of the country and Spring shed based wastershed management plan in those areas under the Chairmanship of Joint Secretary (A, IC & GW), DoWR, RD & GR	Committee Room, S SBhawan, New Delhi Committee Room, Labour & Employment at S SBhawan, New Delhi
45.	Feb. 15-17, 2023	• DST-NWO Hindon River Rejuvenation Workshop • 15th R&D Session on PDS under the Chairmanship of Director, NIH for review of approved PDS by the Sub-Committee on PDS • Discussion on approach for 8th India Water Week in the context of 7th IWW under the Chairmanship of Secretary, DoWR, RD & GR • Pursued the pending cases of NIH with DoWR, RD & GR	cGanga Office, New Delhi CWC, New Delhi Shram Shakti Bhawan, New Delhi
46.	Feb. 20, 2023	1st meeting of the National Level Steering Committee on World Bank assisted "Rejuvenation Watershed for Agricultural Resilience through Innovative Development (REWARD)" programme under the Chairmanship of Secretary, Dept. of Land Resource.	DoLR, NirmanBhawan, New Delhi
47.	Feb. 28, 2023	Meeting with DHI-India on DSS (PM) updates and groundwater connector	Virtual Mode

48.	Mar. 13, 2023	Second meeting of steering committee on "Springshed Mapping of Indian Himalayan Region Including Mountainous Regions of the Country and Springshedbased Watershed Management Plan"constituted by DoWR, RD&GR, Ministry of Jal Shakti	ShramShatiBhawan, Ministry of Jal Shakti, New Delhi
49.	Mar. 16 - 17, 2023	53rd meeting of Working Group of NIH	NIH
50.	Mar. 17-18, 2023	Stakeholder Meeting-cum-Workshop on 'The study of Ground Water Quality Dynamics with special reference of Arsenic Toxicity in Groundwater regime in and around Ghaghra basin' under NHP	Civil Engg., Shri Ram Swarup Memorial Univ., Lucknow
51.	Mar. 19-22, 2023	• Workshop of GRACERS. • Meeting of Assessment Promotion Board for promotion of Sc. E, Sc. F & Sc. G and Selection Board for direct recruitment of Sc. F under the Chairmanship of DG, IMD. • Discussion with Secretary, DoWR, RD & GR, MoJS reg. Brain Storming Session on 'Glacier studies' and pursued NIH matters at DoWR, RD & GR.	IITB, Mumbai CWC, Committee Room, New Delhi Shram Shakti Bhawan, New Delhi
52.	Mar. 26-30, 2023	2nd G20 Environment & Climate Sustainability Work Group (ECSWG)	Gandhinagar (Gujarat)

REPRESENTATION IN NATIONAL, REGIONAL AND OTHER COMMITTEES:

During the year 2022-23, scientists of the Institute participated and contributed in meetings of various national, regional and other Committees. The details of some of such committees are as follows:

S.N.	NAME OF THE COMMITTEE	MEMBER FROM NIH	ROLE	MINISTRY/ DEPARTMENT
1.	Preparation of India's Adaptation Communication on the Himalayan Ecosystem Sectoral Working Group on April 11, 2022	Dr. M.K. Goel, Scientist 'G'	Member	DST, Delhi
2.	Project Monitoring Committee of CWC for consultancy of Extended Hydrological Prediction (Multi-week Forecast) for Yamuna, Narmada and Cauvery basins under NHP on May 02, August 05, November 18, November 28 and December 07, 2022	Dr. M.K. Goel, Scientist 'G'	Member	CWC, Delhi
3.	Decision Support System (Planning & Management) meet on May 25, 2022	Dr. M.K. Goel, Scientist 'G'	Member	NIH, Roorkee
4.	Interview for the post of Chief Civil Hydrographic Officer on June 02, 2022	Dr. M.K. Goel, Scientist 'G'	Invitee	UPSC

5.	Meet of DoWR, RD&GR related to Special Campaign 2.0 for Swachhta Pakhwada, September 27, 2022. Made presentation on the outcome of M-G Link project (Phase-II)	Dr. M.K. Goel, Scientist 'G'	Invitee	DoWR, RD&GR, New Delhi
6.	Meetings of the Sub-committee on System Studies for identification of most appropriate alternative plan, organized by NWDA on August 30, 2022 and January 20, 2023	Dr. M.K. Goel, Scientist 'G'	Invitee	NWDA, Delhi
7.	22nd meet of Reservoirs and Lakes Sectional Committee of BIS (WRD 10) on October 10, 2022 through VC	Dr. M.K. Goel, Scientist 'G'	Member of WRD-10	BIS, Delhi
8.	Meet of GWHD Scientists with the students and faculty from Purdue University, USA on January 04, 2023	Dr. M.K. Goel, Scientist 'G'	Invitee	NIH, Roorkee
9.	Roorkee Water Conclave -2024 meet with IIT, Roorkee on February 03, 2023	Dr. M.K. Goel, Scientist 'G'	Member	IIT, Roorkee
10.	India-Australia cooperation in the field of Water Resource Management	Dr. A.K. Lohani, Scientist 'G'	Member	MoJS, New Delhi
11.	State Ganga Rejuvenation, Protection and Management Committee for the State of Uttarakhand	Dr. A.K. Lohani, Scientist 'G'	Member	-
12.	High Level Review Committee for Flood Forecasting and Inundation mapping Model for Rapti Basin in U.P.	Dr. A.K. Lohani, Scientist 'G'	Expert Member	-
13.	Expert Group for Preparation of Flood Hazard Atlas, NDMA, New Delhi	Dr. A.K. Lohani, Scientist 'G'	Member	-
14.	Regional Committee for Scientific Assessment of Flood Prone Areas in Odisha	Dr. A.K. Lohani, Scientist 'G'	Expert Member	-
15.	Sub-committee for Hydro-met Equipment under National Hydrology Project	Dr. A.K. Lohani, Scientist 'G'	Member	-
16.	DSS (PM) review Committee under NHP	Dr. A.K. Lohani, Scientist 'G'	Member	-
17.	Task Force of Experts for Preparation of Guidelines for Management of Glacial Hazards and Risks especially Glacial Lake Outburst Floods (GLOFs), NDMA	Dr. A.K. Lohani, Scientist 'G'	Member	NDMA
18.	Joint Committee constituted for flood Plain of Mahanadi River at Cuttack by Hon'ble NGT with its order dated 15.12.2020 in OA No. 22/2020(EZ)	Dr. A.K. Lohani, Scientist 'G'	Member	Hon'ble NGT

19.	Uttarakhand Flood Committee	Dr. A.K. Lohani, Scientist 'G'	Member	-
20.	Committee for formulation of Strategy for Flood Management Works in the entire country and River Management Activities and Work related to Border Areas	Dr. A.K. Lohani, Scientist 'G'	Member	-
21.	Monitoring Committee for Haora Riverfront Development Project, Agartala Smart City Ltd.	Dr. A.K. Lohani, Scientist 'G'	Member	-
22.	Mini Hydel Projects on Bhakra Main Line Canal, Ministry of New and Renewable Energy, Govt. of India	Dr. A.K. Lohani, Scientist 'G'	Member	Ministry of New and Renewable Energy, Govt. of India
23.	Programme Advisory Committee (PAC)-Earth & Atmospheric Sciences (E&AS) of Science and Engineering Research Board (SERB)	Dr. A.K. Lohani, Scientist 'G'	Member	Science and Engineering Research Board (SERB)
24.	Joint Committee in compliance to the Hon'ble National Green Tribunal (NGT) Order dated 07.02.2022 in the matter of Pradip Kumar Pattnaik vs. Union of India & Ors. in OA No. 68/2020(EZ) Mahanadi Flood Plain Cuttack	Dr. A.K. Lohani, Scientist 'G'	Member	Hon'ble NGT
25.	Joint Committee constituted by the Hon'ble NGT (ONA 433/2022) to demarcate the flood plain zone on the left and right banks of Suav river in Urban Municipal Limits of Balrampur City, U.P.	Dr. A.K. Lohani, Scientist 'G'	Member	Hon'ble NGT
26.	Study to analyses carrying capacity of Ratmau and Solani rivers in order to transfer water to Shukratal, U.P.	Dr. A.K. Lohani, Scientist 'G'	Member	-
27.	Committee constituted by the Hon'ble NGT (IA No. 99/2022) to demarcate the flood plain zone at Moga Resort Rishikesh, Uttarakhand	Dr. A.K. Lohani, Scientist 'G'	Member	Hon'ble NGT
28.	State Committee on Dams Safety for the dams of Maharashtra (Maharashtra State Govt. Gazette, Dated-15.06.2022 and 22.06. 2022)	Dr. A.K. Lohani, Scientist 'G'	Member	Govt. of Maharashtra
29.	State Committee on Dams Safety for the dams of Uttar Pradesh (UP State Govt. Gazette, Dated 18.06. 2022)	Dr. A.K. Lohani, Scientist 'G'	Member	Govt. of U.P.

30.	State Committee on Dams Safety for the dams of Gujarat (Gujarat State Govt. Gazette, Dated 14.12. 2021)	Dr. A.K. Lohani, Scientist ‘G’	Member	Govt. of Gujarat
31.	State Committee on Dams Safety for the dams of Andaman and Nicobar Islands	Dr. A.K. Lohani, Scientist ‘G’	Member	-
32.	Departmental promotional Interview Committee of National Remote Sensing Centre (NRSC) Hyderabad 30.05.2022 (in online mode from IIRS, Dehradun)	Dr. A.K. Lohani, Scientist ‘G’	External Member	IIRS, Dehradun
33.	Experts for upgradation of JRF to SRF in the Department of Mathematics, IIT, Roorkee and Examiner of M. Tech. for Department of Hydrology and WRDM, IIT, Roorkee	Dr. A.K. Lohani, Scientist ‘G’	Expert	IIT, Roorkee
34.	Assessment Committee to consider promotion Cases of ASRB Scientists	Dr. R.P. Pandey, Scientist ‘G’	Chairman	ICAR-IISWC, Dehradun
35.	High Level Technical Committee for evaluation of Red Oil Palm cultivation in Andaman. Committee formulated on the direction of Hon’ble Supreme Court	Dr. R.P. Pandey, Scientist ‘G’	Member	MoEF& CC, GoI, New Delhi
36.	Project Appraisal Committee, Chemical & Environmental Engg. (PAC-CEE) of SERB	Dr. R.P. Pandey, Scientist ‘G’	Member	Department of Science and Technology (DST), New Delhi
37.	Project Appraisal Committee, Environmental Engg. (PAC) of SERB-POWER	Dr. R.P. Pandey, Scientist ‘G’	Member	Department of Science and Technology (DST), New Delhi
38.	State Level Scheme Sanction Committee	Dr. R.P. Pandey, Scientist ‘G’	Member	Jal Jeevan Mission, Uttarakhand
39.	Expert Committee for assessment of drinking water source sustainability for Karnataka	Dr. R.P. Pandey, Scientist ‘G’	Member	National Jal Jeevan Mission, DDWS, MoJS, GoI
40.	Member of NGT appointed committee for evaluation of Oussudu Lake, Pondicherry	Dr. Y.R.S. Rao, Scientist ‘G’	Member	Hon’ble NGT
41.	Association of Hydrologist of India (AHI) for a period of three years (2020-2023)	Dr. Y.R.S. Rao, Scientist ‘G’	Executive body member	Association of Hydrologists of India (AHI)
42.	Member for BIS on Coastal Zone Water Management Sectional Committee, WRD 28	Dr. Y.R.S. Rao, Scientist ‘G’	Member	Bureau of Indian Standards (BIS), New Delhi

43.	Review Committee member for Ph.D thesis on "Application of Optimization Techniques and Machine Learning Algorithms to DRASTIC and DRASTIC-L for Groundwater Vulnerability Assessment and mapping"	Dr. Y.R.S. Rao, Scientist 'G'	Ph.D review committee member	NIT, Tiruchirapalli
44.	National Symposium cum workshop on Springshed management on November 10, 2022	Dr. S.V. Vijaya Kumar, Scientist 'G'	Co-organiser	NERIWALM, Tezpur
45.	28th General Body meeting Hybrid Mode (online/offline) of WALMI Society on June 28, 2022	Dr. B. Venkatesh, Scientist 'G'	Invitee	WALMI Society, Dharwad
46.	37th TAC of CWPRS at CWPRS Pune chaired by Chairman, CWC, New Delhi on September 29,2022	Dr. B. Venkatesh, Scientist 'G'	Invitee	CWPRS, Pune
47.	53rd Governing Council meeting of WALMI Society on January 16, 2023	Dr. B. Venkatesh, Scientist 'G'	Invitee	WALMI Society, Dharwad
48.	Western Ghats Eco-sensitive Area meeting under the Chairmanship of Shri Sanjay Kumar (IFS Retd.) former DGF&SS, MoEF&CC Governments of Western Ghats region on December 21, 2022	Dr. B. Venkatesh, Scientist 'G'	Invitee	Govt. of Karnataka
49.	Technical Advisory Committee	Mr. B. Chakravorty, Scientist 'G'	Member	FMISC, WRD, Govt. of Bihar
50.	Regional Committee for scientific assessment of flood-prone areas in the states of West Bengal and Bihar	Mr. B. Chakravorty, Scientist 'G'	Member	Central Water Commission (CWC), DoWR, RD&GR, MoJS, Govt. of India
51.	Standing Review Committee to review different reports of water resources projects funded by the World Bank	Mr. B. Chakravorty, Scientist 'G'	Member	WRD, Govt. of Bihar
52.	Bihar State Wetland Development Authority	Mr. B. Chakravorty, Scientist 'G'	Member	Govt. of Bihar
53.	State Resource Group (SRG) for Environment & Climate Change Division, Bihar State Disaster Management Authority	Mr. B. Chakravorty, Scientist 'G'	Member	BSDMA, Govt. of Bihar
54.	Indian National Committee on Ground Water (INCGW)	Dr. Anupma Sharma, Scientist 'G'	Member	CGWB, New Delhi

55.	Accreditation Board for Granting Accreditation to Groundwater Professionals	Dr. Anupma Sharma, Scientist 'G'	Member	CGWB, New Delhi
56.	Ground Water Consultant Organizations Accreditation Committee, NABET – Quality Council of India	Dr. Anupma Sharma, Scientist 'G'	Member	Quality Council of India, New Delhi
57.	Working Group for Identification of 5G Use Cases and its Adaptation in Water Resources Sector	Dr. Anupma Sharma, Scientist 'G'	Member	NWIC, New Delhi
58.	Committee for preparation of DPR & New Scheme for Salinity Ingress Management Projects and Setting up of National Centre for Scientific Study of Salinity Ingress in Delta Regions	Dr. Anupma Sharma, Scientist 'G'	Member	CWC, New Delhi
59.	Ground Water and Related Investigation Sectional Committee, WRD 03	Dr. Anupma Sharma, Scientist 'G'	Member	Bureau of Indian Standards (BIS), New Delhi
60.	Central Level Expert Group (CLEG) for Periodic Re-assessment of Ground Water Resources of the Country	Dr. Anupma Sharma, Scientist 'G'	NIH Representa tion	CGWB, New Delhi
61.	Technical evaluation Committee for "Study on the issue of Flood and Siltation in River Ganga and its Tributaries due to Farakka Barrage in the state of Bihar"	Dr. Pankaj Mani, Scientist 'G'	Member	Central Water Commission (CWC)
62.	Task Force for review of 'R0' draft (being prepared by an in-house working group) of the revised guide and preparation of 'R1' draft towards revision of the AERB Safety Guide No. AERB/SG/S-6A	Dr. Pankaj Mani, Scientist 'G'	Member	Atomic Energy Regulatory Board (AERB), Govt. of India
63.	Regional Committee for scientific assessment of flood-prone areas in Uttar Pradesh, Upper Ganga Basin Organisation	Dr. Pankaj Mani, Scientist 'G'	Member	CWC, DoWR, RD&GR, MoJS, GoI
64.	Expert Committee on Groundwater for Sikkim State	Dr. Surjeet Singh, Scientist 'G'	Groundwater Expert	Water Resources Department, Govt. of Sikkim
65.	Review meeting on implementation of MoU between the Government of the Republic of India and Government of the Kingdom of Morocco on Cooperation in the field of Water Resources	Dr. M.S. Rao, Scientist 'F'	Member Expert, India Representa tive	MoJS, GoI

66.	Participation in the synopsis meeting and final DC meeting of the scholar on April 20, 2022 and July 07, 2022	Dr. V.S. Jeyakanthan, Scientist 'F'	Doctoral Committee member	NIT, Tiruchirapalli
67.	Participation in the Doctoral Committee meeting for the confirmation of provisional registration of the scholar on June 03, 2022	Dr. V.S. Jeyakanthan, Scientist 'F'	Doctoral Committee member	SRM University, Chennai
68.	30th National Children's Science Congress organized by Andhra Pradesh State Council of Science and Technology at Kakinada on November 24, 2022	Dr. V.S. Jeyakanthan, Scientist 'F'	Evaluator	Ministry of Environment, Forests, Science & Technology, Govt. of Andhra Pradesh
69.	State Specific Action Plan for the Andaman Nicobar Islands	Dr. V.S. Jeyakanthan, Scientist 'F'	Coordinating Member	MoJS, New Delhi
70.	Australia India Water Centre	Dr. Archana Sarkar, Scientist 'F'	Member	Western Sydney University, Australia
71.	Board of Studies (BoS) committee of the Amity Institute of Environmental Sciences, Amity University, Noida	Dr. Archana Sarkar, Scientist 'F'	Expert Member	Amity University, Noida
72.	IFERP (Institute for Engineering Research and Publication) by invitation http://www.iferp.in/	Dr. Archana Sarkar, Scientist 'F'	Honorary Fellow Member	-
73.	VinFuture Prize	Dr. Archana Sarkar, Scientist 'F'	Official Nominator	The VinFuture Foundation, Vietnam
74.	Technical Session (TS-3b) in 9th International Groundwater Conference (IGWC-2022) during November 02-04, 2022	Dr. M.K. Sharma, Scientist 'F'	Chairman	IIT, Roorkee
75.	9th International Groundwater Conference (IGWC-2022) organized by DoH, IIT, Roorkee during November 02-04, 2022	Dr. M.K. Sharma, Scientist 'F'	Member	IIT, Roorkee
76.	Technical session of 7th Edition of India Water Impact Summit [IWIS], organized during December 15-17, 2022 at Dr. Ambedkar International Centre (DAIC), New Delhi	Dr. M.K. Sharma, Scientist 'F'	Panellist	NMCG and cGanga
77.	Public Drinking Water Services Sectional Committee, SSD 14	Dr. M.K. Sharma, Scientist 'F'	Principal member	Bureau of Indian Standards (BIS), New Delhi

78.	Advisory Committee of online International Conference on EWASH-2022: Strategizing A Greener Future during January 12-13, 2023	Dr. M.K. Sharma, Scientist 'F'	Member	Hindu College, University of Delhi and Save the Environment
79.	Expert Committee for ensuring compliance to Hon'ble NGT (PB) order dated 23.12.2021 in O.A. No. 1002/2018, Abhisht Kusum Gupta vs. State of Uttar Pradesh & Ors.- Reg.	Dr. M.K. Sharma, Scientist 'F'	Member	CPCB, Delhi
80.	Expert Committee to provide measures regarding rejuvenation of the River Hindon and its tributaries constituted by CPCB	Dr. M.K. Sharma, Scientist 'F'	Member	CPCB, Delhi
81.	Tender Evaluation Committee for procurement of Water Quality Equipments (GCMS & ICPMS) constituted by CWC, RDC-I Directorate, New Delhi	Dr. M.K. Sharma, Scientist 'F'	Member	CWC, New Delhi
82.	Steering Committee on "Springshed Mapping of Indian Himalayan Region including Mountainous Regions of the Country and Springshed based Watershed Management Plan"	Dr. S.S. Rawat, Scientist 'F'	Member-Secretary	DoWR, RD&GR, MoJS, New Delhi
83.	Board of Studies of Department of Himalayan Aquatic Biodiversity, Hemvati Nandan Bahuguna Garhwal University, Srinagar. Monitoring of Implementation of UGC Guidelines	Dr. S.S. Rawat, Scientist 'F'	Member	Hemvati Nandan Bahuguna Garhwal University, Srinagar
84.	Committee constituted by Ministry of Jal Shakti for Investigation of Joshimath Subsidence	Dr. S.S. Rawat, Scientist 'F'	Investigation member	MoJS, New Delhi
85.	Committee constituted by NGT for estimation of carrying capacity of Mussoorie town	Dr. S.S. Rawat, Scientist 'F'	Member	NGT
86.	5th Upper Indus Basin Network (UIBN) India Country Chapter meeting held virtually on May 30, 2022	Dr. P.G. Jose, Scientist 'E'	Invitee	Upper Indus Basin Network, ICIMOD
87.	2nd meeting of the Wetland Authority for the Union Territory of Jammu & Kashmir under the Chairmanship of the Chief Secretary, Jammu on August 03, 2022	Dr. P.G. Jose, Scientist 'E'	Member Nominee	Govt. of UT of Jammu & Kashmir

88.	76th Technical Advisory Committee (TAC) of National Institute of Hydrology, chaired by Chairman, Central Water Commission, GoI held in VC mode on August 29, 2022	Dr. P.G. Jose, Scientist 'E'	Invitee	NIH, Roorkee
89.	Committee on Flood Risk Management	Dr. R.V. Kale, Scientist 'E'	Member	Intl. Association for Hydro-Env.Engg. and Research (IAHR)
90.	Technical Session on Flood Risk Management at 3rd IAHR Young Professionals Congress- 2022	Dr. R.V. Kale, Scientist 'E'	Session Chair	Intl. Association for Hydro-Env. Engg. and Research (IAHR)
91.	Sub Group B-1.4 on Preparation of Draft document on Hydraulics of Bridges	Dr. R.V. Kale, Scientist 'E'	Member	Indian Roads Congress (IRC), MoRTH, GoI
92.	Hydrology Expert at U.P. State Wetland Authority	Dr. R.V. Kale, Scientist 'E'	Non-Official member	U.P. State Wetland Authority
93.	M. Tech. Thesis Evaluation	Dr. R.V. Kale, Scientist 'E'	Examiner	GBPUA&T, Pantnagar
94.	M. Tech. Thesis Evaluation	Dr. R.V. Kale, Scientist 'E'	Examiner	NIT, Jamshedpur
95.	Nominated Member of the Sectional Committee of Bureau of Indian Standards for "WRD 24: Environmental Assessment and Management of Water resources projects"	Dr. Pradeep Kumar, Scientist 'E'	Member	Bureau of Indian Standards (BIS), New Delhi
96.	Nominated Member from NIH for implementation of e-flows notification of MoJS for Ganga river from Haridwar to Unnao	Dr. Pradeep Kumar, Scientist 'E'	Member	CWC, New Delhi
97.	Nominated Member from NIH for Uttarakhand State Wetlands Authority	Dr. Pradeep Kumar, Scientist 'E'	Member	Govt. of Uttarakhand
98.	Member of Board of Studies, Department of Himalayan Aquatic Biodiversity, Garhwal University, Srinagar (Uttarakhand)	Dr. Pradeep Kumar, Scientist 'E'	Member	Hemvati Nandan Bahuguna Garhwal University, Srinagar
99.	Technical Officer for the Jal Shakti Abhiyan Phase II: Catch the Rain, MoJS, GoI for the Uttarkashi District	Dr. Pradeep Kumar, Scientist 'E'	Member	NWM, MoJS, New Delhi

100.	Member, National Jal Jeevan Mission Expert Team to assess the ground level situation of Jal Jeevan Mission in the state of Rajasthan	Dr. Pradeep Kumar, Scientist 'E'	Member	DDWS, MoJS, New Delhi
101.	ISO/TC-113/SC 1/WG 9	Dr. M.K. Nema, Scientist 'E'	Member	Bureau of Indian Standards (BIS), New Delhi
102.	Scientist Promotion Committee, CGWB on December 22, 2022	Dr.Gopal Krishan, Scientist 'D'	Expert-Interview Committee	DoWR, RD&GR, New Delhi
103.	Committee Constituted for Joshimath Land Subsidence, USDMA, and high level committee of NDMA	Dr.Gopal Krishan, Scientist 'D'	Expert-Hydrology	National Disaster Management Authority, Govt .of India
104.	Member of Public Drinking Water Services Sectional Committee (SSD 14) constituted by BIS	Dr. Rajesh Singh, Scientist 'D'	Alternate Member	Bureau of Indian Standards (BIS), New Delhi
105.	Member of Panel (SSD 14/P1) for drafting standards on distribution networks and vocabulary	Dr. Rajesh Singh, Scientist 'D'	Member	Bureau of Indian Standards (BIS), New Delhi
106.	Member of Panel (SSD 14/P3) for drafting standards on distribution networks and vocabulary	Dr. Rajesh Singh, Scientist 'D'	Member	Bureau of Indian Standards (BIS), New Delhi
107.	Member of the Technical Advisory Board of Vulture Innovations Pvt. Ltd., Gurugram	Dr. Rajesh Singh, Scientist 'D'	Member	M/s. Vulture Innovations Pvt. Ltd., Gurugram
108.	Member of Assessment Committee for SRF-NET-02 nos.	Dr. Rajesh Singh, Scientist 'D'	Member	IIT, Roorkee
109.	Member of the Technical Committee constituted by BHU, Varanasi for finalization of specifications of Ion chromatograph	Dr. Rajesh Singh, Scientist 'D'	Member	BHU, Varanasi
110.	Special session on "Young Water Professional" in 7th India Water Week conclave, November 01-05, 2022	Dr. Vinay Kumar Tyagi, Scientist 'D'	Member	Greater Noida, U.P.
111.	Special session on "Water Resources Management" in Sustainability fair & International Symposium on Sustainable Urban Environment (ISSUE-2022), October 13-14, 2022	Dr. Vinay Kumar Tyagi, Scientist 'D'	Member	University of Petroleum and Energy Studies (UPES), Dehradun
112.	Advances in Environment, Agriculture and Plants. In: International Congress of Biotechnology 2022, June 10-11, 2022	Dr. Vinay Kumar Tyagi, Scientist 'D'	Chair	Dr. B. Lal Institute of Biotechnology, Jaipur

113.	Workshop on "Plastic Waste Flow in India" organized on August 05, 2022	Dr. Vinay Kumar Tyagi, Scientist 'D'	Panelist	CSIR-NEERI, Nagpur
114.	Conference Committee: International Conference on Alternative Fuels, Energy and Environment-2023 (ICAFEE 2023), October 06-08, 2023	Dr. Vinay Kumar Tyagi, Scientist 'D'	Member	Kayseri, Turkey
115.	VSI on Anaerobic Digestate Management: Towards New Insight from Waste to Resource Recovery in Biomass and Bioenergy Journal	Dr. Vinay Kumar Tyagi, Scientist 'D'	Guest Editor	Elsevier
116.	VSI on Cutting-Edge Technologies for Wastewater Management and Environmental Protection in Sustainability Journal	Dr. Vinay Kumar Tyagi, Scientist 'D'	Guest Editor	MDPI
117.	VSI on Leachate Management in Journal of Environmental Management	Dr. Vinay Kumar Tyagi, Scientist 'D'	Managing Guest Editor	Elsevier
118.	Frontiers in Sustainability- Waste Management	Dr. Vinay Kumar Tyagi, Scientist 'D'	Editorial Board Member	Frontiers
119.	Frontiers in Chemical Engineering- Environmental Chemical Engineering	Dr. Vinay Kumar Tyagi, Scientist 'D'	Editorial Board Member	Frontiers
120.	Frontiers in Environmental Chemistry- Chemical Treatments	Dr. Vinay Kumar Tyagi, Scientist 'D'	Editorial Board Member	Frontiers
121.	Environmental Science and Ecotechnology	Dr. Vinay Kumar Tyagi, Scientist 'D'	Editorial Board Member	Elsevier
122.	Joint Committee for Temple Precinct DPR & Works for the development of Badrinath Dham	Dr. S.M. Pingale, Scientist 'D'	Member	NMCG, MoJS, Govt .of India
123.	Joint meeting regarding Joshimath Disaster at Dehradun	Dr. S.M. Pingale, Scientist 'D'	Nominated Member	NDMA, Gov.of Uttarakhand
124.	Hydroclimatology Panel-GEWEX (World Climate Research Programme, WMO)	Dr. S.M. Pingale, Scientist 'D'	Member	WMO through Center for Ocean-Land-Atmosphere Studies, U.S.A.
125.	Hydrological Sciences Journal, Taylor & Francis	Dr. S.M. Pingale, Scientist 'D'	Associate Editor	IAHS, UK

126.	2nd Proceedings Editors of the Mediterranean Geosciences Union Annual meeting (MedGU-22) held in Marrakech, Morrocco during November 27-30, 2022	Dr. D.S. Bisht, Scientist 'C'	Member	Springer
127.	Scientific Committee of the Mediterranean Geosciences Union Annual meeting (MedGU-22) held in Marrakech, Morocco during November 27-30, 2022	Dr. D.S. Bisht, Scientist 'C'	Member	Springer
128.	Core group on Data Collection formed by Steering Committee on "Springshed Mapping of Indian Himalayan Region	Dr. D.S. Bisht, Scientist 'C'	Member	DoWR, RD&GR, New Delhi
129.	Sectional Committee for Reservoir and Lakes	Dr. Kalzang Chhoden, Scientist 'C'	Member	Bureau of Indian Standards (BIS), New Delhi

DIGNITARIES WHO VISITED NIH

Following International and National dignitaries and experts visited the National Institute of Hydrology, Roorkee and Regional Centres during 2022-23:

S.N.	NAME	DEPARTMENT & COUNTRY	DATE
1.	Dr. Laura Richards	Dept. of Earth and Env. Sciences, The University of Manchester, UK	August 23, 2022
2.	Prof.Thomas Grischek	Department of Civil Engineering, University of Applied Sciences, Germany	September 15-16, 2022
3.	Prof. Christophe Cudennec	Secretary General, International Association of Hydrological Sciences (IAHS), Institut Agro Rennes-Angers, France	November 23, 2022
4.	Prof Mark Bailey	Executive Director, UK Cente of Ecology and Ecology (UKCEH), Wallingford (United Kingdom)	December 07, 2022
5.	Dr. Vijay P. Singh	Chair in Water Engineering at TEXAS A&M University, Department of Biological and Agricultural Engineering, USA	December 07, 2022
6.	Mr. Joel Stafford	Innovation Centre Denmark (ICDK)- India	January 04, 2023
7.	Prof. Alan Bradley	Department of Civil Engineering, University of Iowa, USA	January 04-06, 2023
8.	Prof. Venkatesh Marwade	Purdue University, USA	January 04-06, 2023

VISITS ABROAD

Following scientists of NIH visited abroad during 2022-23:

S.N.	NAME & DESIGNATION	PERIOD	FUNDING AGENCY	PLACE OF VISIT (CITY/ COUNTRY)	PURPOSE
1.	Dr. Sumant Kumar, Scientist 'D'	December 07, 2022- December 09, 2023	Oregon State University, USA	Corvallis, Oregon, USA	Postdoctoral Research
2.	Dr. S.M.Pingale, Scientist 'D'	July 26-30, 2022	WMO	Monterey, California, USA	34th Session of the Global Energy and Water Exchanges (Scientific Steering Group) and World Climate Research Programme (WMO)
3.	Dr. R.V. Kale, Scientist 'E'	February 18-22, 2023	ICHARM, Tsukuba, Ibaraki, Japan	Tsukuba, Japan	9th International Conference on Flood Management

Signing of MoU between NIH Roorkee and UK-CEH on 7th Dec., 2022

12 Infrastructure

Laboratories provide a dynamic and broad-based research environment. The Institute has well-equipped laboratories with state-of-art monitoring and analytical instruments powered by a team of expert scientists, supporting scientific and technical staff. Besides, the laboratories the institute has a number of other units with ultra-modern facilities. Following laboratories and units have been established at the Institute.

12.1 Nuclear Hydrology Laboratory

The Nuclear Hydrology laboratory is equipped with modern instruments for measurement of stable and radioisotopes in water and sediments. The instruments are used for the study of soil moisture movement and estimation of recharge to groundwater, surface water and ground water interaction, lakes studies, groundwater dating and identification of recharge sources and zones of deeper aquifers and springs. Nuclear Hydrology Laboratory has three units, (i) Stable Isotope Laboratory, (ii) Groundwater Dating Laboratory, and (iii) Sediment dating laboratory. Important instruments available in the Stable Isotope Laboratory are: Dual Inlet Isotope Ratio Mass Spectrometer (DIIRMS) and Continuous Flow Stable Isotope Ratio Mass Spectrometer (CFIRMS) for measurement of δD, $\delta^{13}C$, $\delta^{18}O$ and $\delta^{34}S$ in water and solids; Isotopic Water Analyzer (Liquid+Vapor) for measuring $\delta^{2}H$, $\delta^{17}O$, $\delta^{18}O$. Groundwater Dating Unit is equipped with Tritium Enrichment Units (2 No.), Ultra Low Level Liquid Scintillation Spectrometer (Quantulus), Soil Moisture Extraction Units and Liquid Nitrogen Plant etc. Sediment Dating unit has Multichannel Gamma Ray Spectrometer, Geolog Rate Meter. Two sets of radon detectors are also available in the laboratory. The laboratory is also equipped with Ion Chromatograph System-5000(Dionex) for analysis of major ions in water.

Apart from the Hydrological Investigations Division, other divisions of the Institute and the Regional Centres also use the facilities of the laboratory for their technical studies. The facilities of the laboratory were also extended to various other departments/agencies like; NCAOR, Goa, various IITs, Delhi University, Central Ground Water Board, UP Irrigation etc.

During the year 2022-23, a total of 8369 water samples (precipitation, rivers, springs, lakes, and groundwater etc.) were analysed for stable isotopes including δD (4372 samples) and $\delta^{18}O$ (3997samples). Apart from this, 260 water samples were analysed for environmental tritium on Quantulus and 1465 water samples were analysed for water chemistry on Ion Chromatograph. Various dignitaries visited the lab across the year and appreciated the working environment of the lab.

Visit of Union Minister of Jal Shati (GoI), Shri Gajendra Singh Shekhawat to NHLab

Visit of Secretary, Ministry of Jal Shati (GoI), Shri Pankaj Kumar, IAS in NH lab

12.2 Remote Sensing and GIS Laboratory

Remote Sensing and GIS Application (RSA) Laboratory is a shared computing facility of the institute. This laboratory is attached to the Water Resources Systems Division (WRSD) of NIH Roorkee. The scientific studies and research on various aspects of hydrology and water resources using remotely sensed data and GIS platforms were carried out in the laboratory. This laboratory assists in RS and GIS applications in various Institute Funded/ Sponsored/Consultancy studies and research projects of the institute. Different remote sensing and GIS software are available in the laboratory: ArcGIS, ERDAS Imagine, ENVI, and R2V (Raster to Vector Conversion software). The laboratory has A0 Colortrac Smart-F Image Scanner, Laser Printer and A0 size Cannon Colour plotter. The laboratory maintains a large inventory of maps from various organisations, namely the National Remote Sensing Centre (NRSC), Survey of India (SOI) and National Bureau of Soil Survey and Land Use Planning (NBSSLUP). Several topographic maps and state soil maps are available in the laboratory. The laboratory also has satellite remotely sensed data about different parts of the country. Software, maps and data available in the laboratory are utilised in various studies carried out by the institute. The laboratory also has Differential GNSS (DGPS), to collect location and altitude information. The laboratory facilities are also used during the interactive awareness programmes on remote sensing applications and GIS in various fields, organised by the Institute for students from different schools and colleges. During 2022-23, around 80 students/ trainees and their teachers from other schools and institutes visited the laboratory.

Glimpse of Remote Sensing and GIS Laboratory of NIH Roorkee

12.3 Soil Water Laboratory

The Soil Water Laboratory has modern equipment for laboratory and field measurement of the soil physical and hydrologic properties. The major capabilities include determination of soil particle size distribution for textural analysis, permeability, porosity, infiltration, soil density, soil moisture at different suction for determination of the soil moisture characteristics curves, saturated hydraulic conductivity, sorptivity and matrix flux potential of soils, in-situ soil moisture, soil salinity and pH, leaf area index, foliage and other canopy measurements in command area etc. using advanced instrumentation and techniques. Major instruments available in the laboratory include Pressure Plate Apparatus, Soil Particle Size Analyzer, CHNS/O Analyzer, Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) Microwave Digestion System, Water Purification System, Guelph In-situ Permeameter, TDR Soil Moisture Probe, ICW Lab Permeameter, Multi Volume Pycnometer, Digital pH & Conductivity meter, Constant Head Permeameter, Falling Head Permeameter, Electromagnetic Sieve Shaker, Tensiometers, Double Ring Infiltrometers, and Plant Canopy Analyser. In addition to routine laboratory-based analysis of soil samples, the laboratory is providing services in the field for collecting disturbed/undisturbed samples, conducting in-situ measurement of various soil parameters and for field surveys related to the studies taken up by various divisions including the sponsored / consultancy projects. During the year 2022-23, various field and laboratory-based analysis were carried out for different projects. During the year a total of 2985 soil samples were analysed in the laboratory using CHNS analyser (595), Sieve Shaker and master sizer (154), ICW Lab Permeameter (88) and pressure plate (113) for determination of CHNS (carbon, hydrogen, nitrogen, sulphur), soil texture, soil moisture characteristic curve, permeability, bulk density, soil moisture, etc. A total of 2035 water samples were also analysed on ICP-OES for trace metals analysis. In addition, SW lab equipment such as Double Ring Infiltrometer and Guelph Permeameter etc. are also being used to conduct field experiments for measuring insitu soil properties.

Pressure Plate Apparatus in SW Lab

ICW Lab Permeameter Soil Water Lab

12.4 Centre of Excellence for Advanced Groundwater Research

In India, groundwater resource is under continuous threat of depletion and contamination due to manifold inevitable causes like rapid urbanization and industrialization, intense irrigation withdrawals and limited natural recharge. To cope up such issues, NIH prospectively planned to strengthen the R&D activities with national and international organizations by developing a platform to work in groundwater domain. Accordingly, a Centre of Excellence for Advanced Groundwater Research (CEAGR) has been established under the Division. The centre has the state-of-art tools on hardware and software for dealing with computationally challenged problems.

The centre is equipped with various soft-computing tools related to groundwater like: groundwater quantity and quality modeling using MODFLOW/ MODFLEX Premium/ FEFLOW; integrated catchment modelling using MikeSHE; unsaturated zone modelling using WHI UnSat Suite Plus; spatial analysis using ArcGIS/TNT Mips; geological characterizing using Hydro GeoAnalyst; 3D contouring using Surfer; water quality characterization using AquaChem; and aquifer parameter estimation using AquferTest Pro. The facilities of Centre are being used by scientists, project staff working under various national and international projects, and students working on their Masters/ Ph.D dissertation work.

Centre of Excellence for Advanced Groundwater Research

12.5 Water Quality Laboratory

The Water Quality Laboratory is well-equipped with well qualified staff and state-of-art equipments to identify and quantify physical, chemical and bacteriological parameters in water. The laboratory has facilities and capabilities to determine major ions, trace elements, pesticides, PAHs and bacteriological parameters in water samples. The major equipments available in the laboratory include Ion Chromatograph with Auto Titrator, Voltammetry, Liquid Chromatography– Inductively Coupled Plasma – Mass Spectrometry (LC-ICP-MS), TOC Analyzer, Triple Quadrupole Gas Chromatograph Mass Spectrometer (GC-MS/MS), Autotitrator Potentiometric (ATP), UV-Vis Spectrophotometer, Flame Photometer, Portable Environmental Laboratory, Biosafety Cabinet, Research Microscope, Microwave Digester, Ultrapure Water Purification System, Deep Freezer, Autoclave, Orbital Shaker Incubator, BOD Incubator, Bacteriological Incubator, COD Digestion System, Total Kjeldahl Nitrogen (TKN) System, Parallel Evaporation and Concentration System, Bacteriological Testing Kit, Centrifuge, Toxicity Characteristic Leaching Procedure (TCLP) etc. The laboratory also provides its services for sample collection and analysis for outside agencies. Water Quality Laboratory was accredited by NABL in accordance with the standard ISO/IEC 17025: 2017– General Requirements for The Competence of Testing & Calibration Laboratories for 22 parameters for a period of two years w.e.f. 14.04.2021 (Certificate Number: TC-9421) (Lab ID: T-5679) and is under renewal of accreditation by NABL for next two years.

Ion Chromatograph in WQ Lab

Total Kjeldahl Nitrogen (TKN) Analyzer in WQ Lab

Liquid Chromatography - Inductively Coupled Plasma – Mass Spectrometer(LC-ICP-MS) in WQ Lab

Total Orgnaic Carbon (TOC) Analyzer in WQ Lab

12.6 Hydrological Instrumentation Laboratory

Hydrological Instrumentation (HI) Laboratory is equipped with conventional as well as modern equipment's for various hydrologic measurements. Important instruments available in the laboratory include: Automatic Infiltrometer, Automatic Weather Station, Automatic Rain Gauges (Tipping Bucket type), Current Meters, Depth Soil Water Samplers, Digital Evaporation Recorder, Digital Wind Speed & Direction Recorder, Digital Surface and Ground Water Level Recorders, Differential Global Positioning System (DGPS), Earth Resistivity Meter, Echo-sounder with DGPS for Bathymetric survey, Multi-parameter Water Quality Kit, Mini-Disc Infiltrometer, Optical Temperature Profiler, Self-Recording Rain Gauges (Siphon type), Sediment corer, Suspended Solid Analyzer, Time Domain Reflectometry (TDR) for soil moisture measurement, Water Level Indicators (Sounders), Water Temperature Profiler, Total Station, Portable TLC meter, Water level and water flow meter for well etc. During the year 2022-23, hydro-geological investigations were carried out by the laboratory for various R&D, Sponsored and Consultancy projects.

Earth Resistivity Meter

Water Level Indicator

DGPS

Multi-parameter Water Quality kit

Sediment Corer

Depth Water Sampler

Mini-Disc Infiltrometer

Multi-parameter Water Quality Sonde

12.7 Hydro-Meteorological Observatory

The Meteorological Observatory at NIH campus has been operational since 1985. The instruments operational are: (i) ordinary rain gauge, (ii) autographic rain gauge (siphon), (iii) maximum and minimum temperature thermometer, (iv) dry and wet bulb thermometer, (v) thermograph, (vi) hygrograph, (vii) anemometer, (viii) pan evaporimeter, (ix) sunshine recorder, (x) automatic weather station (AWS). The observations such as maximum temperature, minimum temperature, relative humidity, rainfall, evaporation, sunshine hours, wind speed and wind direction are noted on daily basis at 08:30 AM and 05:30 PM. The data collected at NIH campus are provided to various research organizations, state government departments and research scholars on their requisition. A weather display unit has been installed at the main building for display of current recorded weather parameters for the general public.

Visit of students showing AWS installed in NIH Hydro-meteorological Observatory

12.8 Library

The institute since its inception has been in the continuous process of building and updating a good technical library with latest publications in the area of hydrology and water resources. In the year 2022-23, 156 new books, 12 Technical reports and 405 issues of national and international periodicals have been added to the collection of the library. The total collection of the library has reached up to 25,443 publications, comprising 13,330 books, 4,425 bound periodicals, 6,330 technical reports, 322 Indian and foreign standards,1036 technical papers/reprints. The library is currently subscribing 33 Indian and 26 foreign periodicals. Out of them, online versions of 26 International periodicals are also available. Nine periodicals are in Hindi. In addition to the Institute employees, library's resources are being utilized widely by users from other organizations.For automated management of library's activities and services, latest version of KOHA software with Web OPAC and separate server and client PCs are in operation.Institute Digital Repository (IDR) of institute's own publications have been created and being popularized regularly.

A view of NIH Library

12.9 Computer Centre

Computers of latest configuration are available in the Computer Centre of the Institute for conducting complex hydrological analyses and modeling studies. High-speed internet and email facilities are routinely provided for accessing scientific literature as well as transmission of information. The Centre also provides IT services to the administrative and finance wings of Institute. The Centre procures and provides maintenance to computers and related peripherals available within the Institute.

The local area network (LAN) of the Institute provides interconnectivity between the computers in different building blocks of the campus. The Centre has implemented 1Gbps internet connectivity in the institute under the National Knowledge Network (NKN) framework. A centralized server receives and stores/forwards emails to respective users. A dedicated web server (www.nihroorkee.gov.in) provides a platform for hosting institute information, research publications, important announcements, tender notices, recruitment, etc. and also maintains useful hydrologic information on its website. An intranet is also available for sharing office orders and forms, etc. The Wifi services have also been provided at different locations in the Institute. The Centre is providing training to NIH employee on various software & web applications. The Centre also supports NIH Administration in the operation and maintenance of the Aadhar Based Biometric Attendance System (BAS) at the Institute. STQC Certification has been awarded to NIH Website. The Centre is also maintaining the account server for payslip of NIH employee.

During the year 2022-23, the Computer Centre has made regular procurements of latest version of Laptops, Desktop computers, Servers and accessories for the scientists. Computer Centre is also providing the facility of anti-plagiarism to the users for their publications. Computer Centre has also developed a NIH Scientist Web Profile Portal. Computer Centre is continuously developing in-house software utilities for various purposes and also develops web-based applications. The result framework document (RFD) system has been hosted by the Computer Centre. The Computer Centre is actively involved in social media activities of the Institute. The e-HRMS and e-office has also been implemented in the Institute.

Training Hall of Computer Centre at NIH Roorkee

12.10 Maintenance Division

The Maintenance Division is responsible for the creation of new infrastructural facilities as per the Institute's requirements, besides the regular work of maintaining the existing facilities including renovation and maintenance of existing buildings, laboratories, residential quarters, etc. During the year 2022-23, the division has taken up various renovation works within the institute. These works have been entrusted to the central construction agency CPWD. The details of the major works of the Division for the year 2022-23 are as follows:

S. No.	NAME OF THE WORK
Completed	
1	Coba works on the roof of the substation in the NIH office.
2	Renovation of Scooter stands in NIH office.
3	Aluminium grills on windows in NIH office.
4	Renovation of maintenance division in NIH office.
5	Construction of parapet wall of lab block in NIH office.
6	Display Board in corridor of Lab Block-II (2nd Floor)
7	Gymnastic facilities at NIH Residential Colony
8	Raising of apron & drain of Lab Block near Nuclear Hydrology Lab.
9	R&M work of boundary wall with barbed wire fencing of NIH Residential Colony
Under Progress	
1	Renovation of 08 Nos. Quarters (Type -V) of Ganga Block of NIH staff colony.
2	Renovation of Library in NIH office.
3	Shifting of water supply line between water pump to overhead tank in NIH office.
4	Upgradation of kitchens in quarters of Narmada Block-I,II,III & IV.
5	Civil works in quarter no. DG-6, CG-4 & CG-1 of NIH staff colony.
6	Fixing of aluminium frame window in Sub Station of NIH Staff colony

12.11 Workshop

The institute workshop plays an important role in developing and fabricating experimental set-ups and parts of instruments used for various research purposes. It also undertakes the repair and maintenance work of laboratory, office, and field equipment. The workshop is involved in maintaining the operation and maintenance of centralized air-conditioning system of Auditorium and one new is being installed in Library. In addition to this around 296 Air-conditioners, 12 water Coolers, and 12 Water Purifiers systems, Refrigerators of the institute on regular basis. The workshop also provides support to the scientific divisions for field activity, particularly for the installation of the instruments at field sites. The workshop has a lathe machine, power saw machine, welding machine, and various smaller machines and tools.

12.12 Vehicle Section

The vehicle section plays a significant role in assisting the institute in its day-to-day functioning by providing transportation facilities such as local and out of station duties including official meetings at Delhi, Dehradun and nearby locations, field visits related to various studies, local market surveys by committees & local purchases etc. Transportation facilities are also provided by vehicle section for children of NIH employees residing in the NIH colony for drop and pick up to/from school. Besides this, the duties assigned by district administration (SDM Office, Roorkee; District Magistrate, Haridwar), Election Commission, and in national disasters are also performed as per Government of India Rules. The institute also has Annual Rate Contract with local travel agency for hiring of the vehicles (big and small both) on as and when required basis for the scientific and administrative works.

As on 31 March, 2023, the Institute has a total no. of 6 official vehicles (Cars: 02-Innova; 02-Ciaz; 01-Tata Sumoand 01 staff bus) and all are in working condition. There are two non-working cars (01-Qualis and 01-Tata Sumo) with the institute, for which the process for condemnation has been started.

13 National Committee on Climate Change (INCCC)

The Indian National Committee on Climate Change' (INCCC), Department of Water Resources, River Development and Ganga Rejuvenation (DoWR, RD & GR), Ministry of Jal Shakti, Govt. of India is functioning at NIH Roorkee. The Chairman of INCCC is the Mission Director, National Water Mission (NWM). The INCCC has sponsored eight R & D studies on Climate Change assessment to different premier institutes as given in Table. The INCCC is coordinating, monitoring and reviewing the progress these studies on impact of climate change. A total of seven numbers of studies have been completed and reports have been reviewed. The study on "dynamic downscaling (*Sl. no. 8 in Table*)" is expected to be completed by March 2024, whereas as two partner institutes have completed their components.The 13th INCCC meeting was organised in hybrid mode on 30 September 2022 for presentation the completed studies and to review progress of one remaining study. The PIs/Co-PIs of various completed studies presented their respective reports before INCCC members & Chairperson. Also, the six new study proposals were got reviewed and subsequently presented in the13th INCCC meeting. These new proposals were accepted for further processing and for formal approval in SCA meeting. The primary purpose of the INCCC meeting was to share the methodologies and techniques applied for different basins to arrive at/achieve comparable output and common deliverables from the various studies. The reported progress of all the ongoing projects was satisfactory.

List of INCCC Sponsored Projects during 2022-23

S.N.	NAME OF THE PROJECT	LEAD & COLLABORATING INSTITUTIONS	STATUS
1.	Impact Assessment of Climate Change on Hydro-meteorological processes and Water Resources of Mahanadi River Basin	IISc, Bangalore; IIT Bhubaneswar	Completed
2.	Climate Change Impact Studies for Rajasthan (Area of Inland Drainage and Mahi basin	MNIT Jaipur; CU RAJ Ajmer; IIT Delhi	Completed
3.	Impact of Climate Change on Water Resources of Tapi Basin	SVNIT Surat; MNIT Jaipur; MANIT Bhopal	Completed
4.	Effects of Climate Change and land use/land cover changes on spatial and temporal water availability in Subarnarekha Basin	IIT Kharagpur	Completed

5.	Impact of Climate Variability and Climate Change on Water Resources in the Sabarmati River Basin	IIT Gandhinagar; SVNIT Surat	Completed
6.	Impact of Climate Change on Water Resources in River Basins from Tadri to Kanyakumari	IITB Mumbai; NIT Surakthal; CWRDM Kozhikode	Completed
7.	Statistical Downscaling for hydro-climatic projections with CMIP5 Simulations to assess Impact of Climate Change	IIT Bombay: IIT Guwahati; IISC Bangalore; IIT Gandhinagar; IIT Kanpur	Completed
8.	Dynamic Downscaling to study Climate change Impacts on Water Resources in India	IIT Delhi; IIT Madras; Anna University; BHU Varanasi	On-Going(Component of IIT Delhi is in progress; Expected completion by March 2024)

14 Human Resources

The Institute had a total sanctioned strength of 253 personnel, including all Group A (105 posts), Group B (76 posts) and Group C (72 posts) as on 31 March 2023. At the end of the year 2022-23 i.e. on 31 March, 2023, the Institute had a team of 70 Group A Officers (including Director, Scientists, SAO, FO); 50 Group B and 43 Group C supporting scientific/technical/administrativeand other supporting personnel. The position of staff as on 31.3.2023 is given in Appendix-XII and the list of employees as on 31.03.2023 is given in Appendix XIII.

The scientists of the Institute are highly qualified and well trained to handle diverse hydrological problems being faced by the country. Most of the scientists have Ph.D. degree in Engineering and Science and have long research experience.

14.1 Promotions Of Employees

During the year 2022-23, seven employees were promoted to higher grades through DPC as per details given below:

S.N.	NAME	FROM	TO	DATE
1.	Shri Chandra Kr. S	S.R.A.	P.R.A.	30.06.2022
2.	Smt. Bina Prasad	R.A.	S.R.A.	30.06.2022
3.	Shri J.S. Bisht	Assistant	Section Officer	01.07.2022
4.	Shri Naresh Kumar	Driver Gr. II	Driver Gr. I	11.07.2022
5.	Shri Sanjay Mittal	S.R.A.	P.R.A.	22.11.2022
6.	Shri S.L. Srivastava	S.R.A.	P.R.A.	22.11.2022
7.	Shri Jatin Malhotra	S.R.A.	P.R.A.	22.11.2022
8.	Shri Rajesh Agarwal	S.R.A.	P.R.A.	22.11.2022
9.	Shri Ved Pal	Tech.Gr.III	Tech. Gr.II	22.11.2022
10.	Shri Alok Kr. Sharma	Tech.Gr.III	Tech. Gr.II	22.11.2022
11.	Shri Atm Prakash	S.R.A.	P.R.A.	01.12.2022
12.	Shri Drona Khurana	S.R.A.	P.R.A.	01.12.2022
13.	Shri N.R. Allaka	R.A.	S.R.A.	01.01.2023
14.	Shri Praveen Kumar	U.D.C.	Assistant	01.01.2023
15.	Shri N.K. Lakhera	Tech.Gr.I	Senior Technician	01.01.2023
16.	Smt. Kiran Ahuja	Personal Assistant	Private Secretary	01.03.2023

Following scientists were also promoted during 2022-23:

S.N.	NAME	FROM	TO	PROMOTION W.E.F.
1.	Sh. Omkar Singh	Scientist F	Scientist G	13.05.2022
2.	Dr. Sanjay Kumar	Scientist E	Scientist F	13.05.2022
3.	Dr. V.S. Jayakanthan	Scientist E	Scientist F	13.05.2022

4.	Dr. T. Thomas	Scientist E	Scientist F	13.05.2022
5.	Dr.Manohar Arora	Scientist E	Scientist F	13.05.2022
6.	Sh. R. V. Galkate	Scientist E	Scientist F	13.05.2022
7.	Dr.Archana Sarkar	Scientist E	Scientist F	13.05.2022
8.	Sh. R. Venkataramn	Scientist D	Scientist E	13.05.2022
9.	Dr. Sanjay Kr Sharma	Scientist C	Scientist D	19.07.2022
10.	Dr. A.R. Senthilkumar	Scientist F	Scientist G	16.09.2022
11.	Dr.(Miss)Anupama Sharma	Scientist F	Scientist G	16.09.2022
12.	Dr. M.K. Sharma	Scientist E	Scientist F	16.09.2022
13.	Dr. M.K. Jose	Scientist E	Scientist F	16.09.2022
14.	Dr. S.M. Pingale	Scientist C	Scientist D	06.01.2023
15.	Dr. Swapnali Barman	Scientist C	Scientist D	06.01.2023
16.	Dr. Sunil Gurrapu	Scientist C	Scientist D	06.01.2023
17.	Dr. Vishal Singh	Scientist C	Scientist D	06.01.2023
18.	Mrs. Anjali	Scientist B	Scientist C	06.01.2023
19.	Dr. Deepak Singh Bisht	Scientist B	Scientist C	06.01.2023
20.	Dr. Nitesh Patidar	Scientist B	Scientist C	06.01.2023
21.	Dr.WaikhomRahul Singh	Scientist B	Scientist C	06.01.2023
22.	Sh. Rohit Sampatrao Sambare	Scientist B	Scientist C	06.01.2023

14.2 New Appointments

During the year 2022-23, following new employees joined NIH under direct recruitment (DR) as per details given below:

S.N.	NAME	DESIGNATION	DATE	MODE
1.	Sh. Subham Kr. Meena	S.R.A	16.03.2023	Direct Rectt.
2.	Shri Gaurav Kumar	R.A.	27-02-2023	Direct Rectt.
3.	Shri Amit Rawat	Tech.Gr.III	27.02.2023	Direct Rectt.
4.	Shri Rohit Negi	L.& I.A	01.03.2023	Direct Rectt.
5.	Shri Hakim Singh Meena	R.A.	03-03-2023	Direct Rectt.
6.	Shri Gurpreet Singh	R.A.	09-03-2023	Direct Rectt.
7.	Shri Asif	R.A.	09-03-2023	Direct Rectt.
8.	Shri Anil Kumar	R.A.	13-03-2023	Direct Rectt.
9.	Shri Rahul Kumar	R.A.	13-03-2023	Direct Rectt.
10.	Shri Amit Sharma	R.A.	15-03-2023	Direct Rectt.

14.2 Employees who left the Institute

During the year 2022-23, following employees left the Institute due to various reasons as given below:

S.N.	NAME	DESIGNATION	DATE	REASON
1.	Smt. Deepa Chalisgaonkar	Scientist G	30-04-2022	Superannuation
2.	Shri Dharam Nath	MTS	30-04-2022	Superannuation
3.	Shri Subhash Kichlu	PRA	31-05-2022	Superannuation
4.	Smt. Alka	Section Officer	30-06-2022	Superannuation
5.	Shri Dayal Singh	Assistant	30-06-2022	Superannuation
6.	Shri Shekhar Saini	SRA	13-05-2022	Resign
7.	Dr. J.V. Tyagi	Director	31-08-2022	Superannuation
8.	Shri T.Vijaya	Scientist B	31-08-2022	Superannuation
9.	Shri Ashok Kumar	MTS	31.08.2022	Superannuation
10.	Shri Gulshan Tirkey	Scientist B	08.09.2022	Expired
11.	Dr. V.C. Goyal	Scientist G	30.09.2022	Superannuation
12.	Shri Hussain Khan	Technician Gr.I	30.09.2022	Superannuation
13.	Shri G.S. Dua	Sr. Technician	30-09-2022	Superannuation
14.	Shri Om Prakash	MTS	30-09-2022	Superannuation
15.	Shri P.K. Agarwal	Scientist B	31.10.2022	Superannuation
16.	Shri U.V. N. Rao	Scientist B	30.11.2022	Superannuation
17.	Shri Rajeev Saran Ahluwalia	Scientist C	27.12.2022	Resigned
18.	Shri Rockey Khokhar	Sr. Technician	30.12.2022	Expired
19.	Smt. Meenakshi Mishra	P.A.	30.12.2022	Superannuation
20.	Shri Yatveer Singh	Scientist B	28.02.2023	Superannuation
21.	Shri Kalar Singh	MTS	28.02.2023	Superannuation
22.	Shri N.K. Varshney	D/m Gr.I	28.02.2023	Superannuation
23.	Shri Hukam Singh	Scientist B	28.02.2023	Superannuation
24.	Shri R.K. Nema	Scientist B	28.02.2023	Superannuation
25.	Shri Digamber Singh	Scientist D	28.02.2023	Superannuation
26.	Shri A.S. Mehra	P.S.	28.02.2023	Superannuation
27.	Shri Satendra Prasad	Staff Car Driver Gr.I	28.02.2023	Superannuation
28.	Dr. B. Chakravorti	Scientist G	31.03.2023	Superannuation

14.4 Awards for Group A, B, and C Staff

Scientists of the Institute won the following awards during the year 2022-23

S.N.	NAME & Designation	DETAILS	DATE/PERIOD
1.	Vinay Kumar Tyagi, Scientist 'D'	Listed in top 2% scientists worldwide based on the list published by Stanford University [https://elsevier.digitalcommonsdata.com/datasets/btchxktzyw/4]	Oct. 2022

2.	Vinay Kumar Tyagi, Scientist 'D'	Finalist: NASI -Scopus Young Scientist Awards 2023 in "Environmentally Sound Sustainable Development Category".	Mar. 2023
3.	Dr. Gopal Krishan, Scientist D	Felicitated by Shri Brahm Shankar Sharma, Hon'ble Cabinet Minister of Water Supply, Govt. of Punjab.	Sep. 15, 2022
4.	Dr. Gopal Krishan, Scientist D	Best paper award for research paper on"influence of changing isotopic conditions of atmospheric moisture, precipitation, and groundwater on the seasonal variations in the isotopic composition of transpiration", ICRAWST-2022.	Dec. 09, 2022
5.	Dr. Gopal Krishan, Scientist D	Mahamana Puruskar by Mahamana Seva Sansthan, Haridwar on the occasion of Madam Mohan Malviya Jayanti.	Dec. 25, 2022
6.	Ms. Anjali, Scientist B	Best Paper Award : Integrated Management of Groundwater pollution caused by Landfill Leachate emanating from Gazipur Landfill, New Delhi, through source apportionment and Remediation Strategies; Special Session for Young Scientist, India Water Week -2022, organized by M/o Jal Shakti, GoI.	1-5 Nov.,2022
7.	Dr. DS Bisht Scientist 'C'	First prize for paper presentation in the Special Session for Young Professionals at 7th India Water Week -2022, organized by M/o Jal Shakti, GoI.	1-5 Nov.,2022
8.	Sh.Sabyasachi Swain, Scientist-B	Best Presentation Award under the Theme "Climate, Extreme Weather and Natural Hazards", Third International Workshop on Biodiversity and Climate Change (BDCC 2023), IIT Kharagpur.	16-19 Feb., 2023.
9.	Dr. A K. Lohani	Rajbhasha Gaurav Purashkar -2022for Hindi Paper on " Bharat mein barh prabandhan ke liye barhpoorv chetavani tantr" (Published in Pravahinee), First Prize awarded by Hon'ble Union Home Minister, M/o Home Affairs(GoI).	14th Sep. 2022
10.	Dr. A K. Lohani	Received First Prize for the article entitled "Google arth engine ka jal evam aapda prabandhan ke liye anupryog" published in the Hindi Magazine - Pravahini of NIH	Sep., 2022
11.	Dr. Archana Sarkar	Received "Distinguished Woman Researcher in Hydrology" award in the Engineering Discipline of 8th Venus International Women Awards in	March 4, 2023
12.	Dr. Manohar Arora	Rajbhasha Ratan Samman, 26th Rashtrabhasha Vikas Sammelan, New Delhi	March 10, 2023
13.	Shri Rohit Sambare, Sc. B & Shri N R Allaka, RA	Best Stall Award to NIH in the Exhibition, "Aspiring Haryana 2022" at Hisar, Haryana.	28-30 July, 2022

Rajbhasha Gaurav Purashkar-2022 awarded by Shri Amit Shah, Hon'ble Union Home Minister (GoI)

Cash awards for meritorious services among the Group B, C and D staff in the Institute were given on 15th August 2022 for the year 2021-22. The list of awardees is given below:

GROUP	NAME AND DESIGNATION	CATEGORY
Group 'B'	Shri Drona Khurana, SRA	Technical
	Shri P.K. Sarkar, PRA	Technical
	Shri Sandeep Kumar, PS	Non-Technical
Group 'C'	Shri Pankaj Kumar, Tech. Gr. III	Technical
	Shri Arun Kumar, Steno	Non-Technical
	Shri Biren Das, MTS	Non-Technical

Awards for Promotion of Hindi Language in official works (Noting/Drafting) of the Institute were given to the employees on 15th August 2022 for the year 2021-22. The list of awardees is given below:

S.No.	NAME AND DESIGNATION	Prize
1.	Shri Santosh Kumar, LDC	First
2.	Shri Naresh Kumar, Assistant	First
3.	Shri Pawan Kumar, PA	Second
4.	Ms. Neelam Bohra, LDC	Second
5.	Mrs. Hansi, Assistant	Second
6	Shri KVR Vara Prasad, Assistant	Third

7.	Shri Pradeep Kumar, MTS	Third
8.	Shri Pradeep Singh Panwar, LDC	Third
9.	Shri Subhash Chand, LDC	Third

14.5 Scientists/staff of the institute pursuing Ph.D. Degree

To achieve the scientific goals of the Institute, the scientists and the staff is constantly working on enhancement of their skills through pursuing higher studies. During the year 2022-23, number of scientists/staffs were enrolled/awarded for Ph.D. degree, as per details given below:

S N	NAME AND DESIGNATION	TITLE OF THE PH.D. THESIS	DEPARTMENT/ UNIVERSITY	STATUS
1.	Biswajit Chakravorty Scientist 'G'	An Integrated Approach for Management of Waterlogging and Drainage Congestion in Lower Gandak Basin	NIT Patna	Awarded
2.	Dr. W. R. Singh, Scientist 'C'	Hydrological Simulation Using RHESSys and SWAT under projected Climatic Scenarios for Pare River Basin of Arunachal Pradesh	Dept. of Agri . Engg., NERIST	Awarded
3.	Sabyasachi Swain, Scientist-B	A Critical Investigati on of Drought Characterization under Climatic ad Anthropogenic Alterations	Dept. of WRD & M, IIT Roorkee	Awarded
4.	Abhilash R Scientist 'C'	Integrated Command area Management	HRRC, NIH/ VTU, Belagavi	Awarded
5.	Ravi Galkate, Scientist F	Assessment of regional drought characteristics under climate change conditions	Rabindranath Tagore University, Raisen, Bhopal	Pre-Thesis viva-voce completed
6.	Shashi Poonam Indwar, Scientist D	Water Resource Management and Development of Tawa Reservoir Policy under Climate Change.	Rabindranath Tagore University (RNTU)	On-going

14.6 Guidance of Doctoral and Masters Research

The scientists of the Institute are also contributing to the academics through guidance of Doctoral and Master's Thesis. During the year 2022-23, the scientists have guided a total of 62 PhD thesis (including 12 completed) and 73 Master's theses. The details of the guidance of PhD and Master's Thesis are given in Appendix-XIV.

15 ISO 9001:2015

The National Institute of Hydrology was awarded the ISO 9001:2008 certificate on December 13, 2012. The Institute became one of the first few government organizations to have obtained an ISO-9001 certification after the issue of the relevant Guidelines by the PMD of Cabinet Secretariat in March 2012. The certificate was upgraded from ISO 9001:2008 to ISO 9001:2015 on December 13, 2015.

Following areas have been identified for the implementation of ISO 9001:2015 Quality Management System in NIH:

NIH Products	NIH Services	NIH Processes
• Technical reports • Consultancy Project Reports • Sponsored Project Reports • Research Papers • Software Packages; Instruments; Magazines; Newsletter; • Proc. of National/ International Conferences, Seminars, etc.	• Laboratories • Library • Maintenance • Computer Centre • Guest Houses • Vehicles; Telephones • Auditorium; M P Hall • Security • Short courses • Workshop	• Administrative Section work processes • Finance Section work processes • Scientific Divisions work processes • Grievances Cell work processes

During the year 2022-23, one internal audit was conducted by NIH auditees during Dec.2022/Jan. 2023 at NIH, Roorkee. After First Year Surveillance audit of ISO at NIH by M/s SWISSCERT Pvt. Ltd, the requisiteCertification of ISO 9001:2015 has been renewedup to 12th December, 2024.

First Year Surveillance Audit of ISO9001:2015 at NIH

Hindi–The Official Language 16

The National Institute of Hydrology has a Hindi Cell functioning at its Headquarters at Roorkee to assist in proper implementation of the Official Language Policy of the Government of India in the Institute and to help the officials for compliance of the Official Language Act, the rules made there under and the instructions regarding use of Hindi in the Institute and its Regional Centers located in different states of the country. The Hindi Cell has been made responsible to execute various works related to Official Language implementation. Special efforts are being made to promote and propagate the progressive use of Hindi in the Institute so as to ensure strict compliance of the Official Language Policy of the Government and to achieve its targets regarding progressive use of Hindi in Official works as prescribed in the Annual Programme of the Department of Official Language. Awareness is being created among the officers and employees of the Institute to inspire them for carrying out the official work in Hindi through the OLIC meetings, Hindi Maas, Hindi award schemes etc. As a result, the Institute is showing a steady progress in implementation of Official Language Policy of the Government of India.

Keeping in view the targets fixed in the Annual Programme of the Department of Official Language, NIH remained active in organizing number of activities with great enthusiasm and zeal during the year 2022-23. The details of major activities organized by the Institute during the year 2022-23 are as under:

S.N.	NAME OF ACTIVITY	DATE/PERIOD	VENUE	REMARKS
1.	83rd meeting of Official Language Implementation Committee, NIH	28-06-2022	NIH	-
2.	Hindi Workshop for the employees of NIH	30-06-2022	NIH	24 participants
3.	Hindi Pakhwada- 2022 (05 Hindi competitions held)	14-09-2022 to 29-09-2022	NIH	31 participants were given cash awards and merit certificates.
4.	Rajbhasha/Hindi Week	14-09-2022 to 21-09-2022	CFMS, Patna	-
5.	Hindi Workshop for the employees of NIH	23-09-2022	NIH	23 participants
6.	84th meeting of Official Language Implementation Committee, NIH	30-09-2022	NIH	-
7	85th meeting of Official Language Implementation Committee, NIH	27-12-2022	NIH	-
8.	86th meeting of Official Language Implementation Committee, NIH	14 -03- 2023	NIH	-
9.	Hindi Workshop for the employees of NIH	28-03-2023	NIH	31 participants

In addition to above, NIH participated/Organized/ arranged the following activities:

- Essay Competition for the employees of member organizations of TOLIC Haridwar was organised/arranged by NIH during 23-27 May, 2022. A total number of 47 members participated in this competition.
- Two Officers of NIH participated in the Rajbhasha Coordinators Conference organized by TOLIC Haridwar on 16 Jun, 2022 at Central School, BHEL Haridwar.
- Four Scientists of NIH participated in the Online "Hindi Workshop" organized by CBRI, Roorkee on 24th Jun, 2022.
- On the occasion of 75th anniversary of "Azadi ka Amrit Mahotsava" a workshop was organised at village Khanpur under Khanpur Block, Haridwar on 14-07-2022. As many as 100 women and children participated in the workshop.
- Four officers including Director NIH participated in 34th Half Yearly meeting of Town Official Language Implementation Committee (TOLIC) Haridwar organized on 26 August, 2022.
- Three officers of NIH participated in "Akhil Bharatiya Rajbhahsa sammelan evam puraskar vitran samaroh" held atSurat (Gujarat) during14 -15 Sep, 2022. Dr Anil Kumar Lohani, Scientist-G was awarded with Rajbhasha Gaurav puraskar-First for the year 2021-22 for his best adjudged article entitled "*Bharat mein baarh prabandhan ke liye baarh poorv chetawani tantra" published in Annual Magazine "Pravahini"*.
- Hindi workshop for the member organizations of TOLIC, Haridwar located at Roorkee was organized in NIH on 17 Nov, 2022. Total 38 employees participated in the workshop and received training.
- Two Officers of NIH participated in the Rajbhasha Coordinators Conference organized by TOLIC Haridwar on 15 Dec, 2022 at Hotel Tulsi, Rishikesh.
- Under the Rajbhasha Chal Shield Pursakar Scheme, two shields were awarded to (i) Surface water Hydrology Division (at Headquarters), and (ii) Regional Centre, Jammu, respectively, for doing maximum Official work in Hindi during the year 2021-22.
- Four officers including Director Incharge,NIH participated in 35th Half Yearly meeting of Town Official Language Implementation Committee (TOLIC) Haridwar organized on 23 Jan, 2023. NIH received Rajbhasha Vaijayanti Puraskar (3rd) for excellent performance in various Hindi activities organised during the year 2021-22.
- Two Officers of NIH participated in Rajbhasha sammelan organized by Rashtrabhasha Swabhiman Trust, Ghaziabad (UP) on 10 Mar, 2023.
- Hindi version of Institute's Annual Report (2021-22) was prepared.
- Two Hindi magazines were brought out by the Institute during the year 2022-23 namely 29th issue of Annual Hindi magazine *"PRAVAHINI"* (2022) and two issues of *"JAL CHETNA"* (January-2022 and July-2022).

Inaugural Function of Hindi Pakhwada -2022

85th meeting of TOLIC, NIH Held on 27th Dec., 2022

Hindi workshop for the employees of member organization of TOLIC Haridwar organized on 17 Nov, 2022

Organization of Hindi workshop for the employees of NIH on 30 June,2022

83rd meeting of TOLIC, NIH Held on 28th June, 2022

Release of Institute's Annual Hindi Magazine "PRAVAHINI" on 29th Sep, 2022 during Hindi Pakhwada-2022

Prize Distribution by chief guest on 29 Sep, 2022

86th meeting of TOLIC, NIH Held on 14th March, 2023

17 Vigilance

Central Vigilance Commission (CVC), the apex integrity institution of the country, endeavours to promote integrity, transparency and accountability in public life. A Chief Vigilance Officer (CVO), appointed by Department of Water Recourses, River Development and Ganga Rejuvenation (DoWR, RD & GR), Ministry of Jal Shakti with approval from CVC, functions in the Institute to look after the vigilance matters of the Institute. The directives of CVC and DoWR, RD & GR, Government of India, are implemented for maintaining preventive vigilance in major purchases and construction activities of the Institute. Dr. A. K. Lohani, Scientist "G" served as the Chief Vigilance Officer of NIH during the year.

As a compulsory requirement, Annual Property Returns of all Group A and B employees for the year ending 31st December 2022 were received, checked and verified by the Chief Vigilance Officer. The Director, Senior Administrative Officer, Finance Officer and other officers were updated with the instructions of CVC and DoWR, RD & GR, Ministry of Jal Shakti from time to time for making the rules and procedures more transparent in day-to-day functioning of the Institute. Instructions of CVC regarding transparency in tendering system, e-governance, and adoption of e-purchase procedures were pursued with the Head of the Institution for compliance and transparent functioning in major procurement matters.

As per CVC directives and letter no. C-31018/5/2022-VIG dated 28 September, 2022, the Vigilance Awareness Week (VAW-2022) was observed in NIH and its Regional Centres from 31st Oct. – 6th Nov., 2022. The theme of VAW – 2022 was "Corruption Free India for a developed Nation".

During the VAW - 2022, a pledge was administered to all the employees of the Institute by the Director at NIH, Roorkee and by the respective Head/Officer-in-Charge at Regional Centres. Banners and posters were displayed at various locations for spreading the message of integrity and transparency. Special banners related to PIDPI initiative were also displayed and its information was widely spread. Further, to spread the message of Vigilance Commission among the general public, a slogan competition on the theme of VAW – 2022 was organized and 79 slogans were received from general public of Roorkee and NIH employees. The valedictory function of the VAW–2022 was organized on November 07, 2022. Smt. Nupar Verma, Deputy Collector Haridwar was the Chief Guest of the function. She, along with Director, distributed the prizes to the winners of various competitions. Following activities were organized at NIH Roorkee on this occasion:

S. No.	ACTIVITY	TOPIC	DATE
1.	Oath	Vigilance Awareness Week - 2022	31st October, 2022
2.	Drawing Competition	"Corruption Free India for a developed Nation"	01 November, 2022
3.	Debate Competition	Corruption is the only curse for the development of a nation	02 November, 2022
4.	Essay Competition	Corruption has haunted India's growth	03 November, 2022
5.	Slogan Competition	"Corruption Free India for a developed Nation	04 November, 2022
6.	Vigilance Awareness Week (CFMS, Patna)	"Corruption Free India for a Developed Nation"	31-10-2022 to 06-11-2022

Director, NIH administering the Integrity pledge to NIH employees

Winning children of Drawing competition receiving the prize

Winner of Essay competition receiving the prize

Essay competition in progress during VAW - 2022

Winner of Debate competition receiving the prize

Winner of Slogan competition receiving the prize

18 Right to Information (RTI) Act

The Right to Information Act-2005 provides for setting out the practical regime of right to information for citizens of India to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority. "Information", according to the Act, means any material in any form, including records, documents, memos, e-mails, opinions, advices, press releases, circulars, orders, log books, contracts, reports, papers, samples, models, and data material held in any electronic form. The "right to information" means the right to information accessible under this Act and includes the right to: (i) inspection of work, documents, records; (ii) taking notes, extracts or certified copies of documents or records; (iii) taking certified samples of material; and (iv) obtaining information in the form of diskettes, floppies, tapes, video cassettes or in any other electronic mode or through print-outs where such information is stored in a computer or in any other device.

As per section 5 of the Act, every public authority has to designate the Central Public Information Officers (CPIO) or State Public Information Officers (SPIO), in all administrative units or offices under them, as may be necessary to provide information. The CPIO or SPIO, as the case may be, may seek the assistance of any other officer as he or she considers it necessary for the proper discharge of his or her duties. Any officer, whose assistance has been sought, shall render all assistance to the CPIO or SPIO. Where an application is made to a public authority requesting for an information which is held by another public authority; or the subject matter of which is more closely connected with the functions of another public authority, the public authority, to which such application is made, shall transfer the application or such part of it as may be appropriate to that other public authority and inform the applicant immediately about such transfer.

Right to Information Act-2005 mandates timely response to citizen requests for government information. The name, designation and address of the appellate authority, PIO and APIO for HQ and the RC's of NIH are given under Right to Information Act menu in NIH website

http://ww:nihroorkee.gov.in

During the year 2022-23, total 99 applications were received at the headquarters for seeking information under the RTI Act and all have been disposed of within the prescribed time limit.

Awareness Activities 19

Public or mass awareness is the process of informing the general public about the important issues like conservation and management of water resources in different hydrological regions. Department of Water Resources, River Development & Ganga Rejuvenation under Ministry of Jal Shakti, Government of India lays special emphasis on organization of public/mass awareness programs on water conservation and its management. The National Institute of Hydrology is carrying out mass awareness programs in different areas, participation and organization in various exhibitions, distribution of pamphlets and informative material, advertisements in newspapers, web publishing etc. Besides the awareness programme on water conservation, the Government of India is also giving special emphasis to various other mass awareness programmes like Azadi ka amrit mohatsav@ 75 years (Phase I & II), Swachhta Pakhwada 2023, under Swachh Bharat Mission and Poshan Pakhwara. Azadi Ka Amrit Mahotsav is an initiative of the Government of India to celebrate and commemorate 75 years of independence and the glorious history of India' people, their culture and achievements. This Mahotsav is dedicated to the people of India who have not only been instrumental in bringing India thus far in its evolutionary journey but also hold within them the power and potential to enable government's vision of activating India 2.0, fuelled by the spirit of Aatmanirbhar Bharat. Accordingly, a large number of activities related to these programmes were organized at the Institute and its regional centers during 2022-23. The Institute celebrated a number of activities during Swachhta Pakhwada (16-31 March, 2023) under Swachh Bharat Mission. Various activities namely motivational and awareness programs for schoolchildren, and women on Swachhta and water conservation were held. A number of awareness activities related to the official language Hindi were also organized by the Institute during the year to promote the use of Hindi. Similarly, various awareness activities were also organized during the year under the Vigilance Awareness Week. The list of various mass awareness programs, organized by the Institute during 2022-23 is given at Appendix XV.

Workshop for Women under Swachchata Pakhwada in the Institute on 31.03.2023

An educational visit for the students of GIC, Podowali, Khanpur (Dist. Haridwar) on 03.02.2023

Workshop for sensitizing Women under Poshan Maah-2022 in Jeevan Jyoti Inter College, Mewar Kalan, Roorkee, Haridwar on 30.9.2022

Essay Competition in Mahila Vidyalaya Mandal English Medium School, Belagavi under Azadi Ka Amrit Mahotsav on 22.02.2023

Awareness workshop in Methodist Girls PG College, Roorkee under Azadi ka Amrit Mahotsav on 03.8.2022

Drawing and Essay writing competition under Azadi ka Amrit Mahotsav (2nd Phase)at DRC Kakinda on 25.1.2023

Celebration of 'World Water Day' at CFMS- NIH, Patna on 22.3.2023

Awareness Activityin Govt. Upper Primary School, Jhabredi Kalan (Haridwar)under AKAM@ India 75 on 04.05.2022

Painting and Speech Competition at GMMS Satwari, Jammu under Swachhata Pakhwada on 30th March 2023

Plantation drive in WALMI Campus, Bhopal under Swatchta Pakhwada on 28.3.2023.

Participation in National/International Level Exhibitions

National Level Exhibition on "Rise in Uttarakhand-2022" during 07-09 July, 2022 at Dehradun, Uttarakhand (Visit of Shri Pushkar Singh Dhami, Hon'ble CM)

National Level Exhibition on "Rise in Uttarakhand-2022" during 07-09 July, 2022 at Dehradun, Uttarakhand (Visit of Shri Satpal Maharaj, Hon'ble Minister of Tourism; Shri Naresh Bansal, Hon'ble MP-Rajya Sabha)

Ninth Indian National Exhibition cum Fair 2022, 4-8 August, 2022 at Kolkata

Jaipur Expo 2022 during 22-24 September, 2022 at Jaipur, Rajasthan

Aspiring Haryana 2022 during 28-30 July, 2022 at Hisar, Haryana

108th Indian Science Congress (ISC) at Rashtrasant Tukadoji Maharaj Nagpur University (RTM Nagpur University, Nagpur) during 03-07 January 2023

Vision Rajasthan 2022 at Sirohi, Rajasthanduring 1st to 3rd November, 2022

7th India Water Week 2022 at India Expo Centre, Greater Noida during 01-05 November, 2022 (Visit of Shri Bishweswar Tudu, Hon'ble MoS, MoJS, GoI)

7th India Water Week 2022 at India Expo Centre, Greater Noida during 01-05 November, 2022 (Visit of Shri Prahlad Singh Patel, Hon'ble MoS, MoJS, GoI)

Community interaction and water conservation awareness programme during Jal Shakti Abhiyaan (MoJS, GoI), July 8, 2022 at Bagheshwar, Uttarakhand

G20 Summit at Gandhinagar, Gujarat during 27-29 March, 2023

e-Governance

20

A lot of emphasis is being given for implementing various e-Governance activities in the Institute. The e-Governance Cell, headed by a Scientist-G, has been working to plan and supervise various activities for the implementation of e-Governance in the Institute. Internet connectivity of 1Gbps is available in the institute under the National Knowledge Network (NKN) framework of the government of India and the BSNL Network is also available for backup. The Institute is availing the cloud services provided by NIC, Bhubaneshwar and is being used for e-office and website hosting. During the year 2021-22, the Institute website was regularly updated as per the Guidelines for Indian Government Website (GIGW). The Institute website has been granted the status of Certified Quality Website as per GIGW 2.0, Level 1 by the STQC Department, Ministry of Electronics and Information Technology, Govt. of India. The social media team of the Institute is actively working in posting the activities of the Institute and the Ministry of Jal Shakti on various social media platforms like Facebook, Twitter, Instagram, YouTube etc. for public awareness.

Following e-Governance related activities are being implemented at NIH so far:

Library	• Operation of the library automation software Web-Centric LIBSYS 10 EJB • Subscription of online journals related to hydrology and water resources • Creation of Institutional Digital Repository (IDR) of NIH's publication. • Membership under the National Digital Library to most of the scientists.
Computer Centre	• Updating the NIH website as per Guidelines for Indian Government Website (GIGW). • Providing the institute's information to the e-Governance Cell of DoWR, Ministry of Jal Shakti on fortnightly basis for the ministry's website. • Operationalization of High-Speed NKN Network connectivity. • Providing Gov. email services to all the employees of the Institute including its regional centers. • Providing data and cyber security to the users of the Institute. • Providing the support to organize video conferencing and virtual meetings and online Interview. • Providing the operational and technical support to smoothly run the e-HRMS activities in the Institute and its regional centers. • Providing the operational and technical support to smoothly run the e-Office in the Institute and its Regional Centres. • Regularly updating the information of R&D activities of the Institute and its Regional Centres on social media.
Administration/ Finance Section	• Implementation of e-HRMS • Implementation of e-Office • Implementation of Aadhaar Based Attendance System (ABAS) • Implementation of PFMS system • Operationalization of e-tendering and GeM procurement • Generation of Salary slips of employees through software and its distribution through e-mail.

	• Computation of income tax of individuals through spreadsheet and software • Online transfer of unspent balance under Non-Recurring head and interest earned to the Government account as "Bharat Kosh". • Online uploading of data of autonomous bodies' Bharat Kosh on the Government site • Online uploading of Form 16 through TDS Reconciliation Analysis and Correction Enabling System • Maintaining CPF account and interest calculation through software • Online transfer of funds to regional centres of NIH • Online payment to individuals/vendors and intimation through e-mail • Online uploading of NPS subscription & contribution and transaction of NPS funds • Online transaction of GST, GTDS amount of contactors and consultancy projects to the Government

Welfare of Women Employees 21

Various measures for welfare of women employees are taken by NIH.

Committee for Protection of Women against Harassment

As per directives of the Govt. of India, a committee was constituted to look into the complaints of women employees working in the Institute. The members of the committee include lady employees of Group A, B and C categories in the Institute with Senior Administrative Officer as the Member-Secretary. The terms of reference of the committee are as follows:

i) To receive complaints on incidents of sexual harassment in workplace in the Institute.

ii) To investigate all issues related with such complaints and report to Director for taking proper action against the offender(s).

iii) Evolve suitable mechanism for non-recurrence of such events and prevention of sexual harassment of women employees in workplace.

During 2022-23, the committee received no case of harassment or complaint.

Child Care Leave and Maternity Leave

During 2022-23, one (1) women employee of the Institute availed the Child Care Leave and maternity leave admissible to the women employees.

Encouragement in Technical Activities

During 2022-23, the women employees were encouraged to participate in national/international conferences, training courses and other activities of the institute.

22 Welfare of SC/ST and OBC Employees

The Institute is implementing Reservation Policy in vacancies to SC/ST and OBC employees as per the Govt. of India instructions. Accordingly, separate rosters for direct recruitment and promotions are being maintained in the Institute. Actions for filling the vacant posts of reserved category are taken up regularly.

The group-wise staff strength of the Institute indicating posts of SC/ST and OBC category at the end of the year 2022-23 is given below:

GROUP	TOTAL	SC	ST	OBC
A	70	10	04	14
B	50	08	02	07
C	43	13	-	11
TOTAL	**163**	**31**	**06**	**32**

Liaison Officers for SC/ST and OBC employees have been functioning in the Institute effectively. During 2022-23, the Liaison Officers ensured the compliance of various reservation orders and benefits admissible to SC/ST and OBC employees in the Institute. The rosters maintained in the Institute were scrutinized from time to time and the reports and returns were submitted to the DoWR, RD & GR, Ministry of Jal Shakti at regular intervals as specified. Queries and grievances of SC/ST and OBC candidates in connection with appointment/ promotion were also taken care of by the Liaison Officer.

At the end of year 2022-23, status of various activities for SC/ST/OBC employees of the Institute is given below:

ACTIVITY	STATUS
Promotion of eligible SC/ST employees	Nothing is pending
MACP's of eligible SC/ST & OBC employees	Nothing is pending
Grievances of SC / ST employees	Nothing is pending
SC/ST member in selection/promotion Committees	One officer in each committee
Study leave to SC/ST/OBC employees	-
SC/ST employee on Lien	-
Appointment of new SC/ST employee	Dr. Kalzang Chhoden, (Sc. C) Sh.Shubham Kumar Meena (SRA) Shri Hakim Singh Meena (RA)
Appointment of new OBC employees	Shri Abhilash R. (Sc.C) Shri Anil Kumar (RA) Shri Asif (RA)

Welfare of Differently Able Employees

23

For effective implementation of the Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act, 1995; the Institute is following reservation in vacancies for the persons with disabilities, as per Government of India instructions. Accordingly, the Institute is maintaining separate reservation roster register in the prescribed format for determining/effective reservation for the disabled – one each for Group A, Group B and Group C posts filled by direct recruitment; and one for Group C posts by promotion.

Relaxation in upper age limit for persons with disabilities is also given as per Government of India guidelines.

The Institute has appointed a Liaison Officer to ensure that all the reservation orders and benefits admissible to persons with disabilities are implemented to the Institute. The Liaison Officer is also required to ensure that the roster is being maintained properly in the Institute and the relevant reports and returns are submitted to the Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation, Government of India at regular intervals as specified.

At the end of the year 2022-23, the group-wise staff strength of the disabled persons is given below:

GROUP	TOTAL STAFF STRENGTH	PERSONS WITH DISABILITIES		
		Visually Handicapped	Hearing Handicapped	Orthopedically Handicapped
Group A	70	01	-	-
Group B	50	-	-	01
Group C	43	-	-	
Total	**163**	01	-	01

24 NIH Employees Welfare Activities

The Institute is working for the welfare of its employees through various activities. Main activities are as given below:

NIH Benevolent Fund Scheme

The NIH Benevolent Fund Scheme for the staff of the Institute was approved in the 44th meeting of the Governing Body of NIH held on March 18, 1994. The scheme has been implemented and working smoothly through contribution by employees and an equal matching grant from Government of India since 1994. Assistance is being provided to the Member/Member's Family from NIH Benevolent Fund. During 2022-23, no request for assistance was received. Total 10 employees of the Institute have received the benefit under this scheme since its inception until 31.03.2023.

NIH Cooperative Society

The NIH Cooperative Society was formed with the objective to create thrift and savings among the employees; to make available loans at low interest without any security; to start a 'General Provision Store' for the benefit of the employees etc. The NOC for opening the 'General Provision Store' was approved in 48th meeting of Governing Body of NIH held on 25 March, 1996. NIH Cooperative Society was registered with Registration No. 2349 vide letter No. 996-98/Nibandhan, dated 4/11/1997, from the Office of Assistant Registrar, Cooperative Societies, Saharanpur, Uttar Pradesh. The NIH Cooperative Society is run by a “Sanchalak Mandal” elected from amongst its members. At present, there are nine members in the “Sanchalak Mandal”. NIH Cooperative Society functions with the money collected under Compulsory Deposit (CD) Scheme. Presently, each member deposits @ Rs. 500/- per month under CD scheme. This CD money is returned only at the time of surrendering the membership of the Cooperative Society. Presently NIH Cooperative Society collects funds of Rs. 15.50 lakhs per month on an average from Compulsory Deposits, Recurring Deposits and recovery of loans.

The Society had 139 members as on 31.03.2023. During the year 2022-23, medium term loan was sanctioned and provided to 39members amounting to Rs. 1.39 crores and short-term loan was sanctioned and provided to 12members amounting to Rs. 11.9 lakhs. The total loan against the employees including the earlier years' backlog is Rs. 3.72 crores.

NIH Society

APPENDIX-I

PRESIDENT			
1	Hon'ble Union Minister for Jal Shakti, Government of India, Shram Shakti Bhawan, Rafi Marg, New Delhi-110 001		
VICE-PRESIDENT			
2	Hon'ble Minister of State for Jal Shakti, Government of India, Shram Shakti Bhawan, Rafi Marg, New Delhi-110 001		
MEMBERS			
3	Advisor (Water Resources), National Institution for Transforming India (NITI), Room No. 233, Yojna Bhawan, Sansad Marg, New Delhi-110 001	4	Hon'ble Minister of Jal Shakti, Irrigation and Water Res. Dept., Bapu Bhawan, Govt. of UP, Lucknow-226001
5	Hon'ble Minister of Water Resources Punjab Vidhan Sabha Secretariat Sector -1, Chandigarh-160 001	6	Hon'ble Minister of Water Resources Secretariat Panaji , Goa
7	Hon'ble Chief Minister and Minister for Water Resources, Govt. of Telangana 5th Floor, Burgula Rama Krishna Rao Bhawan, NH44, Hill Fort, Adarsh Nagar, Hyderabad – 500063	8	Hon'ble Minister for Water Resources, Water Resources Department, Govt. of Madhya Pradesh Jal Sansadhan Bhawan, Tulsi Nagar Bhopal - 462003
9	Dr. Rajeev Rai Bhatnagar, Advisor to Hon'ble Lieutenant Governor, UT of Jammu & Kashmir, Jal Shakti Department, 2/44, Main Building, Civil Secretariat Jammu -180001	10	Hon'ble Minister-in-Charge, Dept. of Water Resources, Govt. of Odisha Kehari Nagar Bhubaneswar-51001
11	Hon'ble Minister of Irrigation Govt. of Tripura New Secretariat, New Capital Complex Agartala (Tripura)	12	Hon'ble Minister of Irrigation (Water Resources), Government of Andhra Pradesh, Mogalrajapuram, Vijayawada (AP)-520010
13	Hon'ble Minister of Irrigation (Water Resources Department) Govt. of Arunachal Pradesh Civil Secretariat Itanagar-791111	14	Prof. Ajit Kumar Chaturvedi, Director, Indian Institute of Technology, Roorkee-247 667

15	Dr. Narendra Singh Raghuwanshi Director Maulana Azad National Institue of Technology, Link Road Number 3, Near Kali Mata Mandir, Bhopal-462003	16	Director, Indian Institute of Remote Sensing 4, Kalidas Road, Hathi Barkala Dehradun-248001
17	Director, Centre for Environment and Developent Studies, BB-92, Nityanand Nagar, Gandhi Path, Queen Road Jaipur-302021	18	Dr. Rajendra Singh, Brahmaputra Chair Professor for Water Resources, Department of Agriculture and Food Engineering, Indian Institue of Technology, 1-161, IIT Campus, Kharagpur-721302
19	Er. R. D. Singh Ex-Director, NIH 348, Friends Lane, Solanipuram Roorkee-247667	20	Prof. N. K. Goel Department of Hydrology Indian Institue of Technology Roorkee-247667
21	Sh. A. K. Bajaj, Ex-Chairman Central Water Commission, C-71, GF, Defence Colony, New Delhi-110024	22	Prof. Chandan Mahanta, Professor and Head Department of Civil Engineering Indian Institute of Technology Guwahati
23	Dr. Debasis Chaterjee Profesor and Ex-Head, Department of Chemistry, University of Kalyani, Flat No. A/1/10, 312, B.B. Chaterjee Road, Kolkata-700042 (WB)	24	Shri. Gopal Singh Bhati, Chief Engineer (Retired), Royal Cottage, Krsna Kunj Enclave, Ramdeora Road, Gomat Pokhran – 345021 (Rajasthan)
25	Secretary to Govt. of India, Department of Water Resources, RD & GR, Ministry of Jal Shakti, Shram Shakti Bhawan, Rafi Marg, New Delhi-110 001	26	Secretary to Govt. of India, Ministry of Science & Technology, Department of Science & Technology, Technology Bhawan, New Mehrauli Road, New Delhi-110 029
27	Secretary to Govt. of India, Ministry of Agriculture & Co-operation, Krishi Bhawan, New Delhi-110 001	28	Secretary to Govt. of India, Ministry of Power, Shram Shakti Bhawan, Rafi Marg, New Delhi-110 001.
29	Joint Secretary & Financial Advisor, Dept. of Water Resources, RD & GR, Ministry of Jal Shakti Shram Shakti Bhawan, Rafi Marg, New Delhi-110 001	30	Secretary to Govt. of India, Ministry of Urban Development, Nirman Bhawan, New Delhi-110 002
31	Chief Executive Officer (CEO), National Institution for Transforming India (NITI), Yojna Bhawan, Sansad Marg, New Delhi-110 001	32	Secretary to Govt. of India, Ministry of Environment, Forest & Climate Change, Indira Paryavaran Bhawan, Aliganj, Jor Bagh Road, New Delhi-110 003

33	Secretary to Govt. of India, Department of Drinking Water and Sanitation, Ministry of Jal Shakti C Wing, 4th Floor, Paryavaran Bhawan, CGO Complex, Lodhi Road, New Delhi – 110 003	34	Chairman, Central Water Commission, R. No. 315, Sewa Bhawan, R.K. Puram, New Delhi-110 066
35	Additional Secretary to Govt. of India, Department of Water Resources, RD & GR, Ministry of Jal Shakti Shram Shakti Bhawan, Rafi Marg, New Delhi -110 001	36	Member (D&R), Central Water Commission, Seva Bhawan, R.K. Puram, New Delhi – 110 066
37	Chief Engineer (Hydrology Studies Organization), Central Water Commission, Seva Bhawan, R.K. Puram, New Delhi-110 066.	38	Chairman, Central Electricity Authority, Seva Bhawan, R.K. Puram, New Delhi-110 066.
39	Chairman, Central Ground Water Board, Jamnagar House, Man Singh Road, New Delhi-110 001	40	Director General, India Meteorological Department, Lodhi Road, New Delhi-110 003
41	Director General, Geological Survey of India, 27, Jawaharlal Nehru Road, Dharmatala, Taltala, Kolkata (W.B.)-700016	42	Chairman, Central Pollution Control Board, CBD-cum-Office, East Arjun Nagar, New Delh-110 021
43	Director (R&D), Dept. of Water Resources, RD & GR, Min. of Jal Shakti, 1st Floor, Wing-4, West Block, R.K. Puram, New Delhi-110 066	44	Joint Secretary (Admn), Dept. of Water Resources, RD & GR, Min. of Jal Shakti,Shram Shakti Bhawan, Rafi Marg, New Delhi-110 001
45	Joint Secretary (RD & PP), Dept. of Water Resources, RD & GR, Min. of Jal Shakti, Shram Shakti Bhawan, Rafi Marg, New Delhi-110 001	46	Commissioner (FM), Dept. of Water Resources, RD & GR, Min. of Jal Shakti, Block 11, 8th Floor, CGO Complex, Lodhi Road, New Delhi-110 001
		MEMBER SECRETARY	
47	Commissioner (SPR), Dept. of Water Resources, RD & GR, Shram Shakti Bhawan, Rafi Marg, New Delhi-110 001	48	Director, National Institute of Hydrology, Roorkee (Uttarakhand)-247 667

APPENDIX-II

Governing Body

CHAIRMAN			
1.	Secretary to Govt. of India, Department of Water Resources, River Development and Ganga Rejuvenation Ministry of Jal Shakti, New Delhi		
VICE-CHAIRMAN			
2.	Director Indian Institute of Technology, Roorkee		
MEMBERS			
3.	Chairman or Member, Central Water Commission, New Delhi	4.	Additional Secretary, Dept. of Water Resources, RD & GR Ministry of Jal Shakti, New Delhi
5.	Joint Secretary (Finance) and Financial Advisor, Dept. of Water Resources, RD & GR Ministry of Jal Shakti New Delhi	6.	Advisor (Water Resources), NITI Ayog (Planning Commission), New Delhi (Representative of Planning Commission)
7.	Head (NRDMS & NSDI), Ministry of Science & Tech., (Dept. of Science & Technology), New Delhi (Representative of Ministry of Science & Technology, Govt. of India)	8.	Adviser (PHEE), CPHEEO, Ministry of Urban Development (Dept. of Urban Development), New Delhi (Representative of Ministry of Urban Development, Govt. of India)
9.	Advisor / Joint Secretary, National River Conservation Directorate, Ministry of Environment, Forests & CC New Delhi (Representative of Min. of Environment, Forests & CC, Govt. of India)	10.	Chief Engineer (Hydrology), Water Resources Development Organization, Govt. of Karnataka Bangaluru (Representative of Govt. of Karnataka)
11.	Principal Secretary (Irrigation), Government of Uttar Pradesh, Lucknow	12.	Secretary (Irrigation) Govt. of Uttarakhand, Dehradun
13.	Chief Engineer (I&FCD), Govt. of Jammu & Kashmir, Jammu (Representative of Govt. of Jammu & Kashmir)	14.	Engineer-in-Chief (Irrigation Wing), Govt. of Andhra Pradesh Hyderabad (Representative of Govt. of A.P.)
15.	Chief Engineer, Major Irrigation Irrigation Department, Govt. of Assam, Guwahati (Representative of Govt. of Assam)	16.	Chief Engineer (BODHI), Water Resources Development Govt. of Madhya Pradesh, Bhopal (Representative of Govt. of M.P.)
17.	Secretary Water Resources Department, Govt. of Bihar, Patna (Representative of Govt. of Bihar)	**MEMBER SECRETARY**	
		18.	Director, National Institute of Hydrology, Roorkee

Standing Committee

APPENDIX-III

CHAIRMAN	
1.	Special Secretary/Additional Secretary to Govt. of India, Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti New Delhi
MEMBERS	
2.	Financial Advisor & Joint Secretary (Finance), Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti New Delhi
3.	Joint Secretary, Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti New Delhi
4.	Representative of DST (not below the rank of joint Secretary) Department of Science & Technology, New Delhi
MEMBER SECRETARY	
5.	Director, National Institute of Hydrology, Roorkee

APPENDIX-IV

Technical Advisory Committee

CHAIRMAN			
1.	Chairman, Central Water Commission Govt. of India New Delhi		
MEMBERS			
2.	Member (D&R) Central Water Commission, New Delhi	3.	Chief Engineer (HSO) Central Water Commission New Delhi
4.	Director National Institute of Hydrology, Roorkee	5.	Chairman, Central Ground Water Board, Bhujal Bhawan, NH-IV, Faridabad-121001
6.	Representative of India Meteorological Department, New Delhi		
7.	A Professor engaged in research in Water Resources areas from IIT, Roorkee		
8.	A Professor engaged in research in Water Resources areas from any one of the other six IITs		
9.	A Professor engaged in research in Water Resources areas from one of the State Universities		
10.	Director of one of the Water Technology Centres: Water Technology Centre, Indian Agricultural Research Institute (IARI), Pusa,New Delhi – 110012		
11 & 12	Two Experts of Hydrology in individual capacity: i) Dr. Suhas P. Wani, International Rice Research Institute South Asia Regional Centre NSRTC Campus, G.T. Road, Collectry Farm P.O. Industrial Estate Varanasi (U.P.)- 221 106 ii). Prof. Rohit Goyal, Department of Civil Engineering MNIT, Jaipur		
13.	Head of one of the State Hydrology Cells: State Water Data Centre near WALMI Campus, Gandhinagar, Gujarat		

14.	Expert from Non-Government Scientific Organization in the field of Hydrology: Dr. Himanshu Kulkarni, ACWDAM, Pune
15.	Commisiner PP, Dept. of Water Res., Ministry of Jal Shakti, New Delhi
16 & 17	Two Nominees of the Water related industries: i). Nominee of NHPC ii). Nominee of WAPCOS
18	Special Nominee: Prof. Arup Sarma Department of Civil Engineering IIT Guwahati
19	Representative of IWMI, New Delhi
20.	Representative of UNESCO, New Delhi
21	**MEMBER SECRETARY** (Scientist G/F, to be nominated by Director, National Institute of Hydrology, Roorkee)
	Head, RMO Division,NIH, Roorkee

APPENDIX-V

Working Group

(As approved by 78th Governing Body)

CHAIRMAN			
Director, National Institute of Hydrology Roorkee			
MEMBERS			
A) Central Government Organizations (Including R & D Organizations)			
1.	Two Nominees (Director Level) CWC, New Delhi	2.	Nominee of CGWB, Faridabad
3.	Nominee of IMD, New Delhi	4.	Nominee of CPCB, New Delhi
5.	Nominee of NWDA, New Delhi	6.	Nominee of Department of Drinking Water and Sanitation, Ministry of Jal Shakti Govt. of India, New Delhi
7.	Nominee of Ministry of Environment & Forest (NRCD), GoI	8.	Nominee of North East Council, Shillong
9.	Nominee of Ministry of Earth Sciences, Govt. of India	10.	Nominee of Ministry of Agriculture (NRM), Govt. of India
11.	Nominee of Geological Survey of India, Kolkata	12.	Director, NIC, New Delhi
13.	Indian Institute of Tropical Meteorology, Pune	14.	ICAR-Indian Institute of Soil & Water Conservation, Dehradun
15.	Wadia Institute of Himalayan Geology, Dehradun	16.	GBP National Institute of Himalayan Environment & Sustainable Development, Almora
17.	National Institute of Disaster Management, New Delhi	18.	BARC, Mumbai
19.	Physical Research Laboratory, Ahmedabad	20.	CAZRI, Jodhpur
21.	NEERI, Nagpur	22.	Forest Research Institute, Dehradun
23.	IIRS, Dehradun	24.	NGRI, Hyderabad
25.	ICAR-IARI, New Delhi	26.	Nominee of Brahmaputra Board, Guwahati
B) State Government Organizations (including R & D Organizations)			
27.	Nominee of Water Resources Department, Karnataka	28.	Nominee of State Water Investigation Directorate, West Bengal
29.	Nominee of Water Resources Department, Orissa	30.	Nominee of Water Resources Department, Madhya Pradesh

31.	Nominee of Ground Water Department, Maharashtra	32.	Nominee of Water Resources Department, Punjab
33.	Nominee of Water Resources Department, Chhattisgarh	34.	Nominee of Jal Sansthan, Uttarakhand
35.	Nominee of Ground Water Department, Andhra Pradesh	36.	Nominee of Ground Water Department, Telangana
37.	Gujarat Pollution Control Board, Gandhinagar	38.	CWRDM, Kozhikode
39.	Nominee of Water Resources Department, Rajasthan	40.	Irrigation Research Institute, Roorkee
C) Academic Institutions			
41.	Dr. Varun Joshi, Professor University School of Environment Management, Guru Gobind Singh Indraprastha University, New Delhi	42.	Prof. K. K. Singh Department of Civil Engineering NIT Kurukshetra, Haryana
43.	Prof. Vimal Mishra Civil Engineering Department IIT Gandhinagar, Gujarat	44.	Prof. A. K. Saraf Department of Earth Sciences IIT Roorkee, Uttarakhand
45.	Prof. M L Kansal Department of Water Resources Development & Management IIT Roorkee, Uttarakhand		
D) Members in Individual Capacity (including NGOs)			
46.	Dr. Bhishm Kumar Prof. Staff & Advisor (Retd.), IAEA, Roorkee	47.	Dr. S. S. Grewal Director (Retd), Reg. Station of PAU-Ludhiana, Chandigarh
48.	Dr. C. T. Dhanya Assistant Professor, IIT Delhi, New Delhi	49.	Dr. Kaushal K. Garg Senior Scientist-NRM ICRISAT, Hyderabad, Telangana
50.	Prof. Ramakar Jha NIT Patna, Bihar	51.	Prof. A. P. Dimri Jawaharlal Nehru University, New Delhi
52.	Dr. Debashish Sen, Director Peoples Science Institute, Dehradun	53.	Dr. Sadhna Malhotra (Economist) Director, Mindspace, Dehradun
54.	Mr. Sudhindra Mohan Sharma Consultant, Ex-Nodal Officer National Drinking Water Security Pilot Projects, MoDWS (GoI), Indore		
E) Internal (NIH)			
55.	Divisional Head, SWH Div. NIH	56.	Divisional Head, GWH Div. NIH

57.	Divisional Head, EH Div. NIH	58.	Divisional Head, HI Div. NIH
59.	Divisional Head, WRS Div. NIH	60.	Divisional Head, RMOD Div. NIH
MEMBER SECRETARY			
Head (RMOD),NIH, Roorkee			

Regional Coordination Committees

APPENDIX-VI

DECCAN HARD ROCK REGIONAL CENTRE, BELGAUM			
CHAIRMAN			
1.	Director, National Institute of Hydrology, Roorkee		
MEMBERS			
Central Govt. Institutions			
2.	Regional Director Central Ground Water Board, Bangalore	3.	Chief Engineer Krishna and Godavari Basin Organization, CWC, Hyderabad (Telangana)
4.	Nominee of Director Indian Institute of Tropical Meteorology (IITM), Pashan, Pune	5.	Nominee of Director NRSC, Balanagar, Hyderabad (Telangana)
State Govt. Institutions			
6.	Chief Engineer Water Resources Development Organization, Bangalore	7.	Chief Engineer Water Resources Dept., Goa
8.	Chief Engineer (Project II and HP-II) Kerala State Irrigation Department, Thiruvanthapuram, Kerala	9.	Chief Engineer Hydrology Project (Surface Water), Nashik
10.	Chief Engineer State Ground and Surface Water Resources Data Centre, Chennai	11.	Director Groundwater Survey and Development Agency, Pune
12.	Director State Groundwater Dept., Thiruvanthapuram	13.	Director, State Ground Water Department, Hyderabad
14.	Chief Engineer (Hydrology) I&CAD Dept., Hyderabad	15.	Director, WTC, TNAU, Coimbatore, Tamil Nadu
Academic Institutions			
16	Nominee of Director NIT Trichy, TN	17.	Nominee of Director IISc Bangalore
NGOs and Individual Experts			
18.	Prof. Lakshman Nandagiri Dept. of Applied Mechanics, NIT Surathkal, Karnataka	19.	Prof. AG Chachadi Dept. of Earth science, Goa University,Goa
20.	Director Ashoka Trust for Research in Ecology and Environment, Bangalore	21.	Director Dhan Foundation, Madurai, Tamil Nadu

MEMBER SECRETARY			
22.	Head, Deccan Hard Rock Regional Centre, NIH Belgaum		
WESTERN HIMALAYAN REGIONAL CENTRE, JAMMU			
CHAIRMAN			
1.	Director, National Institute of Hydrology, Roorkee		
MEMBERS			
Central Govt. Institutions			
2.	Regional Director North West Himalayan Region (NWHR), Central Ground Water Board, Jammu	3.	Nominee of Director Snow & Avalanche Study Establishment (RDC), Him Parisar, Chandigarh
4.	Nominee of Director GB Pant Institute of Himalayan Environ. & Development, Almora (Uttarakhand)	5.	Chief Engineer (Indus Basin) Central Water Commission, Chandigarh
6.	Director India Meteorological Department (IMD), Srinagar	7.	Nominee of Director Wadia Institute of Himalayan Geology, Dehradun
8.	Regional Director Geological Survey of India, Jammu	9.	Director Central Water Commission, Jammu
10.	Representative of Bhakra Beas Management Board, Chandigarh		
State Govt. Institutions			
11.	Chief Engineer Irrigation and Flood Control Department (I&FC, J&K), Jammu	12.	Nominee of Engineer-in-Chief Irrigation and Public Health (I&PH) Department (HP), Shimla
13.	Nominee of Engineer-in-Chief Irrigation Department (Uttarakhand Govt.), Dehradun	14.	Regional Director J & K State Pollution Control Board, Jammu
Academic Institutions			
15.	Chief Scientist & Head (WM) Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), Jammu	16.	Nominee of Director National Institute of Technology (NIT), Srinagar
17.	Nominee of Vice-Chancellor Himachal Pradesh Krishi Vishav-vidalaya (HPKV), Palampur		
NGOs and Individual Experts			
18.	Prof. M. N. Kaul Department of Geography, University of Jammu, Jammu	19.	Mr. Chewang Norphel Chief Project Officer, Leh Nutrition Project, Leh, Laddakh, J&K
20.	Maj. Gen. (retd) G. S. Jamwal President, J&K Paryavaran Sansthan, Jammu		

MEMBER SECRETARY			
21.	Head, Western Himalayan Regional Centre, NIH Jammu		
CENTRAL INDIA HYDROLOGY REGIONAL CENTRE, BHOPAL			
	CHAIRMAN		
1.	Director, National Institute of Hydrology,Roorkee		
MEMBERS			
Central Govt. Institutions			
2.	Chief Engineer Narmada Basin, Central Water Commission (CWC), Bhopal	3.	Regional Director North Central Region (NCR), Central Ground Water Board (CGWB), Bhopal, Madhya Pradesh
4.	Director Meteorological Centre, India Meteorological Department (IMD), Bhopal	5.	Nominee (dealing with water resources) of Director, CSIR-AMPRI Regional Research Laboratory (RRL), Bhopal
6.	Representative of Central Pollution Control Board (CPCB) Zonal Office, Bhopal		
State Govt. Institutions			
7.	Chief Engineer BODHI, Bhopal	8.	Chief Engineer Chambal Betwa Basin, Water Resources Department (WRD), Bhopal
9.	Chief Engineer Dhasan-Ken Basin, WRD, Sagar	10.	Chief Engineer MG Basin, Raipur, Chhattisgarh
11.	Chief Engineer Betwa Pariyojna, Jhansi (UP)	12.	Chief Engineer Sone Basin, Bihar
13.	Superintending Engineer Ground Water Survey, WRD, Bhopal	14.	Nominee of MP Council of Science & Technology
Academic Institutions			
15.	Chief Engineer, & Director Irrigation Management and Training Institute (IMTI), Kota	16.	Nominee of Director (dealing with water resources) MANIT Bhopal, Madhya Pradesh
17.	Nominee of Director Water and Land Management Institute (WALMI), Bhopal		
NGOs and Individual Experts			
18.	Samaj Pragati Sahyog, Dewas	19.	Development Alternatives, Jhansi

20.	Dr. Salim Romani Chairman (Retd.), Central Ground Water Board (CGWB), Bhopal		
MEMBER SECRETARY			
21.	Head, Central India Hydrology Regional Centre, NIH, Bhopal		
DELTAIC REGIONAL CENTRE, KAKINADA			
CHAIRMAN			
1.	Director, National Institute of Hydrology,Roorkee		
MEMBERS			
Central Govt. Institutions			
2.	Director Meteorological Centre, Bhubaneswar	3.	Regional Director Central Ground Water Board (CGWB), SE Coastal Region, Chennai
4.	Chief Engineer (Krishna & Godavari Basin) CWC, Hyderabad	5.	Nominee (dealing with water resources) of Director National Geophysical Research Institute, Hyderabad
6.	Head WR Division, National Remote Sensing Centre (NRSC), Hyderabad	7.	Director Directorate of Water Management, Indian Council of Agricultural Research (ICAR), Bhubaneswar
8.	Nominee of Director, Water Resources Centre, Anna University, Chennai	9.	Nominee of Director, National Institute of Ocean Technology (NIOT), Chennai
State Govt. Institutions			
10.	Engineer-in-Chief, Rural Water Supply and Sanitation (RWS & S), Vijayawada	11.	Nominee of Director General AP State Remote Sensing Applications Centre (APSRAC), Vijayawada
12.	Managing Director West Bengal Minor Irrigation Corporation, State Water Investigation Directorate, Kolkata	13.	Nominee of Member Secretary Andhra Pradesh Pollution Control Board, Hyderabad
Academic Institutions			
14.	Nominee (dealing with water resources) of Vice Chancellor Jawahar Lal Nehru Technological University (JNTU), Kakinada		

NGOs and Individual Experts			
15.	Prof. L Elango Anna University, Chennai	16.	Dr. K. P. Sudheer IIT Madras
17.	Prof B. E. Vijayam PROGRESS, Hyderabad	18.	Dr. T. P. Raghunath Pondicherry Science Forum, Puducherry
MEMBER SECRETARY			
19.	Head, Deltaic Regional Centre, NIH Kakinada		
NORTH EASTERN REGIONAL CENTRE, GUWAHATI			
CHAIRMAN			
1.	Director, National Institute of Hydrology, Roorkee		
MEMBERS			
Central Govt. Institutions			
2.	Advisor (IFC&WSM) North East Council Secretariat, Shillong	3.	Chief Engineer (B&B Basin) Central Water Commission, Shillong
4.	Regional Director Central Ground Water Board, Guwahati	5.	Deputy Director General (DDG) Regional Meteorological Centre (RMC), India Meteorological Department (IMD), Guwahati
6.	General Manager Brahmaputra Board, Guwahati	7.	Director North-East Space Application Centre (NE-SAC), Shillong
State Govt. Institutions			
8.	Meghalaya State Pollution Control Board, Shillong	9.	Chief Engineer Department of Water Resources, Govt. of Assam, Guwahati
10.	Chief Engineer Water Resources Department, Govt. of Meghalaya, Shillong	11.	Nominee of Sikkim State Council of Science & Technology, Sikkim
Academic Institutions			
12.	Nominee of Director North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli	13.	Nominee of Director North Eastern Regional Institute of Water and Land Management (NERIWALM), Tezpur
14.	Nominee (dealing with water resources) of Director, IIT Guwahati	15.	Nominee (dealing with water resources) of Vice-Chancellor, Manipur University, Imphal

16.	Nominee (dealing with water resources) of Vice-Chancellor North Eastern Hill University (NEHU), Shillong		
NGOs and Individual Experts			
17.	Dr. Biswajit Sarma Director Confederation of Indian Industry (CII) TDB T Net Centre, Jorhat Engg. College, Jorhat	18.	Dr. Biplab B. Basu Director, School of Fundamental Research, Kolkata
19.	Aaranyak, Guwahati		
MEMBER SECRETARY			
20.	Head, Centre for Flood Management Studies, NIH Guwahati		
CENTRE FOR FLOOD MANAGEMENT STUDIES, PATNA			
CHAIRMAN			
1.	Director, National Institute of Hydrology, Roorkee		
MEMBERS			
Central Govt. Institutions			
2.	Chief Engineer Central Water Commission (CWC), Patna	3.	Representative of Chairman Ganga Flood Control Commission (GFCC), Patna (not below the rank of Director)
4.	Director India Meteorological Department, Patna	5.	Regional Director Central Ground Water Board (CGWB), Patna
6.	Indian Council of Agricultural Research Research Complex for Eastern Region, Patna	7.	Central Pollution Control Board (CPCB) Zonal Office, Kolkata
State Govt. Institutions			
8.	Chief Engineer (Civil) Damodar Valley Corporation (DVC), Maithon	9.	Chief Engineer Irrigation and Waterways, Kolkata
10.	Chief Engineer (Design, Master Planning & Hydrology), Ranchi	11.	Chief Engineer (WR) UP Irrigation Department, Lucknow
12.	Chief Engineer (Monitoring), Water Resources Department, Patna		

Academic Institutions			
13.	Nominee (dealing with water resources) of Director, NIT Patna	14.	Nominee (dealing with water resources) of Director, IIT Patna
15.	Chief Engineer & Director Water and Land Management Institute (WALMI), Patna		
NGOs and Individual Experts			
16.	Society for Rural Industrialization, Ranchi	17.	Prof S. P. Sinha Society for Hill Resource Management School, Daltonganj-Jharkhand
MEMBER SECRETARY			
18.	Head, Centre for Flood Management Studies, NIH Patna		

APPENDIX-VII

Institute Funded R & D Studies During 2022-23

(Completed and On-going)

WORK PROGRAMME OF NIH (HQ) FOR THE YEAR 2022-23

SN	TITLE OF THE STUDY	PI	DURATION & STATUS
	ENVIRONMENTAL HYDROLOGY DIVISION		
1	Characterisation of Groundwater Dynamics in Krishna-Godavari Delta interims using groundwater levels, Hydrochemistry, Isotopes and Emerging Contaminants	M.K. Sharma	04/2022 - 03/2024 Ongoing
2	Understanding Arsenic mobilization in groundwater of Haridwar and formulating remediation measures	Rajesh Singh	07/2021 - 06/2024 Ongoing
3	Simulation of Non-Point Source Pollution Processes in Song River	Pradeep Kumar	11/2019 - 10/2023 Ongoing
4	Comprehensive evaluation of disinfection units of STPs in Ganga basin: Occurrence and control the formation of emerging oxidation precursors	Vinay Kumar Tyagi	12/2022 - 03/2026 Ongoing
5	Hydrological Studies for the Conservation of Rewalsar lake	Kalzang Chhoden	12/2022 - 03/2026 Ongoing
	GROUNDWATER HYDROLOGY DIVISION		
1	Studying arsenic genesis and developing alternate water supply management strategies in Ganga basin	Sumant Kumar	04/2022 - 03/2025 Ongoing
2	Hydrogeological and Isotopic investigation of groundwater in Himalayan Watershed of Kashmir, India	Gopal Krishan	09/2022 -03/2024 Ongoing
3	Integrated GEE-MODFLOW based Groundwater Recharge Assessment System for Hindon River System	Nitesh Patidar	08/2020 - 07/2022 Completed
4	Conjunctive Management of Water Resources in IGNP Command	Nitesh Patidar	04/2022 - 03/2024 Ongoing
	HYDROLOGICAL INVESTIGATIONS DIVISION		
1	Assessment of the Possible Impact of Climate Change on Evapotranspiration for Different Climatic Regions Of India	S.D. Khobragade	04/2022 -03/2025 Ongoing
2	Ascertaining the efficacy of use of State of the art technologies for spring mapping and sustainabilityof springs through suitable interventions	S.S. Rawat	07/2022 -06/2025 Ongoing
3	Feasibility of Open Sources Data for the Estimation of Runoff and Water Storage Capacity for Rainwater Harvesting Strategies	S.M.Pingale	04/2023 -03/2025 Ongoing
4	Assessment of dissolved radon concentration in Uttarakhand	Hukum Singh	03/2019 -02/2023 Completed

SURFACE WATER HYDROLOGY DIVISION			
1	Uncertainty in rating curves and discharge estimation	Sanjay Kumar	04/2021 - 03/2023 Completed
2	Evaluation of the influence of low-frequency atmosphere-ocean oscillations on annual floods in the Godavari and Narmada River basins	Sunil Gurrapu	11/2018 - 10/2021 Completed
3	Probabilistic dam break flood wave simulation and flood risk assessment for preparation of EAP for Mahi Bajaj Sagar dam in Rajasthan	J.P. Patra	08/2020 - 07/2022 Completed
4	Hydrologic and hydraulic modeling for floodplain inundation mapping under future climate change scenarios: A case study of Tawi River, India	R.V. Kale	08/2018 - 06/2022 Completed
5	Application of unified-extreme-value (UEV) distribution for flood frequency: selected rivers of U.S.A.	S.K. Singh	04/2022 - 03/2023 Completed
6	Application of unified-extreme-value (UEV) distribution for flood frequency: Comparison of results using GEV distribution	S.K. Singh	10/2022 - 03/2023 Completed
7	Development of Cloud Data Based Integrated Framework to Forecast Flood for Efficient Operation of Reservoirs	A.K. Lohani	04/2022 - 03/2024 Ongoing
8	Flood Forecasting under Changing Climate Conditions- Role of Machine Learning and Conceptual/Physical based Model	P.C. Nayak	07/2022 - 06/2025 Ongoing
9	Hydrological Study to conserve the water resources of Bikaner, Rajasthan	L.N. Thakural	07/2022 - 06/2024 Ongoing
10	Review of design flood and dam break analysis of Khadakhai Dam in Odisha	J.P. Patra	04/2022 - 03/2025 Ongoing
11	Investigating gap areas, current trends and future directions of research in Climate Change Impact on Hydrology and Water Resources in India through Scientometrics	Archana Sarkar	04/2022 - 10/2023 Ongoing
12	Investigation of hydrodynamic approach of flood inundation mapping along with assessment of changes in river planforms using a cloud-based Google Earth Engine (GEE) computing platform in data-scarce Western Himalayan River basin	R.V. Kale	09/2021 - 07/2024 Ongoing
13	Investigation on occurrences of extreme rain events across Northwest Himalaya in relation to global atmospheric thermal and circulation changes	Ashwini Ranade	04/2022 - 03/2025 Ongoing
14	Climate change scenarios for Andhra Pradesh and its impact on streamflow and groundwater levels in the Pennar River basin	Sunil Gurrapu	04/2022 - 03/2024 Ongoing

WATER RESOURCES SYSTEMS DIVISION			
1	Seasonal characterization of Gangotri Glacter mel runoff and simulation of streamflow variation under different climate scenarios	Manohar Arora	04/2021 - 03/2023 Completed
2	Impacts of glacier and climate change on runoff for selected basins of Himalayan region	Vishal Singh	08/2020 - 07/2022 Completed
3	Monitoring and hydrological modeling of Henval watershed in Lesser Himalaya	M.K. Nema	08/2020 - 12/2023 Ongoing
4	Spatio-temporal Water Availability under Changing Climate and Landuse Scenarios in Wainganga River Basin	M.K. Nema	04/2022 - 03/2024 Ongoing
RESEARCH MANAGEMENT & OUTREACH DIVISION			
1	Integrated assessment of water resources for sustainable use in Upper Dhasan basin in Bundelkhand region	Jyoti P. Patil	09/2020-02/2023 Ongoing
2	Hydrology-based scenario planning for water productivity and optimization of income from farming practices in Mewat region, Haryana	A. R. Senthil Kumar	09/2020-08/2022 Ongoing

WORK PROGRAMME OF NIH REGIONAL CENTRES AND CENTRE FOR FLOOD MANAGEMENT STUDIES: 2022-23

SN	TITLE OF THE STUDY	PI	DURATION/STATUS
HARD ROCK REGIONAL CENTRE, BELAGAVI			
1	Monitoring and evaluation of groundwater quality of Belagavi City, Karnataka, India	N. Varadarajan	05/2022 - 04/2024 Ongoing
WESTERN HIMALAYAN REGIONAL CENTRE, JAMMU			
1	Estimation of changes in snow cover and glacier mass balance for Upper Chenab River Basin	P.G. Jose	08/2020 - 03/2023 Ongoing
2	Mass Balance of Phuche and Khardung glaciers, Ladakh Range with implications for downstream water availability under changing climate	P.G. Jose	07/2021 - 06/2024 Ongoing
3	Investigation of hydrodynamic approach of flood inundation mapping along with assessment of changes in river planforms using a cloud-based Google Earth Engine (GEE) computing platform in data-scarce Western Himalayan River basin	R. V. Kale	09/2021 - 07/2024 Ongoing
4	Early Signatures of 21st Century on Snow Cover Dynamics in Zanskar River Basin, Ladakh	D.S. Bisht	07/2021 - 06/2022 Ongoing
5	Comparative analysis of fine-scale satellite & reanalysis precipitation products in UGB using Multi-Criterion Decision-Making	D.S. Bisht	06/2022 - 05/2023 Ongoing

CENTRAL INDIA HYDROLOGY REGIONAL CENTRE, BHOPAL			
1	An experimental assessment of low-cost auger hole technique for accelerating groundwater recharge	R.V. Galkate	09/2020 - 03/2023 Completed
2	Re-assessment of evapotranspiration (*ETo*) estimation for irrigation planning in Madhya Pradesh	R.V. Galkate	11/2021 - 10/2024 Ongoing
3	Water Availability Assessment for Project Formulation in Madhya Pradesh	R.K. Jaiswal	11/2021 - 10/2024 Ongoing
4	Development of reservoir Operation Plan under Climate Change Scenarios for Kolar reservoir in Madhya Pradesh	Shashi Indwar	10/2021 - 09/2024 Ongoing
DELTAIC REGIONAL CENTRE, KAKINADA			
1	Identification of Recharge and Discharge areas of Palar basin in Tamil Nadu	V.S. Jeyakanthan	09/2021 - 03/2023 Ongoing
2	Impact assessment of backwater through drains, creeks and river mouths on groundwater salinity in the Godavari delta, Andhra Pradesh	Y.R. Satyaji Rao	08/2022 - 08/2024 Ongoing
NORTH EASTERN REGIONAL CENTRE, GUWAHATI			
1	Hydrological behaviour of two mid-sized mountainous catchments under the influence of climate change	Waikhom Rahul Singh	07/2019 - 06/2022 Completed
2	Drought characterization and vulnerability assessment in Assam	Waikhom Rahul Singh	07/2022 - 06/2024 Ongoing
3	Impact of Climate Change on Flood Inundation in Beki River Basin	Sanjay Kumar Sharma	07/2022 - 06/2023 Ongoing
CENTRE FOR FLOOD MANAGEMENT STUDIES, PATNA			
1	Integrated flood management plan for a stretch of Burhi Gandak river from Sikanderpur to Rosera	B. Chakravorty	04/2020 - 09/2022 Completed
2	Hydraulic and mathematical model studies for long term safety and solution measures for flood problem in Mahav	Pankaj Mani	04/2022 - 03/2023 Completed
3	Design flood estimation for small structures in the south Bihar area	Pankaj Mani	04/2021 - 09/2023 Ongoing

APPENDIX-VIII

Sponsored Projects During 2022-23

(Completed and On-going)

SN	TITLE	SPONSORING AGENCY	PI	DURATION & STATUS	BUDGET (RS)
INTERNATIONAL SPONSORED PROJECTS					
1	Groundwater Rejuvenation As Climate change Resilience for marginalized and gendersensitive Ganges(GRACERS)	IHE Delft through IIT Bombay	Sudhir Kumar	04/2019 -03/2023 Completed	€ 18,400
2	Dating very old groundwaters of deeper aquifers in the Indo-Gangetic plains, India	IAEA, Vienna	M.S. Rao	06/2016 -03/2023 Completed	Rs .16.50 Lakh
3	Capacity Development Program on Site Suitability Mapping for Managed Aquifer Recharge (MAR) under Varying Climatic Conditions using Remote Sensing and Machine Learning based Hydrological Modelling Tools	Asia-Pacific Network (APN)	Nitesh Patidar	01/2022 - 10/2022 Completed	Rs. 8.47 Lakh
4	Groundwater Fluctuations and Conductivity Monitoring in Punjab-New Evidence of Groundwater Dynamics in Punjab from High Frequency GW Level and Salinity Measurements	BGS, UK	Gopal Krishan	12/2017 -11/2024 Ongoing	£ 39,300
5	Expansion of the Indo-German Competence Centre for Riverbank Filtration-CCRBF	Federal Min .of Education and Research, Germany	Gopal Krishan	07/2020 -06/2023 Ongoing	Rs. 16.10 Lakh
6	High Performance Advanced Septic system for Villages and Roadside Restaurants	IC-IMPACTS, Canada	Y.R. Satyaji Rao	04/2018 -12/2023 Ongoing	Rs. 35.00 Lakh

NATIONAL SPONSORED PROJECTS					
1	Assessment of Impacts of Groundwater Salinity on Regional Groundwater Resources, Current and Future Situation in Mewat, Haryana-Possible Remedy and Resilience Building Measures	NHP under PDS	Gopal Krishan	12/2017 -07/2022 Completed	Rs. 65.00 Lakh
2	Ganges aquifer management in the context of monsoon runoff conservation for sustainable river ecosystem services- A pilot study of Sot River Catchment	MoJS, DoWR, RD&GR under the National Hydrology Project	Surjeet Singh	12/2017 -07/2022 Completed	Rs. 39.21 Lakh
3	Chemical & Isotopic Characterization of Deep Aquifer Groundwater of Middle Ganga Basin	NHP, DoWR, RD&GR	Sudhir Kumar	03/2018 - 03/2023 Completed	Rs. 51.00 Lakh
4	Integrated Study on Groundwater Dynamics in the Coastal Aquifers of West Bengal for Sustainable Groundwater Management	NHP, DoWR, RD&GR	M.S. Rao	03/2018 - 03/2023 Completed	Rs. 51.00 Lakh
5	Web-GIS Based Spring Inventory for Vulnerability Assessment and Hydro-Geological Investigation of Selected Springs for Sustaining Local Water Demand in Ravi Catchment of Himachal Pradesh	NHP-PDS	S.S. Rawat	08/2017 -12/2022 Completed	Rs. 69.00 Lakh
6	Web-enabled Inventory of Natural Water Springs of Tawi River Catchment of Jammu and Kashmir State of India for Vulnerability Analysis and Developing Adaptive Measures for Sustaining Tawi River	NMHS	S.S. Rawat	01/2019 -09/2022 Completed	Rs. 38.04 Lakh
7	Dam break studies of Somasila, Kandaleru and Pulichintala dams in Andhra Pradesh	NHP, MoJS	P.C. Nayak	09/2019 - 11/2022 Completed	Rs. 55.60 Lakh

8	Assessment of seasonal variations in Hydrology and Cryosphere of upper Ganga Basin	NRDMS-DST	Vishal Singh	06/2019 - 12/2022 Completed	Rs. 23.19 Lakh
9	River basin planning and reservoir operation studies in Teesta basin in Sikkim	NHP	Swapnali Barman	09/2019 - 03/2023 Completed	Rs. 10.50 Lakh
10	Urban hydrological studies of critical pilot area using of hydrological instruments in Greater Hyderabad Municipal Corporation (GHMC) area Hyderabad	PDS under NHP	R. Venkata Ramana	04/2020 - 03/2023 Completed	Rs. 63.25 Lakh
11	Impacts of Upcoming Irrigation Projects and Climate Change on the Droughts and Desertification Scenario for Chambal Basin in Western Madhya Pradesh	PDS under NHP	T. Thomas	12/2017 - 10/2022 Completed	Rs. 44.40 Lakh
12	Development of Decision Tool for Efficient Utilization of Water Resource in Parbati Canal & Dholpur Piped Irrigation Project of Rajasthan	PDS under NHP	R.K. Jaiswal	04/2019 - 03/2023 Completed	Rs. 86.37 Lakh
13	Water Efficient Irrigation by Using SCADA System For Medium Irrigation Project (MIP) Shahnehar	PDS under NHP	R. P. Pandey	12/2017 - 12/2023) Ongoing	Rs. 18.00 Lakh
14	Anaerobic co-digestion of thermo-chemically pretreated OFMSW and sewage sludge: Effect on process performance and microbial community development	Department of Biotechnology (DBT)	Vinay Kumar Tyagi	04/2018 - 03/2023 Ongoing	Rs. 103.60 Lakh
15	SARASWATI 2.0-Identifying best available technologies for decentralized wastewater treatment and resources recovery for India	Department of Science & Technology (DST)	Vinay Kumar Tyagi (Co-PI), A.A. Kazmi (PI, IIT, Roorkee)	03/2020 - 02/2024 Ongoing	Rs. 160.77 Lakh

16	Comprehensive characterization of variably processed sewage sludge in Ganga basin to classify its suitability for safe disposal	Central Pollution Control Board (CPCB)	Vinay Kumar Tyagi (Co-PI), A.A. Kazmi (PI, IIT, Roorkee)	01/2022 - 12/2023 Ongoing	Rs. 58.11 Lakh
17	Isotopic and geochemical approach to study vulnerable confined and unconfined drinking water aquifers in Varanasi and surrounding area, India	BHU	Rajesh Singh	07/2021 - 06/2024 Ongoing	Rs. 10.00 Lakh
18	Integrated Management of Water Resources for Quantity and Quality in Upper Yamuna Basin upto Delhi	Special Study under "Centre of Excellence for Hydrological Modeling" (NHP)	Anupma Sharma	04/2018 - 01/2024 Ongoing	Rs. 248.21 Lakh
19	Enhancing Food and Water Security in Arid Region through Improved Understanding of Quantity, Quality and Management of Blue, Green and Grey Water	DST (Water IC Project)	Anupma Sharma (NIH Lead) Nodal Institution: ICAR-CAZRI, Jodhpur	02/2019 - 01/2024 Ongoing	Rs. 105.68 Lakh (NIH component)
20	Partitioning ET into Evaporation and Transpiration fluxes using Stable Isotopes of Oxygen and Hydrogen	DST-SERB	Gopal Krishan	04/2021 - 03/2024 Ongoing	Rs. 71.83 Lakh
21	Changing the fate of the Hindon river by evaluating the impact of agriculture on the water balance :Developing a template for a cleaner Ganga river	DST	Sudhir Kumar	04/2022 -03/2027 Ongoing	Rs. 240.00 Lakh
22	Development of a comprehensive plan for conservation and sustainable management of Bhimtal and Naukuchiatal lakes, Uttarakhand	NHP)PDS(	S.D. Khobragade	01/2018 -06/2022 Ongoing	Rs. 34.97 Lakh

23	Leachate Transport Modelling for Gazipur Landfill Site for Suggesting Ameliorative Measures	PDS under NHP	Anjali	11/2019 -12/2023 Ongoing	Rs. 76.10 Lakh
24	State Specific Action Plan (SSAP) for Water Sector for 16 States/UTs	National Water Mission, DoWR RD&GR	Sanjay Kumar, Coordinator	Ongoing	Rs. 663.00 Lakh
25	Operational coastal flood management through short-to-medium range (real-time) flood vulnerability mapping in the Brahmani-Baitarani River Basin integrating human and climate induced impacts	Funded under STARS by MoE (formerly MHRD), GoI	R.V. Kale, (Co-PI), B. Sahoo, (PI, IIT, Kharagpur)	07/2020 -06/2024 Ongoing	Rs. 56.06 Lakh (at IIT, Kharagpur)
26	Snow and glacier contribution and impact of climate change in Teesta river basin in Eastern Himalaya	NMHS-MoEF&CC	Sanjay K. Jain	11/2019 - 03/2023 Ongoing	Rs. 143.00 Lakh
27	Development of Water Accounts for the different sub-basins of Brahmaputra and Barak River Basins in the state of Meghalaya Using Water Accounting Plus (WA+) Framework	NHP	P.K. Singh	08/2020 - 12/2023 Ongoing	Rs. 14.50 Lakh
28	Development of Water Accounts for the different sub-basins in the state of Nagaland Using Water Accounting Plus (WA+) Framework	NHP	P.K. Mishra	04/2021 - 03/2024 Ongoing	Rs. 9.00 Lakh
29	Long term hydrological assessment for the development of water security plan into three sub-basins namely Barak, Minor rivers draining into Bangladesh and Minor rivers draining into Myanmar sub-basins in the state of Mizoram	NHP	Vishal Singh	04/2021 - 03/2024 Ongoing	Rs. 25.00 Lakh

30	Monitoring and Assessment of Mountain Ecosystem and Services in North-West Himalaya (Phase-II): Monitoring and Modeling of Hydrological Processes in Glaciated and Non-Glaciated Watersheds of North-West Himalaya	DoS-ISRO	Sanjay K. Jain	04/2022 - 03/2025 Ongoing	Rs. 30.91 Lakh
31	Innovation Centre for Eco-Prudent Wastewater Solutions (IC-EcoWS)	DST (GoI)	V.C. Goyal/Omkar Singh (PI) Partners: NIH, MNIT-Jaipur, IIT-Bombay, IRMA-Anand	04/2019 - 03/2024 Ongoing	Rs. 510 Lakh
32	A Coupled Hydrodynamic and Bank Dynamic Modelling Approach for Forensic Analysis of Bankline Erosion Process Along Majuli Island-The Largest Inhabited River Island in the World	DST-SERB	Swapnali Barman	04/2021 - 03/2024 Ongoing	Rs. 27.34 Lakh
33	Study on behaviors of flooding and unexpected drought like situations in Garo Hills District of Meghalaya	NHP	Sanjay Kumar Sharma	10/2019 -05/2023 Ongoing	Rs. 40.00 Lakh
34	Permafrost mapping and characterization of Western Himalayan Region	NMHS-MoEF&CC	P.G. Jose	11/2019 - 03/2023 Ongoing	Rs. 197.48 Lakh
35	Modeling and management of erosion and sedimentation processes in Gandak river using morphodynamic modeling	PDS under NHP	Pankaj Mani	05/2021 - 04/2024 Ongoing	Rs. 52.42 Lakh
36	Groundwater Model development in Micro Basin of Hard Rock in Krishna and Godavari River basins of Telangana	Telangana State Ground Water Department (PDS under NHP)	B. Venkatesh	09/2019 - 08/2022 Ongoing	Rs. 80.00 Lakh

37	Impact of Sand Mining on Groundwater Regime in parts of Manjira River Basin, Telangana State	Telangana State Ground Water Department (PDS under NHP)	M.K. Jose	04/2021 - 03/2023 Ongoing	Rs. 46.44 Lakh
38	Comprehensive Assessment of Water Availability, Use and Issues for Goa State	Water Resources Department, Goa (PDS under NHP)	B. Venkatesh	01/2022 - 12/2023 Ongoing	-
39	Integrated Assessment of the Impacts of Climate Change on the Hydrology of the Narmada basin through Hydrological Modelling Approaches	Special PDS under NHP	T. Thomas	02/2018 - 09/2023 Ongoing	Rs. 250.00 Lakh
40	Hydrological Modeling for Evaluation of Return Flow and Irrigation Planning for Optimal Utilization of Water Resource in the Command of Sanjay Sagar Project in Madhya Pradesh	PDS under NHP	R.K. Jaiswal	04/2019 - 09/2023 Ongoing	Rs. 64.36 Lakh
41	Integrated reservoir operation studies for Mahanadi reservoir project complex in Chhattisgarh	PDS under NHP	R.K. Jaiswal	04/2022 - 03/2024 Ongoing	Rs. 56.00 Lakh

Consultancy Projects During 2022-23

(Completed and On-going)

APPENDIX-IX

SN	PROJECT TITLE	SPONSORING AGENCY	PI
PROJECTS COMPLETED DURING 2022-23			
1.	Environmental Flow Study of Shongtong Karchamm HEP project in Himachal Pradesh	HPPCL, Kinnaur	Manohar Arora
2.	Hydro-geological investigations in MRM Campus	MRPL Mangalore	B K Purendra
3.	Environmental flow study of Surgani-Sundla HEP in Distt Chamba (HP)	HPPCL, Hamirpur	Manohar Arora
4.	Water Availability Studies for Chutka Lake	NPCIL Mumbai	Rakesh Kumar
5.	Hydrogeological Study for Assessment of Impact of Mining on Bearma River and other water bodies in the study area and its mitigation plan at S.M.P.I. limestone mine area at village Kolkarhiya, Pawai Tehsil Panna Distt MP	Springway Mining Pvt Ltd Damoh MP	Sudhir Kumar
6.	Hydrology and Hydrological study for proposed RW Hybrid Park at Khavda Distt. Rann of Kutch, Gujarat	Gujarat Industries Power Company Limited, P.O. Petrochemicals, Distt. Vadodra	Sudhir Kumar
7.	Evaluation of design of storm water drainage structure in Shaheed Asafaq Ullah Khan Praani Udyan near Ramgarh Taal (Wetland), Gorakhpur	Uttar Pradesh Rajkiya Nirman Nigam Ltd., (UPRNN), Gomti Nagar, Lucknow	V.C. Goyal
8.	Hydro-geological Study of Area in the Vicinity of SEL Manufacturing Company Ltd. Nawanshahr, Punjab	Dr. B.R. Ambedkar NIT, Jalandhar, Punjab	Surjeet Singh

9.	Hydrological Study fo New India Garden(NIG) Project at village Indraprasth, New dehli	CPWD, Central Vista Project Division-IV, Nirman Bhawan, New Delhi	R.P. Pandey
10.	Hydrological study for design of drainage system and evaluation of flood diversion channel for the RBI Campus, Dehradun	CPWD, Dehradun	R.P. Pandey
11.	Vetting Hydrology of Dinki & Baras Barrage	RVRPPL-NEC JV Jubliee hills	R.K. Jasiwal
PROJECTS ON-GOING DURING 2022-23			
1.	Impact Assessment of rejuvenated ponds in Saharanpur Distt. U.P.	People's Action for National Integration (PANI) Ayodha (U.P.)	V.C.Goyal
2.	Engineering Services for carrying out extreme value analysis & statistical analysis of latest metrological data for Mahi Banswara Rajasthan Atomic Power Project (MBRAPP)	NPCIL Nabhikiya Urja Bhawan Anushakti Nagar Mumbai	J.P. Patra
3.	Performance evaluation of Nano Catalytically Instant Water Convertor (NCIWC) equipment for Water waste water treatment	Envirogrreen Minetech India Pvt. Ltd. Indore	Rajesh Singh
4.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Kawas	NTPC Kawas,Kawas Gas Power Project Surat Gujarat	Sudhir Kumar
5.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Singrauli	NTPC Singrauli, singrauli Super Thermal Power Project Shakti Nagar, Sonabhadra U.P.	Sudhir Kumar
6.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Jhanor-Gandhar	NTPC Jhanor Gandhar Gas Power Project Urja Nagar Bharauch Gujarat	Sudhir Kumar
7.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Rihand	NTPC Rihand Super Thermal Power Project Rihand Nagar, sonebhadra U.P.	Sudhir Kumar

8.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Unchahar	NTPC Unchahar Geroz Gandhi Thermal Power Project Unachahar Raebareli U.P.	Sudhir Kumar
9.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Anta Rajasthan	NTPC Anta Gas Power Project Anta Baran Rajasthan	Sudhir Kumar
10.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Sipat	NTPC Sipat Thermal Power Project Bilaspur Chhattisgarh	Sudhir Kumar
11.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Korba	NTPC Korba Super Thermal Power Project Korba Chhattisgarh	Sudhir Kumar
12.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Lara	NTPC Lara Super Thermal Power Project Raigarh Chhattisgarh	Sudhir Kumar
13.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Ramagundam	NTPC Ramagundam Super Thermal Power Station, Peddapalli Telengana	Sudhir Kumar
14.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Mandsaur	Mandsaur Solar PV (5x50mw) Mandsaur, M.P.	Sudhir Kumar
15.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Farrakka	Farakka Super Thermal Power Station Murshidabad West Bangal	Sudhir Kumar
16.	Hydro geological study to assess the impact of mining activities in & around Rampura Agucha Mine Area of Hindustan Zinc Ltd in the Bhilwara Distt. Rajasthan	Hindustan Zinc Ltd. Udaipur Rajasthan	Sudhir Kumar
17.	Study of Rainwater Harvesting Potential assessment & its review / design to increase the water possibility at Talapalli Coal Mining Project	NTPC ltd. Coal Mining (Ranchi) Col Mining HQ, Ranchi Jharkhand	Pankaj Mani
18.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Rajgarh Solar PV Plant	NTPC Rajgarh 1050 Rajgarh SOLAR PV, Rajgarh M.P.	Sudhir Kumar

19.	Study of Rainwater Harvesting Structure/Facilities/Systems at NTPC Solapur Station	NTPC Solapur 1045 Solapur STPP, South Solapur Maharashtra	Sudhir Kumar
20.	Glacial lake outburst Flood (GLOF) study for Arun-4 HEP	SAPDC (SJNV Ltd.)	Sanjay K Jain
21.	Dam Break analysis & flooding simulation, preparation of inundation mapping & emergency action plan for Vasna Barrage, Ahmedabad, Gujarat	Addl. C.E. Ahmedabd Municipal Corporation, Ahmedabad	A K Lohani
22.	Hydrogeological study to assess the impact of dewatering on Groundwater & its quality in the nearby area of Rajpura Dariba Mine of Hindustan Zinc Ltd.	Hindustan Zinc Ltd.	Gopal Krishn
23.	Site selection for intake well in Alakhnanda River near Srinagar for Marhi Chauras Pumpng Peyjal Yojna	Uttarakhand Peyjal Sansthan Vikas Nirman Nigam Devprayag (Tehri Garhwal)	R.P.Pandey
24.	Evaluation of Electrolyte solutions for salt composition	Faith Inovations, Roorkee	Rajesh Singh
25.	Verification of Hydrology and Hydraulic study for proposed Barrage cum Bridgebetween Torrent Power and Camp Sadar Bazar for Sabarmati River Front Development Project (SRFDCL), Ahmedabad	Sabarmati River Front Development Project (SRFDPCL), Ahmdabad	R. K. Jaiswal
26.	Site selection for intake well in Ganga River Bharpoor Pumping Peyjal Yojna Phase II	Uttarakhand Peyjal Sansthan Vikas Nirman Nigam Devprayag (Tehri Garhwal)	R.P.Pandey
27.	System studies for proposed Farakka-Sundarban project	National Water Development Agency (NWDA), Ministry of Jal Shakti	Surjeet Singh
28.	Water quality studies for Tehri reservoir, Tehri HPP (4x50mw)	THDC, India Ltd. Tehri Garhwal	M.K.Sharma

29.	Technical Evaluation of infiltration well of Dadua - Bhandali minral water pumping scheme of Alaknanda river for Feasible options to maintain the supply	Uttarakhand Pey jal Nigam	R.P. Pandey
30.	VOC Analysis of water samples	National Environmenta Engineering Research Institute (NEERI), Nagpur	M.K. Sharma
31.	Comprehensive hydrological analysis of Harangi catchment	chief Engineer Irrigation (South Zone)' Mysore	B. Venkatesh
32.	Study of seasonal change in the quality of Ujjani Dam water & identification of sources of contamination wrt increase in ionic concentrations at Solapur STPP	NTPC Ltd. (Solapur)	Suhas Khobragade
33.	Hydrodynamic Modelling of Krishna River to study backwater effect of Almatti Dam & Barrage in Karnatak State	WRD Govt of Maharastra	A.k Lohani Sc
34.	Hydrological study for water availability assessment in Sukhnai River & runoff diversion to Saprar Dam	Irrigation Constriction Division Mauranipur Irrigation & WRD Govt. of U.P.	R.P. Pandey
35.	Site selection for intake well of Indra-Tipri pumping water supply scheme	Dinesh Prasad Dangwal, Village Masras Distt. Tehri	R.P. Pandey
36.	Site Selection for intake well in Jalkoor River for Jalkoor pumping peyjal yojna	Shree Guru Agencies New Market, Haldwani Distt. Nainital	Pradeep Kumar

APPENDIX-X

List of Publications

BOOKS	
1.	Chandniha, S.K., Lohani, A.K., Krishan, G. and Prabhakar, A.K. (2022).Advances in Hydrology and Climate Change -Historical trends and new approaches in water resources management. Apple Academic Press.
2.	Pilli, S., Bhunia, P., Tyagi, V., Tyagi, R., Wong, J. and Pande, A. (2022). Current Developments in Biotechnology and Bioengineering Sustainable Treatment Technologies for Pre- and Poly-flourakyl Substances. Elsevier (UK), pp 350 (ISBN: 9780323999069).
3	Tyagi, J.V., Lohani, A.K., Arora, M., Rawat, S.S., Singh, P.K., Nema, M.K., Bisht, D.S., Uniyal, P.K., Sapra, T.R., Kumar, R., Kumar, P., Mishra, C., Kumar, N. and Guyal, V. (2022). Hydrological Knowledge in Ancient India (प्राचीन भारत में जलविज्ञानीय ज्ञान.) A bi-lingual (Hindi and English) third edition of a special report published by NIH, Roorkee.
4.	Tyagi, V.K., Aboudi, K. and Eskicioglu, C. (2022). Ananerobic Digestate Management. International Water Association publishing (IWAP), pp 350 (ISBN: 9781789062).
CHAPTERS IN BOOKS	
1.	Ali, M., Pilli, S., Bhunia, P., Tyagi, R.D., Pandey, A. and Tyagi, V.K. (2022). Occurrence, fate, and persistence of perfluorinated compounds (PFCs) in wastewater treatment systems. In: Sustainable Treatment Technologies for Per- and Poly-fluoroalkyl Substances. Currents Development in Biotechnology and Bioengineering Series. Elsevier Publishing, pp. 207-233, ISBN: 978-0-323-99906-9.
2.	Ansari, M.I., Thakural, L.N. and Hassan, Q. (2022). Geo-statistical analysis of ground water fluctuations for sustainable management of groundwater resources within the Chaliyar basin, southwest India ICSEEGT 2022, IOP Conf. Series: Earth and Environmental Science 1084 (2022) 012039, IOP Publishing, doi:10.1088/1755-1315/1084/1/012039.
3.	Ansari, M.Z., Ahmad, I., Singh, P.K. and Eslamian, S. (2023). Hydrological modeling of Hasdeo River Basin using HEC-HMS. Handbook of Hydroinformatics. Volume III: Water Data Management Best Practices. Edited by SaeidEslamianDepartment of Water Engineering, College of Agriculture, Isfahan University of Technology, Isfahan, Iran and FaezehEslamianDepartment of Bioresource Engineering, McGill University, Montreal, QC, Canada. Copyright © 2023 Elsevier Inc.
4.	Barman, S., Tyagi, J.V. and Singh, W.R. (2023). Future Rainfall Trend Analysis Over Puthimari River Basin: A Comparative Study Using Different CMIP5 Models. In: Sustainable Water Resources Management. Advances in Sustainability Science and Technology. Springer, Singapore, pp. 19-28.
5.	Chhoden, K. and Manchanda, C.K. (2023). Ground water and Pond water Quality Assessment of District Ropar, Punjab. In: Water Science and Technology, Published by ABS Books, ISBN: 978-93-94424-62-3.

6.	Chowdhury, S.D., Tyagi, R.D., Pilli, S., Tyagi, V.K., Pandey, A. and Bhunia, P. (2022). Per-and poly-fluoroalkyl substances (PFASs) in water and wastewater. In: Sustainable Treatment Technologies for Per- and Poly-fluoroalkyl Substances. Currents Development in Biotechnology and Bioengineering Series. Elsevier Publishing. pp. 299-327, ISBN: 978-0-323-99906-9.
7.	Debbarma, S., Barman, S., Debnath, A.C. and Nath, M. (2022). Hydrological Simulation Using Coupled ANN-SCS Approach in Pagladiya Watershed: A Sub-catchment of Brahmaputra River Basin. In: Soil-Water, Agriculture, and Climate Change. Water Science and Technology Library, Vol. 113. Springer, Cham, pp. 35-51.
8.	Dhal, L. and Swain, S. (2022). Understanding and modeling the process of seawater intrusion: a review. [Chapter 14] In: Advances in remediation techniques for polluted soils and groundwater, pp. 269-290.
9.	Gahlot, P., Aboudi, K. and Tyagi, V.K. (2022). Effect of digestate recirculation on anaerobic digestion performance. In: Tyagi, V.K., Kaoutar, A., Eskicioglu, C. (Eds.) Anaerobic Digestate Management. International Water Association Publishing (IWAP). U.K. pp. 247-259. Chapter 11, ISBN: 9781789062748.
10.	Gahlot, P., Aboudi, K., Tawfik, A. and Tyagi, V.K. (2022). Biochar-augmented anaerobic digestate treatment. In: Tyagi, V.K., Kaoutar, A., Eskicioglu, C. (Eds.) Anaerobic Digestate Management. International Water Association Publishing (IWAP). UK. pp. 265-282, Chapter 12, ISBN: 9781789062748.
11.	Gunjan, P., Mishra, S.K., Lohani, A.K., Chandniha, S.K. and Tirkey, N. (2022). Long-Term Rainfall Trend Variability Analysis for Rampur Watershed: A Case Study of Mahanadi River Basin. In: Advances in Hydrology and Climate Change. Surendra Kumar Chandniha, Anil Kumar Lohani, Gopal Krishan, Ajay Krishna Prabhakar (Eds.). Apple Academic Press New York, eBook ISBN9781003282365, DOI https://doi.org/10.1201/9781003282365.
12.	Indwar, S.P., Kumar, A. and Thomas, T(.2022 .)Spatio-temporal Variation and Trend Analysis of Groundwater Level in Bina and Khurai Blocks of Sagar District, Madhya Pradesh. In: River and Coastal Engineering, Springer Nature, 117, pp 299-310.
13.	Jaiswal, R.K., Kumari, C., Galkate, R.V. and Lohani, A.K. (2022). Assessment of Productivity Based Efficiencies for Optimal Utilization of Water Resources in a Command. Yadav, B., Mohanty, M.P., Pandey, A., Singh, V.P., Singh, R.D. (Eds.). Sustainabil ity of Water Resources: Impacts and Management, Water, Science and Technology Library, Springer, pp. 265-282.
14.	Jaiswal, R.K., Lohani, A.K., Galkate, R.V. and Jain, S. (2022). Spatial Variability of Climate Extreme Indices Over Mahanadi Basin (India). Anand Babu, S. (Ed.). 5th World Congress on Disaster Management: Volume II, Routledge, Landon.
15.	Khare, D., Choudhary, S. and Pingale, S.M(.2022.)Sustainable Urban Water Management and Development :Issues, Challenges and Strategies .In :Yadav, B., Mohanty, M.P., Pandey, A., Singh, V.P., Singh, R.D(.Eds.). Sustainability of Water Resources .Water Science and Technology Library, Springer, Cham.Vol. 116, 401-414 .https//:doi.org/10.1007/978-3-031-13467-8_25.

16.	Krishan, G. and Bhagwat, A. (2022). Surface and groundwater interactions: Methodology and changing chemical processes, Editor(s): Ashwani Kumar Tiwari, Amit Kumar, Abhay Kumar Singh, T.N. Singh, Enrico Suozzi, Gagan Matta, Stefano Lo Russo. Current Directions in Water Scarcity Research, 5: 27-43. https://doi.org/10.1016/B978-0-323-85378-1.00003-9.
17.	Krishan, G., Kumar, B., Rao, M.S., Yadav, B.K. and Kansal, M.L. (2022). Environmental tracers in identification of the groundwater salinity – case studies from northwest India. In: Sustainability of Water Resources, Impacts and Management (Eds. B. Yadav, MP Mohanty, A Pandey, VP Singh and RD Singh), 12: 181-198.
18.	Krishan, G., Prakash, J., Dasgupta, P., Mackenzie, A. and Devi, T.T. (2022). Groundwater Salinity-Impacts and Possible Remedial Measures and Management Solutions. In: Lama et al (Eds.), Transforming Coastal Zone for Sustainable Food and Income Security. 52: 697-703, Springer.
19.	Krishan, G., Rao, M.S. and Ghosh, N.C. (2022). Groundwater Resources in Punjab and Bist-Doab Area: An Appraisal and Overview. In: Mukherjee A. (eds) Riverine Systems. Springer, Cham. https://doi.org/10.1007/978-3-030-87067-6_11.
20.	Krishan, G., Sandhu, C., Grischek, T., Ghosh, N.C., Singh, S., Ganapathi, H. and Arora, N. (2022). Assessment of heavy metals in sediments from exploratory wells for riverbank filtration sites impacted by extreme environmental conditions using principal component analysis. In: Jha, R., Singh, V.P., Singh, V., Roy, L.B., Thendiyath, R. (Eds.), Groundw ater and Water Quality. Water Science and Technology Library, vol 119, Chap3:29 -52. Springer, Cham. https://doi.org/10.1007/978-3-031-09551-1_3.
21.	Krishan, G., Nagar, A., Angurala, M L., Rana, R., and Sudarsan, N. (2022). Hydrogeology, Groundwater Regimes and Quality Issues in Punjab. In: Chandniha, SK, Lohani, AK, Krishan, G and Prabhakar, A. (Eds). Advances in Hydrology and Climate Change- Historical trends and new approaches in water resources management. Apple Academic Press 419-428.
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48.	Kumar, S., Patra, J.P., Thakural, L.N. and Gurrapu, S. (2022). At Site Flood Frequency Analysis Using L-Moments. International Conference ICCWE2022: Climate and weather-related extremes - New dimensions, Challenges, and Solutions organized by I.I.T. Roorkee, September 19-20, 2022.
49.	Lohani, A.K., Jain, S.K. and Jaiswal, R.K. (2022). Dam break flood simulation: Sensitivity analysis, International Dam Safety Conference, 10-12th October, 2022 at Birla Auditorium, Jaipur.
50.	Lohani, A.K., Jain, S.K. and Jaiswal, R.K. (2022). Reservoir inflow modelling by Neuro Fuzzy and ANN models, International Dam Safety Conference, 10-12th October, 2022 at Birla Auditorium, Jaipur.
51.	Malyan, S.K., Singh, R., Singh, S. and Bhatia, A. (2022). Assessment of Greenhouse gas emissions from a Horizontal Subsurface Flow Constructed wetland in Roorkee, India. In India Water Week (IWW - 2022) organized by NWDA, MoJS, GOI during Nov. 01-05, 2022.
52.	Mangla, R., Jaiswal, R.K., Kumar, V., Tiwari, S., Tulbure, M.G., Galkate, R.V., Lohani, A.K. and Pandey, K. (2022).Understanding Dynamics of Climate Extremes on Irrigation Water Requirement for Kharif Paddy under Climate Change, International Conference ICCWE2022: Climate and weather-related extremes - New dimensions, Challenges, and Solutions organized by I.I.T. Roorkee, September 19-20, 2022.

53.	Mani, P., Chatterjee, C., Kumar, R. and Patra, J.P. (2023). Evaluating Climate Change Adaptation in Infrastructure Development: A Case Study for Estimating Safe Flood Elevation for an Industrial Site. Proceedings of theInternational Conference on Water Management and Climate Change organized by WALMI, Dharwad during 24-25 January, 2023 at Dharwad, Karnataka.
54.	Mani, P., Kumar, R. and Patra, J.P. (2022).Evaluating Flood Risk at an Industrial Site Using 1D-2D Coupled Hydrodynamic Flow Model Under Cascading Effect Of Dam Failure. Proceedings of the International Dam Safety Conference organized by INCOLD in collaboration with CWC, DRIP, CBIP and Water Resources Department, Government of Rajasthan during 10-12 October, 2022 at Jaipur, Rajasthan.
55.	Mourya, G., Nema, M.K. and Nema, A.K. (2022). Groundwater Potential Zone Mapping using Geospatial Techniques: A Case Study of Districts of Southern Madhya Pradesh. Presented and published in the 27th International Conference on Hydraulics, Water Resources and Coastal Engineering (HYDRO 2022 International) at PEC, Chandigarh India, during December 22-24, 2022.
56.	Murali, K., Rao, Y.R.S. and Sharada, S.(2022).Assessment of anthropogenic contaminants of groundwater in and around Kakinada smart city, Andhra Pradesh. Published in proceedings of *International Conference on Integrated Water Resources Management: Prospects and Challenges*. Karunya Institute of Technology and Sciences, Coimbatore, 08-10 December 2022.
57.	Nagashree, G.E., Nema, M.K., Makhdumi, W. and Dwarakish, G.S. (2022). Evaluation and Determination of Reliability on Advanced Neural Network Models for Prediction of Soil Moisture. Presented and published at the 27th International Conference on Hydraulics, Water Resources and Coastal Engineering (HYDRO 2022 International) at PEC, Chandigarh India, during December 22-24, 2022.
58.	Nandi, S. and Swain, S. (2023). Improving Numerical Weather Prediction-Based Short-To-Medium Range Precipitation Forecasts Using LSTM. *The Third International Workshop on BIODIVERSITY AND CLIMATE CHANGE - Sustainable Development Perspective (BDCC 2023)*, IIT Kharagpur, India, 16-19 February 2023.
59.	Nayak, P.C., Ramola, M., Venkatesh, B., Thomas, T. and Lohani, A.K. (2022). Unsteady flood modeling for Pulichintala and Kandaleru dam using Hec-RAS, Three Day International Conference on "Dam Safety" organized by DRIP, CWC New Delhi at Jaipur from October 7-8, 2022.
60.	Nema, M.K. (2022).Field hydrology and Experimental Catchment based research studies in the lesser Himalayain the International online workshop on Scaling Effects on Runoff Assessment/Monitoring organized by ICAR – Indian Institute of Soil and Water Conservation, RC, Udhagamandalam on May 31, 2022.
61.	Nema, M.K., Mishra, P.K. and Jain, S.K. (2022). Dam decommissioning: An option for India's ageing water storage infrastructures, Presented and published in International Dam Safety Conference organized by Indian National Committee on Large Dams, India (INCOLD), CWC and CBIP at Jaipur during October 10-12, 2022.
62.	Noel, D., St. Jacques, J-M and Gurrapu, S. (2022).The effects of the Atlantic Multidecadal Oscillation, Pacific Decadal Oscillation, North Atlantic Oscillation and El Niño-Southern Oscillation on discharge variability in the Canadian Maritimes. AGU Fall Meeting, Chicago, USA. 12 – 16 December, 2022.

63.	Osheen, Kansal, M.L. and Bisht, D.S. (2022).Assessment of Extreme Storm Conditions for an Urban Drainage System. Inaugural International Conference on Smart and Sustainable Infrastructure organized by PDEU, Gandhinagar, India during 23-25 August 2022 at Gandhinagar (Gujarat), India.
64.	Osheen, Kansal, M.L. and Bisht, D.S. (2022).Effectiveness of LIDs in Resilience Enhancement of an Urban Drainage System: A Case Study. AGU Fall Meeting. Chicago, IL & Online Everywhere during 12-16 December 2022.
65.	Padikal, A. and Krishan, G. (2022). Mapping of groundwater salinity in Punjab, India In: Proceedings of International Groundwater Conference (IGWC-2022) Effective Management of (Sub)-Surface Water Resources in Arid and Semi-arid Regions during 02-05 November, 2022 at IIT Roorkee.
66.	Pant, A. and Bhagwat, A. (2022 .)Microplastics :Quantification, identification, and its effects on aquatic invertebrates Roorkee water conclave .Held on 3-4 March, 2022.
67.	Pathak, L. and Barman, S. (2022). Runoff Simulation using SWAT Model: A Case Study for the Baralia River Watershed. International Conference on Sustainable Technologies for River Erosion Alleviation and Management (STREAM 2022) during December 14-16, 2022 organized by Department of Civil Engineering, Indian Institute of Technology Guwahati & Brahmaputra Board held at Assam Water Centre, Guwahati.
68.	Patidar, N., Krishan, G. and Sharma, A. (2022). Integrated GEE-MODFLOW Model for Groundwater Recharge Assessment. India Water Week 2022-Water security for sustainable development with equity (IWW-2022), 1-5 November, 2022 at India Expo Centre, Greater Noida.
69.	Patidar, R., Pingale, S.M., Khare, D. and Choudhary, S.(2022). A multi-scale spatio-temporal evaluation of drought characteristics over semi-arid regions of Bundelkhand, India. Poster Session in AGU Fall Meeting held during 12-16 December, 2022 at McCormick Place in Chicago, IL, USA. https://agu2022fallmeeting-agu.ipostersessions.com/Default.aspx?s=4F-96-F8-83-A9-35-2B-EC-B4-B3-B0-12-86-16-02-D8.
70.	Patidar, R., Pingale, S.M., Khare, D. and Dayal, D(.2022). Spatio-temporal assessment of meteorological, hydrological, and agricultural drought over semi-arid regions of Bundelkhand, India -A multi-scale characterization .*International Conference on Climate and Weather-Related Extremes (New Dimensions, Challenges and Solutions ( )ICCWE 2022)* held at IIT Roorkee during 19 & 20 September 2022 .Paper Id :7445 . https//:www.iitr.ac.in/iccwe2022/index.html.
71.	Patil, P.R., Chakravorty, B. and Mani, P.(2022).Soil Moisture Accounting based Sediment Transport Modeling of Storm Events of Arid Drainage Basin. Proceedings of the International Chemical Engineering Conference (IChEC) on The Role of Chemical and Allied Engineering in Environmental Protection and Green Energy organized by Dept. of Chemical & Biochemical Engineering, Indian Institute of Technology, Patna during 12-13 November, 2022 at Patna, Bihar.
72.	Patil, P.R., Chakravorty, B., Mani, P. and Mishra, S.K. (2023). First-flush Coupled SMA Inspired Modeling of Sediment Yield Events. Proceedings of theInternational Conference on Water Management and Climate Change organized by WALMI, Dharwad during 24 -25 January, 2023 at Dharwad, Karnataka.

73.	Patra, J.P., Mani, P., Kumar, R., Lohani, A.K. and Gurrapu, S. (2022). Probabilistic Dam Breach Modelling of Mahi Bajaj Sagar Dam using Monte Carlo Simulation Technique in INTERNATIONAL DAM SAFETY CONFERENCE organised by Indian Committee on Large Dams (INCOLD) during 10-12th October, 2022 at Jaipur, Rajasthan.
74.	Ramana, R.V., Jeyakanthan, V.S., Sharma, M. and Rao, Y.R.S. (2023). Modeling Drainage Network in Urban Sub-Catchment of Hyderabad using SWMM. 5th Int. Nat. Conf. Recent Trends in Sci. Engg. Management (ICRTSEM - 2023), 24th March 2023 Organized by Karpaga Vinayaga College of Engineering and Technology, Chengalpattu, Tamilnadu, India-603308.
75.	Ramana, R.V., Sharma, M., Jeyakanthan, V.S. and Rao, Y.R.S. (2022). Spatial urban flooding map using hydrodynamic model-SWMM and HEC RAS. *International Conference on Integrated Water Resources Management Prospects and Challenges*. Organized by Karunya Institute of Technology and Sciences, Coimbatore, 08-10 December 2022.
76.	Ranade, A. (2022). Climatic changes in seasonal and extreme rainfall characteristics of seven homogenous zones of India, 9th International Groundwater conference (IGWC-2022), 2-4 Nov 2022 at IIT Roorkee.
77.	Ranade, A. (2022).Global Climatic Changes in 3-D structure of Atmospheric Temperature, International Conference on Climate and Weather –related Extremes (ICCWE-2022), 19-20 Sept 2022, IIT Roorkee.
78.	Ranade, A. (2022).Hydrometeorological Extremes across India under changing climate, Young Scientist Conference held during 22-24 January 2023 at MANIT, Bhopal as a part of India International Science Festival (IISF)-2022.
79.	Ranade, A. (2022).Long-term trend and harmonic analysis of Basin-scale rainfall across India during 1813-2020, 27th International conference on Hydraulics, Water Resources, Environmental and Coastal engineering (HYDRO-2022), 22-24 Dec 2022, Punjab Engineering College, Chandigarh.
80.	Rao, Y.R.S., Prasad, Y.S. and Kumar, S. (2022).Assessment of Salinization Processes in Shallow aquifer of Godavari Delta, India using Stable Isotopes published in the proceedings of 9th IGWC-2022, IIT Roorkee held during 02-04 November, 2022 pp. 61.
81.	Rao, Y.R.S., Prasad, Y.S., Ghosh, N.C. and Vijay, T. (2022).River Bank Filtration (RBF) – A Source for Safe Drinking Water Security published in the Proceedings of India Water Week-2022 held during 01-05, November 2022in New Delhi.
82.	Sandhu, C., Krishan, G., Grischek, T., Bornick, H., Ronghang, M., Fernandes, A.V. and Prasad, D. (2022).Need-based demonstration of riverbank filtration at sites impacted by environmental extremes in Agra and Guwahati, India In: Proceedings of International Groundwater Conference (IGWC-2022) Effective Management of (Sub)-Surface Water Resources in Arid and Semi-arid Regions during 02-05 November, 2022 at IIT Roorkee.
83.	Sharma, M., Ramana, R.V., Jeyakanthan, V.S. and Rao, Y.R.S. (2022). Spatio-temporal variations of land use/ land cover changes in urban catchment of GHMC zone. *International Conference on Integrated Water Resources Management Prospects and Challenges*. Organized by Karunya Institute of Technology and Sciences, Coimbatore, 08-10 December 2022.

84.	Sharma, M., Ramana, R.V., Jeyakanthan, V.S. and Rao, Y.R.S. (2023).Developing Intensity Duration Frequency curves for Urban sub-catchment of Hyderabad City. 5th Int. Nat. Conf. Recent Trends in Sci. Engg. Management (ICRTSEM - 2023), 24th March 2023 Organized by Karpaga Vinayaga College of Engineering and Technology, Chengalpattu, Tamilnadu, India-603308.
85.	Sharma, M.K., Kumar, P., Sharma, B., Prasad, B. and Bhanot, K. (2022). Hydrochemicalbehaviour, its controlling processes and importance of p(CO2) signature of meltwater of River Bhagirathi in Upper Ganga Basin, India, Paper presented in 7th India Water Week 2022, India Expo Centre, Greater Noida during 1-5 November 2022.
86.	Sharma, P., Mishra, P.K. and Sharma, A. (2022).Integrating Multiple Land Use and Assessment of Evapotranspiration for Sustainable Management of Land and Water Resources in Upper Yamuna Basin. Proceedings of the 27th International conference on Hydraulics, Water Resources, Environmental and Coastal Engineering (HYDRO -2022), December 2022, PEC, Chandigarh.
87.	Siddik, A.B., Jaiswal, R.K., Tiwari, H.L. and Galkate, R.V. (2022).Comparative Study of Parsimonious Hydrological Models in a Sub-Catchment of Betwa River Basin. 27th International Conference on Hydraulics, water Resources Environment and Water Engg. (HYDRO 2022), organised by Punjab Engineering College, Chandigarh during 22-24 December 2022 at Chandigarh (Punjab), India.
88.	Singh, K., Singh, R., Pandey, G., Singh, S. and Malyan, S.K. (2022).Scenario of Hydrochemistry, Health risk, and Solute Source in Groundwater of Bathinda District, Punjab. In India Water Week (IWW - 2022) organized by NWDA, MoJS, GOI during Nov. 01-05, 2022.
89.	Singh, K., Singh, R., Pandey, G., Singh, S. and Malyan, S.K. (2022). Assessment of Lead in groundwater, health risk and leaching behavior from sediments of Mansa district. In: International Groundwater Conference (IGWC 2022) organized by Department of Hydrology, IIT Roorkee during Nov. 02-04, 2022.
90.	Singh, S., Maithani, C., Malyan, S.K., Soti, A., Kulshreshtha, N.M., Singh, R., Brighu, U., Gupta, A.B., Kumar, J., Yadav, S., Singh, O. and Goyal, V.C. (2022). Comparative performance and metagenomic analysis of deep and shallow cells of a full-scale HFCW having sequentially decreasing depths reveals vast enhancement potential. International Conference on Biotechnology for Sustainable Bioresources and Bioeconomy (BSBB-2022), December 7-11, 2022, Indian Institute of Technology, Guwahati.
91.	Singh, S., Malyan, S.K., Singh, K. and Singh, R. (2022). Evaluation of Metals, Pesticides, PAHs and PCBs in groundwater of Malwa Region of Punjab, India. India Water Week (IWW-2022) organized by NWDA, MoJS, GOI during Nov. 01-05, 2022.
92.	Singh, V. (2022). Hydrological modelling using GRACE in Upper Ganga basin in the Second United Nations World Geospatial Information Congress in Hyderabad, India, from 10-14 October 2022.
93.	Singh, W.R., Barman, S., Gogoi, S. and Kalita, B. (2022).Discharge Pattern of Dudhnai Watershed, Brahmaputra Basin under the Influence of Climate Change. International Conference on Sustainable Technologies for River Erosion Alleviation and Management (STREAM 2022) during December 14-16, 2022 organized by Department of Civil Engineering, Indian Institute of Technology Guwahati & Brahmaputra Board held at Assam Water Centre, Guwahati.

94.	Swain, S., Mishra, S.K. and Pandey, A. (2023).A novel probabilistic approach of multi-scalar drought severity mapping using a bias-corrected blended precipitation product. The *Third International Workshop on BIODIVERSITY AND CLIMATE CHANGE - Sustainable Development Perspective (BDCC 2023)*, IIT Kharagpur, India, 16-19 February 2023.
95.	Swain, S., Nandi S., Mishra, S.K. and Pandey, A. (2022).Assessing the impacts of climatic and socio economic changes on drought vulnerability of a transboundary river basin in India: A multi-dimensional perspective. *The water security and Climate change conference* Bangkok, Thailand, 01-03 December 2022 (Virtual Mode).
96.	Tejaswi, A., Sahoo, B., Kale, R.V. and Murty, P.L.N (2022). Integrated ADCIRC-SWAN-HEC-RAS 2D Modelling Framework for Cyclonic Coastal Flood Inundation Mapping. Proceedings of the 3rd IAHR Young Professional Congress organized by the International Association for Hydro-Environment Engineering and Research (*IAHR*) during 28 Nov – 1 Dec 2022 (Online mode).
97.	Thakur, A., Sharma, A., Sarkar, A. and Thakural, L.N. (2022). Assessment of the suitability of several precipitation datasets for the Upper Yamuna Basin upto Delhi, 27th International Conference On Hydraulics, Water Resources, Environmental and Coastal Engineering organised by Department of Civil Engineering, Punjab Engineering College, Chandigarh during 22nd-24th December, 2022.
98.	Thakur, D., Sharma, A., Sharma, M.K., Anand, L.V., Sharma, R.K. and Kumar, S. (2022).Factors affecting fluoride concentration in groundwater of semi-arid region, India, 9th International Ground Water Conference (IGWC-2022), organized by IIT Roorkee during 2-4 November, 2022, at Roorkee (Uttarakhand), India.
99.	Thakural, L.N., Abhishikta, Samad, A., Alam, M., Ansari, I. and Lohani, A.K. (2022).Geospatial and AHP Techniques for Selection of Potential Zones for Water Harvesting in Dehradun, Uttarakhand. 9th International Groundwater Conference- 2022 organized by I.I.T. Roorkee, November 2-4, 2022.
100.	Thakural, L.N., Bamrara, M., Mishra, N., Samad, A., Alam, M., Lohani, A.K. and Thakur, A. (2022). Morphometric Characterization of Netravati River Basin using Geospatial Tools, 27th International Conference On Hydraulics, Water Resources, Environmental and Coastal Engineering organised by Department of Civil Engineering, Punjab Engineering College, Chandigarh during 22nd-24th December, 2022.
101.	Thakural, L.N., Kumar, S., Ansari, I., Lohani, A.K., Patra, J.P. and Gurrapu, S. (2022).Evaluating long-term temperature trends for districts of Gujarat, India. International Conference ICCWE2022: Climate and weather-related extremes - New dimensions, Challenges, and Solutions organized by I.I.T. Roorkee, September 19-20, 2022.
102.	Thomas, T., Sharma, G., Nayak, P.C., Venkatesh, B. and Patel, L. (2022). Development of a Framework for Integrated Assessment of Drought Vulnerability in Chambal basin in Western Madhya Pradesh. Proceedings of the International Conference on Water and Environmental Management (WEM-2022): Sustainable Water Management in the context of Changing Environment, organised by Centre for Water Resources Development and Management, Kozhikode during 22-24 June 2022 at Kozhikode (Kerala), India.
103.	Tomar, A., Rajpal, A., Kazmi, A.A. and Tyagi, V.K. (2022). Removal of Nutrients from Dairy Wastewater using Sequencing Batch Reactor. In: 7th India Water Week conclave, 1st -5th November 2022, Greater Noida, India Oct 29-31, 2022.

104.	Tyagi, V.K., Arora, P., Kapoor, A. and Kazmi, A.A. (2022).Biorefinery of Municipal Solid Waste in a Circular Bio-economy: Case study of 100 TPD Mechanical-Biological Treatment Plant in International Conference on Biotechnology for Sustainable Bioresources and Bioeconomy (BSBB-2022) organized by Indian Institute of Technology, Guwahati, India, December 7-11, 2022.
105.	Tyagi, V.K., Balasundaram, G., Gahlot, P. and Kazmi, A.A. (2022). Thermal hydrolysis of sewage sludge: Organics solubilization, methane yield, and emerging contaminants & pathogens removal": 13th International symposium on southeast asian water environment, 13th-15th December 2022, Bangkok, Thailand.
106.	Venkatesh, B., Abhilash, R., Thomas, T. and Nayak, P.C. (2022).Potential flood zone mapping for risk mitigation of Rakasakoppa dam, Belagavi, India, Three Day International Conference on "Dam Safety" organized by DRIP, CWC New Delhi at Jaipur from Oct7-8,2022.
107.	Venkatesh, B., Mishra, N., Panandiker, A.P. and Mesquita, M.D.S. (2022).Modelling Of Daily Rainfall of Goa State Using Hmm Model, International Virtual Conference on Developments and Applications of Geomatics, (DEVA-2022), Organized by Department of Civil Engineer, NIT Warangal, during August 29-31, 2022.
NATIONAL CONFERENCE/SEMINAR/WORKSHOP	
1.	Chakravorty, B. (2022). An Integrated Approach for Managing of Waterlogged and Drainage Congested areas in Lower Gandak Basin- A Modelling Approach.In the National Workshop on Agricultural Water Management in Changing Climate at organized byICAR RCER Patna on 27 March, 2023.
2.	Krishan, G. (2022).An insight from isotopic data to understand salinity mechanism in the aquifers of semi-arid regions of the north-west, India .In :INC-IAH National Seminar on "Recent approaches in groundwater development and management in arid/semi-arid region of India with a focus on Rajasthan "organized by INCIAH, RIET-Jaipur and Groundwater department, Rajasthan on December 24, 2022.
3.	Mandloi, S., Chakravorty, B. and Mani, P. (2022). Morpho-dynamic changes of Ganga River reach from Sultanganj to Bhagalpur using Remote Sensing Techniques.Proceedings of the National Seminar on Role of Agriculture and Statistics for Sustainable Natural Resources Management (SNRM) organized byDepartment of Farm Engineering, Banaras Hindu University during 11-12December, 2022 at Varanasi, U.P.
4.	Nayak, P.C., Thomas, T. and Venkatesh, B. (2022). Spatio-temporal analysis of rainfall pattern for Krishna basin, Two Day National Symposium on Advances in Weather and Climate prediction and Climate change Projection over South Asia: Applications in Water and Agriculture Sectors on 29th November to 2nd December 2022 organized by Indian Institute of Science, Education and Research (IISER) Bhopal.
5.	Nema, M.K. and Sekhar, M. (2022).Soil Moisture India Network (SMIN) : Exploring Research Possibilities and Expansion of the Network was presented during an online session of UK-India Smart Farm Club (SFC) on Nov 04, 2022.
6.	Pandey, R.P. (2022). Environmental Challenges and Water Resources Management for Resilient Ecosystem in Arid Regions invited Key paper presented in National Conference on Desert Ecosystems: Status, Emerging Challenges and Perspectives, November 15-16, 2022, Jaipur.

7.	Pandey, R.P. (2023). Challenges on sustainability of water resources for drinking water and irrigation. Key note paper presented in Water Summit: 2023 on "Water Security in India: Challenges & Prospects". Organized jointly by the Center for Advance Water Technology and Management and Gurugram University, ManavRachna, International Institute of Research and Studies, 24th February 2023, Faridabad-121004, Haryana
8.	Pandey, R.P. and Galkate, R.V. (2022). Impact of Climate Change on Occurrence of Regional Droughts. Invited lead paper presented in "31st National Conference on Innovative Resource Management Approaches for coastal and Inland Ecosystems to Sustain Productivity" and Climate Resilience, 13-15 Oct 2022, Navsari, Organized by Agricultural University, Navsari, Gujarat.
9.	Prasad, B., Tiwari, H.L., Galkate, R.V. and Khare, S. (2022). Rainfall Runoff Modeling for Wainganga River Sub-Basin Using HEC-HMS Model. IJEP 42(B): 1101-1107.
10.	Rao, Y.R.S. and Swain, S. (2023). Hydrological regime of the Godavari Delta under varying climatic conditions and Land use changes. In: Workshop proceedings on "Climate Change Adaptation & Mitigation" held on 27th January 2023 at Ambajipet, Andhara Pradesh.
11.	Rawat, S.S., Gurjar, S., Bisht, D.S., Kumar, S., Raina, G. and Khurana, D. (2022). हिमालयी जल स्रोतों के कुशल प्रबंधन एवं पुनरुद्धार के लिए वेब-जी.आई.एस. आधारित सूचना प्रणाली. भारतीय हिमालयी पर्यावरण को प्रभावित करने वाले कारक एवं प्रबंधन. जी.बी. पंत राष्ट्रीय हिमालयी पर्यावरण संस्थान अल्मोड़ा, 28-29, July 2022.
12.	Rawat, S.S., Kumar, S. and Bisht, D.S. (2022).Springshed Management: Need for the Development of Scientific Approach and Protocols at Regional Scale. National Symposium Cum Workshop on Springhshed Management organized by NERIWALM, Tezpur, India, during 18-19 November 2022 at Tezpur (Assam), India.
13.	Thomas, T., Nayak, P.C. and Venkatesh, B. (2022).Long-term Changes in Climatic Variables – a case study for Chambal basin in Central India., National Symposium TROPMET 2022: Advances in Weather and Climate Prediction and Climate Change Projection over South Asia: Applications in Water and Agriculture Sectors organised by Indian Institute of Science Engineering and Research, Bhopal during 29 November – 2 December, 2022 at Bhopal (MP), India.
14.	Tomar, A., Rajpal, A., Kazmi, A.A., Goel, A.K. and Tyagi, V.K. (2023).Advanced anaerobic bio-digester: A DRDO based bio-digester for human fecal treatment. In: Institute Research Day, March 14, 2023 at Indian Institute of Technology Roorkee.
15.	Tomar, A., Rajpal, A., Kazmi, A.A., Goel, A.K. and Tyagi, V.K. (2023).Sustainable Solution for Sanitation: A DRDO based bio-digester for human fecal treatment. In: Uttarakhand UdyogMahotsava, March 18-20, 2023.
16.	Venkatesh, B., Bharat, A.L., Nayak, P.C. and Thomas, T. (2022). Evaluation of various Characteristics of Precipitation Concentration Index in part of Western Ghats, Two Day National Symposium on Advances in Weather and Climate prediction and Climate change Projection over South Asia: Applications in Water and Agriculture Sectors on 29th November to 2nd December 2022 organized by Indian Institute of Science, Education and Research (IISER) Bhopal.

Technology Transfer Activities

APPENDIX-XI

SN	ACTIVITES	PERIOD	VENUE
INTERNATIONAL ACTIVITIES			
1.	9th International Groundwater Conference (IGWC-2022) on Effective Management of Sub-Surface Water Resources in Arid and Semi-arid Regions (Organising Secretary-IIT, Roorkee; Joint Org. Secretary-Dr. Gopal Krishan, NIH)	November 02-04, 2022	Dep. of Hydrology, IIT Roorkee
NATIONAL ACTIVITIES			
SEMINARS/SYMPOSIA/CONFERENCES			
1.	Special Session Organised by NIH for Young Professionals on "Water Security for Sustainable Development with Equity" during 7th India Water Week-2022 (IWW-2022), MoJS (GoI).	November 03, 2022	India Expo Center, Greater Noida
2.	National Symposium cum Workshop on "Springshed Management" jointly organized by North Eastern Regional Institute of Water and Land Management (NERIWALM), National Institute of Hydrology and Central Ground Water Board	November 18-19, 2022	NERIWALM, Tezpur
TRAINING COURSES/WORKSHOPS/BRAINSTORMINGS			
1.	Training Workshop on "Hydrodynamic Modelling using HEC-RAS"	April 07-08, 2022	Gandhi Nagar
2.	12-day Training Programme on "Water Resources Planning and Management" sponsored by META, Nashik	April 15-25, 2022	NIH, Roorkee
3.	Training Workshop on "Flood Management and Erosion Control" in collaboration with NEHARI, Brahmaputra Board	April 18-22, 2022	NEHARI, Brahmaputra Board
4.	Training on "Remote Sensing and GIS" in the Induction Course for Newly Appointed AE's of WRD (Irrigation), Govt. of Bihar in four batches organized by CFMS, Patna	May 02, May 12, May 23, May 30, 2022	Jointly with WALMI, Patna
5.	05-day Training Workshop on "Flood Management and Erosion Control" organised by NIH and NEHARI	May 09-13, 2022	NEHARI, Brahmaputra Board
6.	Training on "Approaches for Management of Groundwater Quantity and Quality with special focus on MAR" jointly organized by NIH and IIT, Roorkee	June 06-10, 2022	Virtual mode

7.	Training on "Remote Sensing and GIS" in the Induction Course for Newly Appointed AE's of Project and Development (P&D) Department, Govt. of Bihar in four batches organized by CFMS, Patna	June 06, June 30, July 13 and July 26, 2022	Jointly with WALMI, Patna
8.	05-day Training on “National Hydrology Model” sponsored by National Hydrology Project (NHP)	August 01-05, 2022	NIH, Roorkee
9.	Training on "Remote Sensing and GIS" in the Induction Course for Newly Appointed AE's of Building Construction Department, Govt. of Bihar in two batches organized by CFMS, Patna	August 01 and August 22, 2022	Jointly with WALMI, Patna
10.	05-day online training on “Hydrological Modeling using Soil and Water Assessment Tool (SWAT): Theory and Hands -on” sponsored by National Hydrology Project (NHP)	August 22-26, 2022	NIH, Roorkee
11.	01-day Training Workshop on “Tools and Techniques for Springshed Management” organized by NIH-WHRC in association with Government Degree College, Udhampur Jammu	September 03, 2022	Government Degree College, Udhampur
12.	Scientific Data Collection and Techniques for Springshed Management and Rejuvenation	September 06-09, 2022	NEHARI, Guwahati
13.	Training Workshop on "Flood management and Erosion Control" organised in association with NEHARI, Brahmaputra Board	September 09-23, 2022	NEHARI, Brahmaputra Board
14.	Brief presentation on “TUFLOW Hydraulic modelling software”	September 12, 2022	NIH, Roorkee (Virtual mode)
15.	Training Course on “River Hydraulics with 1D and 2D HEC-RAS” organised in association with US Army Corps of Engineer, USA	September 26-29, 2022	NIH, Roorkee
16.	Training on “Remote Sensing and GIS” in the Orientation Course for Chief Engineers of all Works Department of Govt. of Bihar organized by CFMS, Patna	October 31-November 04, 2022	Jointly with WALMI, Patna
17.	Training on “Remote Sensing and GIS” in the Induction Course for Newly Appointed AE’s of WRD, Govt. of Bihar organized by CFMS, Patna	November 03-16, 2022	Jointly with WALMI, Patna
18.	05-day Online Training Programme on “Hydrologic and Hydrodynamic Flow Analysis Using HEC-HMS and HEC-RAS”	November 07-11, 2022	NIH, Roorkee
19.	Training Workshop on "Flood management and Erosion Control" organised in association with NEHARI, Brahmaputra Board	November 14-18, 2022	NEHARI, Brahmaputra Board
20.	Training cum workshop on “Advanced Tools and Techniques for Managed Aquifer Recharge (ATT-MAR)” jointly organized by NIH and IIT, Roorkee	November 21-25, 2022	IIT, Roorkee

21.	05-Day Training Course on “Integrated Water Resources Modelling under a Changing Climate in the Indian Himalayas”	November 21-25, 2022	NIH, Roorkee
22.	First Training of Trainers on “Usage and Applications of DSS (PM)”	Nov. 21-Dec. 02, 2022	NIH, Roorkee
23.	05-day Training Course on “Application of Water Accounting Plus (WA+) Tool for Water Resources Management”	Nov. 28-Dec. 02, 2022	Kohima, Nagaland
24.	Hydrological modelling using SWAT	December 05-09, 2022	NERC, NIH, Guwahati
25.	One-week Training Course on “Climate Change and Hydrological Impact Assessment”	December 12-17, 2022	NIH, Roorkee
26.	Training Course on “Springshed Management”	December 13-15, 2022	DoLR, Kohima, Nagaland
27.	Training Course entitled “Hands-on Advanced Instrumentations in Water Quality Analysis” under NHP	January 16-20, 2023	NIH, Roorkee
28.	SERB Sponsored High-End Workshop [Karyashala] on the topic “Challenges in Water-Related Disasters Risk Reduction: Vulnerability, Adaptation and Resilience Techniques”	January 16-21, 2023	NIH, Roorkee
29.	Training Course entitled “Environmental Data Processing” under NHP	Jan. 30-Feb. 03, 2023	NIH, Roorkee
30.	05-day Training Workshop on "Flood Management and Erosion Control" organised in association with NEHARI, Brahmaputra Board	February 06-10, 2023	NEHARI, Brahmaputra Board
31.	Training Course on “Water Quality Monitoring and Management” under NHP	February 13-17, 2023	NIH, Roorkee
32.	Training Course on “Hydro-meteorological Data Analysis: Basics and Advanced Techniques”	Feb. 27-Mar. 03, 2023	NIH, Roorkee
33.	05-day Training Programme on “Life cycle Approach for Rejuvenation of Ponds and Lakes Using Nature-based solutions”	March 13-17, 2023	DRC, NIH, Kakinada
34.	05-day Training Programme on “Life cycle Approach for Rejuvenation of Ponds and Lakes Using Nature-based solutions”	March 13-17, 2023	HRRC, NIH, Belagavi
35.	05-day Training Programme on “Life cycle Approach for Rejuvenation of Ponds and Lakes Using Nature-based solutions” organized by Central India Hydrology Regional Centre, Bhopal	March 13-17, 2023	State Water Data Centre, WRD, Bhopal
36.	01-day Training Course on “Analyzing Hydro-Meteorological Data Using R Programming Language”	March 17, 2023	WHRC, NIH, Jammu

37.	05-day Training Programme on "Flood Prone Area Mapping and Modeling" for I&WRD, Mizoram	March 20-24, 2023	NIH, Roorkee
38.	Training Course on "Water and Wastewater Treatment"	March 20-24, 2023	NIH, Roorkee
39.	Modellers Meet under NHP	December 19-20, 2022	New Delhi
40.	Organized the Training Workshop on "Role of Hydrology in Urban Flood Management"	February 06-08, 2023	DRC, NIH, Kakinada
41.	Involved in the organization of 02-day Technical Workshop entitled "WEB.BM model applications for optimization analysis of reservoir systems operation" with Dr. Nesa, Ilich, International Consultant, TAMC under NHP as key resource person	March 13-14, 2023	NIH, Roorkee
42.	The Soil Moisture India Network (SMIN) Steering Committee Meeting along with the Soil Moisture India Network (SMIN) Stakeholders' Workshop	June 07, 2022	NPMU-NHP, New Delhi
43.	Workshop on Application of Decision Support System (Planning & Management) for Upper Krishna Basin	August 26, 2022	YASHADA, Pune
44.	Organized Inception Workshop under NHP special studies entitled "Comprehensive Assessment of Water Availability, Use and issues for Goa State"	September 23, 2022	Water Resources Department, Goa
45.	An "Awareness Session on IPR & Patent"	April 26, 2022	NIH, Roorkee
46.	Brainstorming Session on "Water Security in a Changing Environment- Focus on Indian Himalayan Region (IHR)" during 15th & 16th Uttarakhand State Science and Technology Congress (USSTC) under the aegis of INC-IHP	June 22, 2022	Graphic Era (Deemed to be) University, Dehradun
47.	Swachh Manthan on a theme "Accelerating Change to Solve Water and Sanitation Crisis" on the occasion of "World Water Day" for Bihar Govt. officials	March 22, 2023	CFMS, Patna
48.	Brainstorming Session on R&D in Hydrology: Vision 2047 (on the occasion of NIH Foundation Day)	16th Dec. 2022	NIH, Roorkee
OTHER ACTIVITIES			
1.	World Water Day 2023	March 22, 2023	NIH & IIT Roorkee

Position of Staff

APPENDIX-XII

GROUP	POST	Sacnctioned Strength	Status as per Sanction	ActualPositio nas per DR/APS/DPC
		31.03.2023	**31.03.2023**	**31.03.2023**
A	Director	01	01	01
A	Scientist G	00	00	13
A	Scientist F	01	01	14
A	Scientist E	00	00	03
A	Scientist D	12	07	21
A	Scientist C	26	15	07
A	Senior Administrative Officer	01	01	01
A	Finance Officer	01	01	01
A	Scientist B	63	44	09
	Sub Total	**105**	**70**	**70**
B	Administrative Officer	01	01	01
B	Principal Research Assistant	09	08	08
B	Assistant Engineer	01	01	01
B	Section Officer	03	02	02
B	Private Secretary	05	05	05
B	Senior Research Assistant	15	08	08
B	Senior Technician	01	01	01
B	Senior Translation Officer	01	01	01
B	Asstt. Library& Information Officer	01	01	01
B	Library and Information Assistant	01	01	01
B	Research Assistant	09	07	07
B	Junior Engineer Senior Grade	02	02	02
B	Technician Grade-I	08	02	02
B	Assistant	07	04	04
B	Personal Assistant	09	04	04

B	Draughtsman Grade-I	02	01	01
B	Staff Car Driver Special Grade	01	01	01
	Sub-Total	**76**	**50**	**50**
C	Technician Grade-II	08	04	04
C	Draughtsman Grade-II	01	00	00
C	Stenographer	05	02	02
C	Upper Division Clerk	07	01	01
C	Receptionist	01	01	01
C	Technician Grade-III	05	04	04
C	Lower Division Clerk	07	07	07
C	Staff Car Driver Grade-I	04	03	03
C	Staff Car Diver (Grade-II)	03	01	01
C	Staff Car Driver (Ordinary Grade)	02	00	00
C	Multi-Tasking Staff	31	20	20
	Sub total	**74**	**43**	**43**
	GRAND TOTAL	**255**	**163**	**163**

List of Employees as on March 31, 2023

APPENDIX-XIII

S.N.	NAME	DIVISION / REGIONAL CENTRE
DIRECTOR		
1.	Dr.Sudhir Kumar	Director
SCIENTIST `G'		
1.	Dr. Sanjay K. Jain	Head, Water Resources Systems Division
2.	Dr. M.K. Goel	Head, Ground Water Hydrology Division
3.	Dr. A.K. Lohani	Head, Surface Water Hydrology Division
4.	Dr. R.P. Pandey	Head, Environmental Hydrology Division and Head, Maintenance Division
5.	Dr. B Chakraborty	Head, Centre for Flood Management Studies, Patna
6.	Dr. Y R S Rao	Head, Deltaic Regional Centre, Kakinada
7.	Dr. S.V. Vijay Kumar	Head, North Eastern Regional Centre, Guwahati
8.	Dr. B. Venkatesh	Head, Hard Rock Regional Centre, Belagavi
9.	Dr. S.D. Khobragade	Hydrological Investigations Division
10.	Dr. Tej Ram Nayak	Central India Hydrology Regional Centre, Bhopal (On deputation to NCA, Indore)
11.	Er. Omkar Singh	Head, Research Management & Outreach Division
12.	Dr. A.R. Senthil Kumar	Research Management and Outreach Division
13.	Dr. (Miss) Anupama Sharma	Ground Water Hydrology Division
SCIENTIST 'F'		
1.	Dr. S.K. Singh	Surface Water Hydrology Division
2.	Dr. M. Someshwar Rao	Hydrological Investigations Division
3.	Er. Pankaj Mani	Centre for Flood Management Studies, Patna
4.	Dr. Surjeet Singh	Ground Water Hydrology Division
5.	Dr. Purna Chandra Nayak	Surface Water Hydrology Division
6.	Dr. V.S. Jeyakanthan	Deltaic Regional Centre, Kakinada
7.	Shri R. V. Galkate	Head, Central India Hydrology Regional Centre, Bhopal
8.	Dr. Sanjay Kumar	Surface Water Hydrology Division
9.	Dr. (Mrs.) Archana Sarkar	Surface Water Hydrology Division
10.	Dr. T. Thomas	Central India Hydrology Regional Centre, Bhopal
11.	Dr. Manohar Arora	Water Resources Systems Division
12.	Dr. Mathewkutty Jose	Hard Rock Regional Centre, Belagavi
13.	Dr. M.K. Sharma	Environmental Hydrology Division
14.	Dr. Soban Singh Rawat	Hydrological Investigations Division
SCIENTIST 'E'		
1.	Dr. Pottakkal George Jose	Western Himalayan Regional Centre, Jammu
2.	Dr. R.K. Jaiswal	Central India Hydrology Regional Centre, Bhopal
3.	Er. R. Venkata Ramana	Deltaic Regional Centre, Kakinada
SCIENTIST `D'		
1.	Dr. Chandra Mohan T.	Hard Rock Regional Centre, Belagavi

2.	Dr. Pushpendra Kumar Singh	Water Resources Systems Division
3.	Dr. L.N. Thakural	Surface Water Hydrology Division
4.	Dr. Ravindra Vitthal Kale	Surface Water Hydrology Division
5.	Dr. Pradeep Kumar	Environmental Hydrology Division
6.	Dr. (Mrs.) Jyoti P. Patil	Research Management and Outreach Division (posted at LCU, New Delhi)
7.	Dr. Manish Kumar Nema	Water Resources Systems Division
8.	Er. Jagdish Prasad Patra	Surface Water Hydrology Division
9.	Dr. Sumant Kumar	Ground Water Hydrology Division
10.	Dr. Rajesh Singh	Environmental Hydrology Division
11.	Er. (Mrs.) Suman Gurjar	Ground Water Hydrology Division (On Lien)
12.	Dr. (Mrs.) Ashwini A. Ranade	Surface Water Hydrology Division
13..	Dr. Gopal Krishan	Ground Water Hydrology Division
14.	Dr. (Mrs.) Shashi P. Induwar	Central India Hydrology Regional Centre, Bhopal
15.	Dr. Prabhash Kumar Mishra	Water Resources System Division
16.	Dr. Vinay Kumar Tyagi	Environmental Hydrology Division
17.	Dr. Sanjay Kumar Sharma	North Eastern Regional Centre, Guwahati
18.	Dr. Santosh Murlidhar Pingale	Hydrological Investigation Division
19.	Dr. (Ms.) Swapnali Barman	North Eastern Regional Centre, Guwahati
20.	Dr. Sunil Gurrapu	Water Resources Systems Division
21.	Dr. Vishal Singh	Water Resources Systems Division
SCIENTIST `C'		
1.	Dr. Kalzang Chhoden	Environmental Hydrology Division
2.	Dr. Abhilash R.	Hard Rock Regional Centre, Belagavi
3.	Dr. Pravin Rangarao Patil	Centre for Flood Management Studies, Patna
4.	Mrs. Anjali	Hydrological Investigation Division
5.	Dr. Deepak Singh Bisht	Western Himalayan Regional Centre, Jammu
6.	Dr. Nitesh Patidar	Ground Water Hydrology Division
7.	Dr. Waikhom Rahul Singh	North Eastern Regional Centre, Guwahati
SCIENTIST `B'		
1.	Ms. Nidhi Kalyani	Grount Water Hydrology Division
2.	Shri Rohit S. Sambare	Research Management and Outreach Division
3.	Shri Suryansh Mandaloi	Centre for Flood Management Studies, Patna
4.	Shri Sabyasachi Swain	Deltaic Regional Centre, Kakinada
5.	Shri N.K. Bhatnagar	Surface Water Hydrology Division
6.	Dr. N. Varadarajan	Hard Rock Regional Centre, Belagavi
7.	Shri Rajeev Gupta	Hydrological Investigations Division
8.	Smt. Anju Choudhary	Ground Water Hydrology Division
9.	Shri Om Prakash	Surface Water Hydrology Division
SENIOR ADMINISTRATIVE OFFICER		
1.	Shri Rajneesh Kumar Goel	Administration Section
FINANCE OFFICER		
1.	Shri Surya Kant	Finance Section

ADMINISTRATIVE OFFICER		
1.	Shri Kamal Sharma	Finance Section
ASSISTANT ENGINEER		
1.	Shri Mukesh Kumar Sharma	Maintenance Division
PRINCIPAL RESEARCH ASSISTANT		
1.	Shri V.K. Agarwal	Hydrological Investigations Division
2.	Shri Chandra Kumar S.	Hard Rock Regional Centre, Belagavi
3.	Shri Sanjay Mittal	Ground Water Hydrology Division
4.	Shri S.L. Srivastava	Soil Water Laboratory – Ground Water Hydrology Division
5.	Shri JatinMahrotra	Surface Water Hydrology Division
6.	Shri Rajesh Agarwal	Research Management & Outreach Division
7.	Shri Atam Prakash	Centre for Flood Management Studies, Patna
8.	Shri Drona Khurana	Western Himalayan Regional Centre, Jammu
SENIOR RESEARCH ASSISTANT		
1.	Shri P.R.S. Rao	Deltaic Regional Centre, Kakinada
2.	Shri T.R. Sapra	Computer Centre
3.	Shri Ram Chander	Ground Water Hydrology Division
4.	Smt. Babita Sharma	Environmental Hydrology Division
5.	Shri Vishal Gupta	Hydrological Investigations Division
6.	Smt. Bina Prasad	Environmental Hydrology Division
7.	Shri Nageswara Rao Allaka	Research Management & Outreach Division
8.	Sh. Subham Kumar Meena	North Western Regional Centre, Jodhpur
SENIOR TECHNICIAN		
1.	Shri N K Lakhera	Soil Water Laboratory – Ground Water Hydrology Division
TECHNICIAN GRADE-I		
1.	Shri C S Chowhan	Soil Water Laboratory – Ground Water Hydrology Division
2.	Shri D. Mohan Rangan	Deltaic Regional Centre, Kakinada
RESEARCH ASSISTANT		
1.	Shri Gaurav Kumar	Surface Water Hydrology Division
2.	Shri Hakim Singh Meena	North Eastern Regional Centre, Guwahati
3.	Shri Gurpreet Singh	Western Himalayan Regional Centre, Jammu
4.	Shri Anil Kumar	Deltaic Regional Centre, Kakinada
5.	Shri Rahul Kumar	Central India Hydrology Regional Centre, Bhopal
6.	Shri Asif	Centre for Flood Management Studies, Patna
7.	Shri Amit Sharma	Hard Rock Regional Centre, Belagavi
ASSISTANT LIBRARY & INFORMATION OFFICER		
1.	Mrs. Charu Pandey	Library
LIBRARY & INFORMATION ASSISTANT		
1.	Shri Rohit Negi	Library
JUNIOR ENGINEER SENIOR GRADE		
1.	Shri Sanjeev Kumar Satyarthi	Maintenance Division (Electrical)
2.	Shri Deepak Saha	Maintenance Division (Civil)

3.	Shri Pradeep Singh Panwar	Administration Section
4.	Shri Santosh Kumar	Bill Section
TECHNICIAN GRADE-II		
1.	Shri Mahipal Singh	Remote Sensing Laboratory – Water Resources Systems Division
2.	Shri Shyam Kumar	Maintenance Division (Civil)
3.	Shri Naresh Kumar	Workshop
4.	Shri Ved Pal	Meteorological Observatory – Surface Water Hydrology Division
TECHNICIAN GRADE-III		
1.	Shri Pankaj Kumar	Workshop
2.	Shri Sandeep Kumar	Workshop
3.	Shri Alok Kumar Sharma	Ground Water Hydrology Division
4.	Shri Amit Rawat	Water Quality Lab
DRAFTSMAN GRADE-I		
1.	Shri G Babu	Hard Rock Regional Centre, Belagavi
SECTION OFFICER		
1.	Smt. MadhuSuman	Administration Section
2.	Shri J.S. Bist	Procurement Section
PRIVATE SECRETARY		
1.	Shri Subhash Chand	Water Resources System Division
2.	Shri Sandeep Kumar	Director's Office
3.	Shri Mahendra Singh	Finance Section
4.	Mrs. Nisha Kichlu	Ground Water Hydrology Division
5.	Smt. Kiran Ahuja	Administration
PERSONAL ASSISTANT		
1.	Shri Ram Kumar	Surface Water Hydrology Division
2.	Shri Pawan Kumar	Hindi Cell
3.	Shri Daulat Ram	Research Management and Outreach Division
4.	Shri ParmanandRajak	Centre for Flood Management Studies, Patna
STENOGRAPHER		
1.	Shri Arun Kumar	Environmental Hydrology Division
2.	Mrs Priya Gandhi	Administration
ASSISTANT		
1.	Shri Naresh Kumar	Administration
2.	Mrs. Hansi	Administration
3.	Shri K.V.R. Vara Prasad	Deltaic Regional Centre, Kakinada
4.	Shri Praveen Kumar	Finance Section
SENIOR TRANSLATION OFFICER		
1.	Shri Pradeep Kumar Uniyal	Hindi Cell
UPPER DIVISION CLERK		
1.	Shri S.R. Majaletti	Hard Rock Regional Centre, Belagavi
LOWER DIVISION CLERK		
1.	Mrs. Neelam Bohra	Procurement Section
2.	Miss Kajal Pal	Finance Section

5.	Shri Joni Waker	Procurement Section
6.	Shri Ashis Kumar Banerjee	Bill Section
7.	Shri Subhash Chand	Administration Section
RECEPTIONIST		
1.	Mrs. Seema Bhatia	Administration Section (Security Cell)
DRIVER SPECIAL GRADE		
1.	Shri Kameshwar Tiwari	Vehicle Section
DRIVER GRADE-I		
1.	Shri Iftakhar Ahmad	Vehicle Section
2.	Shri Vijay Kumar	Centre for Flood Management Studies, Patna
3.	Shri Naresh Kumar	Vehicle Section
DRIVERS GRADE-II		
1.	Shri MunasalaThrimurthulu	Deltaic Regional Centre, Kakinada
DRIVERS ORDINARY GRADE		
MULTI TASKING STAFF (TECHNICAL)		
1.	Shri Ashok Kumar	Communication & Telephones
2.	Shri Dinesh Kumar	Soil Water Laboratory – Ground Water Hydrology Division
3.	Shri Iftkharul Hassan	Maintenance Division (Electrical)
4.	Shri Pradeep Kumar	Library
5.	Shri Satya Prakash	Hydrological Instrumentation Laboratory – Hydrological Investigations Division
6.	Shri JagdishChoudhary	Nuclear Hydrology Laboratory – Hydrological Investigations Division
7.	Shri Suraj Prakash Kotwal	Western Himalayan Regional Centre, Jammu
8.	Smt. C. Ambica	Library
MULTI-TASKING STAFF (MINISTERIAL)		
1.	Shri R.N. Pandey	Security Cell
2.	Shri Vish Ram	Maintenance (Guest House)
3.	Shri R.V. Kavalekar	Hard Rock Regional Centre, Belagavi
4.	Shri Chandra Prakash Sharma	Maintenance (Guest House)
5.	Shri Sri Ram Prasad	Maintenance (Guest House)
6.	Shri Biren Das	North Eastern Regional Centre, Guwahati
7.	Smt. Kiran	Administration Section
8.	Smt. Savitri Devi	Finance Section
MULTI-TASKING STAFF (WATCH & WARD)		
1.	Shri Padam Kumar Sharma	Security Cell
2.	Smt. Anita Dhyani	Hydrological Investigations Division
MULTI-TASKING STAFF (GARDENING)		
1.	Shri Bhagat Singh	Maintenance
MULTI-TASKING STAFF (CLEANING)		
1.	Shri Rajendra Kumar	Maintenance

APPENDIX-XIV

Guidance of Doctoral and Masters Research

S.N.	SUPERVISOR	TITLE OF THE PH.D./M. TECH/ M.Sc. THESIS	SCHOLAR/ DEPARTMENT/UNIVERSITY
Ph.D. THESIS GUIDANCE (COMPLETED IN 2022-23)			
1.	Dr. Sanjay Kumar Jain and Dr. Surjeet Singh Scientist G	Modelling the Impact of Climate Change on Water Resources in the Gomti River Basin, India	Mr. Biswajit Das, Uttarakhand Technical University, Dehradun
2.	Dr. A.K. Lohani Scientist G	Glaciers & Glacial Lakes Mapping and Glacial Lake Outburst Flood Risk Modelling For Flood Management	Ms. Nity Tirkey, Centre for Water Engineering & Management, Central University of Jharkhand, Ranchi
3.	Dr. A.K. Lohani Scientist G	Hydrological Modelling and Climate Change	Mr. Prashant, Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee
4.	Dr. R.P. Pandey Scientist G	Assessment of Regional Drought Characteristics under Climate Change Conditions	Mr. Ravi Galkate, Department of Civil Engg., Ravindranath Tagore University, Bhopal
5.	Dr. Y.R.S. Rao Scientist G	Contaminant transport modelling and groundwater remediation	Mr. Kamalakanta Sahu, Research Scholar, Department of Civil Engineering, IIT, Delhi
6.	Dr. B. Venkatesh Scientist G	Integrated Command Area Management	Mr. Abhilash R, HRRC, NIH and VTU, Belagavi
7.	Dr. Purandara B.K. Scientist G	Impact of solid wastes on surface and ground water quality of Belagavi	Mohamed Zameerullah, HRRC, NIH and VTU, Belagavi
8.	Dr. Manohar Arora Scientist F	Hydrologic Characteristics Analysis in Glacierized Basin considering Climate Impact, Land Use Changes and Elevation Dependent Behaviour of Meteorological Data	Ms. Tanmoyee Bhattacharya, Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee
9.	Dr. S.S.Rawat Scientist F	Vulnerability assessment and hydro-geological investigations of selected Himalayan springs for sustaining local water demand in Devika-Birun catchment of Jammu and Kashmir	Ms. Anuradha, Department of Environmental Science, University of Jammu, UT of J&K
10.	Dr. Pradeep Kumar Scientist E	Assessment of Environmental Flows for Geomorphological Purposes of Godavari River Basin	Ms. Aparajita Singh, Institute of Agricultural Sciences, Banaras Hindu University (BHU), Varanasi
11.	Dr.Gopal Krishan Scientist D	Hydrochemical and isotopic study of groundwater in Awash river basin (Ethiopia) & Bhatsa and Kalu river basins, Western Deccan volcanic province (India)	Mr.Biruk Teshome Desta, Department of Earth Sciences, Indian Institute of Technology, Roorkee

12.	Dr. Vinay Kumar Tyagi Scientist D	Effects of Thermal-Alkali Pretreatment on OFMSW Solubilization and Biomethanation	Ms. Banafsha Ahmed, Department of Civil Engineering, Indian Institute of Technology, Roorkee
Ph.D. THESIS GUIDANCE (ONGOING DURING 2022-23)			
1.	Dr. Sudhir Kumar Scientist G	An intelligent model for groundwater characterization and forecasting using soft computing techniques and methods	Mr. Dinesh Rai, Uttarakhand Technical University, Dehradun
2.	Dr. M.K. Goel Scientist G	Assessment and Management of Hydrological Extremes in Rajasthan	Mrs. Suman Gurjar, Centre of Excellence in Disaster Mitigation and Management, Indian Institute of Technology, Roorkee
3.	Dr. R.P. Pandey Scientist G	Study of drought propagation and its effect on reservoir network in a Semi-arid River Basin of Peninsular India	Mr. Ajay Gupta, Department of Hydrology, Indian Institute of Technology, Roorkee
4.	Dr. R.P. Pandey Scientist G	Study of long term changes in drought characteristics and changes in water demand in bundelkhad region	Mr. Manish Dwivedi, Sam Higginbottom University of Agriculture Technology & Sciences (HSUATS), Prayagraj
5.	Dr. R.P. Pandey Scientist G	Soil Conservation Services-Curve Number (SCS-CN) Technique and its Application in Drought Assessment	Mr. Damodar Sharma, Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee
6.	Dr. B. Venkatesh Scientist G	Spatio-Temporal Assessment of Mapping of Droughts for Arid and Semi-Arid Regions of Northern Karnataka	Mr. Bharath A.L., HRRC, NIH and VTU, Belagavi
7.	Dr. B. Venkatesh Scientist G	Impact of climate change on water availability in selected river basins of western ghats	Ms. Shilpa A. Veerabhadrannavar, HRRC, NIH and VTU, Belagavi
8.	Dr. B. Venkatesh Scientist G	Integrated Water Resources Management for Doni River Catchment	Mr. Vijay Vastrad, HRRC, NIH and VTU, Belagavi
9.	Dr. Purandara B.K. Scientist G	Impact of Land use/Land cover changes on the sustainability of natural springs in parts of Western Ghats in India	Mr. Ujval N Utagi, HRRC, NIH and VTU, Belagavi
10.	Dr. Surjeet Singh Scientist G	Modelling the Impacts of Urban Land Use Change on Surface Temperature and Water Resource for Future Water Sustainability in Raipur District, Chhattisgarh	Ms. Tanushri Jaiswal, Department of Applied Geology, National Institute of Technology, Raipur, Chhattisgarh
11.	Dr. Surjeet Singh Scientist G	Mapping of Ground Water Potential and Vulnerable Zones Using Indices and GIS-based MCDA Techniques	Mr. Anshu Gangwar, Institute of Agricultural Sciences, BHU, Varanasi
12.	Dr. M.K. Sharma Scientist F	Study of System Characteristics of River Alaknanda, A tribuatry of River Ganga	Ms. Kunarika Bhanot, Department of Chemistry, Gurukula Kangri Vishwavidyalaya, Haridwar

13.	Dr. M.K. Sharma Scientist F	Hydrochemical Study of Groundwater of Bemetara District in Chhattisgarh	Mr. Mohit Kumar, Department of Zoology and Environmental Sciences, Gurukula Kangri Vishwavidyalaya, Haridwar
14.	Dr. Archana Sarkar Scientist F	Hydrological Modelling of Bisalpur Reservoir including Climate Change	Mr. Sanjay Kumar Agarwal, Department of Civil Engineering, MNIT, Jaipur
15.	Dr. Archana Sarkar Scientist F	Impact of Climate Change on Water Resources of Banas River Basin, Rajasthan	Mr. Vineet Kumar Sharma, Department of Civil Engineering, MNIT, Jaipur
16.	Dr. T. Thomas Scientist F	Understanding the linkages between forest and water in context of changing climate variables of Narmada catchment	Ms. Manisha Singh, Indian Institute of Forest Management, Bhopal
17.	Dr. T. Thomas Scientist F	Climate change impact assessments on the Vamsadhara river basin, Odisha using hydrologic modelling approaches	Ms. Ritu Kumari, Department of Farm Engineering, Banaras Hindu University, Varanasi
18.	Dr. T. Thomas Scientist F	Modeling the Effects of Climate Change on Sediment Yield: A Case Study of Manjira Basin	Mr. Sachin Kumar, Department of Civil Engineering, Maulana Azad National Institute of Technology, Bhopal
19.	Dr. Mathew K. Jose Scientist E	Environmental significance of conjunctive use of water in irrigation command	Mr. Ranjeet Satish sabale, HRRC, NIH and VTU, Belagavi
20.	Dr. R.K. Jaiswal Scientist E	Assessing Climate Change vulnerability using SWAT and CORDEX Projection under RCP4.5 and RCP8.5 Scenario: A case study of Bah River, India	Mr. Sohrat Ali, Department of Civil Engineering, Central University of Jharkhand, Ranchi
21.	Dr. R.K. Jaiswal Scientist E	Development of Optimal Water Resources Utilization Plan Under Climate Change for Parbati Reservoir Project	Mr. Abhishek Agrawal, Maharana Pratap University, Udaipur
22.	Dr. R.K. Jaiswal Scientist E	Irrigation water requirements under climate change and development of mitigation strategies for the future	Ms. Pushpanjali, Department of Civil Engineering, Central University of Jharkhand, Ranchi
23.	Dr. R.K. Jaiswal Scientist E	Studies on Climate Change Pattern for Ravishankar Sagar Reservoir using Mike Hydro Basin Model	Ms. Gunja Dhruv, Indira Gandhi Krishi Vishwavidalaya, Raipur
24.	Dr. R.K. Jaiswal Scientist E	Development of Framework for Flood-Risk Assessment and Management of downstream area of Ravishankar Sagar Reservoir under Climate Change Scenario	Mr. Bhupendra Dhankar, Indira Gandhi Krishi Vishwavidalaya, Raipur
25.	Dr. Jose George Pottakkal Scientist E	Assessment of hydrological and geochemical status of springs of district Kangra, Himachal Pradesh	Ms. Shikha Rawal, Department of Environmental Sciences, Central University of Himachal Pradesh, Dharamshala

26.	Dr. Pradeep Kumar Scientist E	Environmental flow assessment using habitat simulation modelling	Mr. Ashish Kumar, Department of Farm Engineering, Institute of Agri. Sciences, Banaras Hindu University, Varanasi (U.P.)
27.	Dr. Pradeep Kumar Scientist E	Simulation of point and non-point source pollution processes	Mr. Shams Quamar, Department of Water Engineering and Management, School of Engineering and Technology, Central University of Jharkhand, Ranchi
28.	Dr. Pradeep Kumar Scientist E	Assessment of Change in Hydrological Response due to Forest Fires in Madhya Pradesh	Ms. Deepa Sahu, Department of Soil and Water Engg., Swami Vivekananda College of Agricultural Engineering & Technology and Research Station, Faculty of Agricultural Engineering, Indira Gandhi Krishi Vishwavidyalaya, Raipur
29.	Dr. Pradeep Kumar Scientist E	Habitat Ecological Modelling of Himalayan Mahseer (Tor Species) in Upper Ganga Basin	Mr. Arvind Kumar Sharma, Department of Zoology and Environmental Sciences, Gurukula Kangri Vishwavidyalaya, Haridwar
30.	Dr. Pradeep Kumar Scientist E	Environmental Flow Assessment through Perception Analyses of Riparian Communities- A Case of Narmada Valley Dam Project	Mr. Govind M. P., Department of Environmental Planning, School of Planning and Architecture, Bhopal
31.	Dr. Ravindra V. Kale Scientist E	Operational Coastal Flood Management in The Brahmani-Baitarani River Basin (Tentative)	Mr. Ashrumochan Mohanty, School of Water Resources, Indian Institute of Technology, Kharagpur
32.	Dr. Ravindra V. Kale Scientist E	Integrated mHM Model based modeling framework for flood hazard assessment in Transboundary of Rapti River Basin under changing Climate" (Tentative)	Mr. Ankur Kumar, Department of Civil Engineering, Madan Mohan Malviya University of Technology, Gorakhpur
33.	Dr. Sumant Kumar Scientist E	Replenishing Underground Reservoirs through Recharge Structure by Utilizing Surface Runoff in Central Part of India	Ms. Vijeta Singh, Department of Soil and Water Conservation Engineering, VIAET Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj
34.	Dr. Sumant Kumar Scientist E	Arsenic contamination of groundwater in Eastern Uttar Pradesh, India	Mr. Manish Kumar, Department of Agricultural (Farm) Engineering, Institute of Agricultural Science, BHU, Varanasi

35.	Dr .Gopal Krishan Scientist D	Assessment of Spatial and Temporal distribution of groundwater level and groundwater quality of Ghazipur district, Uttar Pradesh	Mr.P.Yadav, Department of Agriculture and Farm Engineering, BHU, Varanasi
36.	Dr .Gopal Krishan Scientist D	Investigation of groundwater potential of dolomite rock in Lesser Himalaya of Nepal, Kushma-Syanja area	Mr .Gunanidhi Pokhrel, Department of Geology, Institute of Science and Technology, Tribhuvan University, Kirtipur Kathmandu, Nepal
37.	Dr .Gopal Krishan Scientist D	Hydrogeological and isotopic studies of groundwater in Doodhganga watershed	Ms.Tanzeel Khan, Department of Soil and Water Engineering, SKUAST-Kashmir
38.	Dr .Gopal Krishan Scientist D	Geochemical and Geophysical Studies of Springs in Kalsi Tehsil of Dehradun, Uttarakhand, India	Mr .Praveen Kumar, Department of Earth Sciences, Indian Institute of Technology, Roorkee
39.	Dr. Rajesh Singh Scientist D	Source identification of trace toxic metals in the groundwater of Bathinda district and its mitigative measures	Mr. Kaptan Singh, Civil Engineering Department, MMM University of Technology, Gorakhpur
40.	Dr. P.K. Mishra Scientist D	Urban Water Management Considering Water Harvesting and Climate Change	Ms. Sakshi Gupta, Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee
41.	Dr. P.K. Mishra Scientist D	Sustainable Water Resources Management under Climate and Land Use Change	Mr. Sarthak Sahoo, School of Civil Engineering, KIIT, Bhubaneswar
42.	Dr. Vinay Kumar Tyagi Scientist D	Thermal pretreatment of municipal wastewater sludge	Mr. Gowtha Balasundaram, Department of Civil Engineering, Indian Institute of Technology, Roorkee
43.	Dr. Vinay Kumar Tyagi Scientist D	Effect of thermal-alkali pretreatment on wheat straw solubilization and biomethanation	Mr. Ali Mohammad Rahmani, Department of Civil Engineering, Indian Institute of Technology, Roorkee
44.	Dr. Vinay Kumar Tyagi Scientist D	Quality assessment of mined MSW from an open dumpsite for Leachate treatment and recycling potential	Mr. Mandeep Singh, Department of Civil Engineering, Indian Institute of Technology, Roorkee
45.	Dr.S.M .Pingale Scientist D	Groundwater management in changing climate	Mr. Sourav Chaudhary, Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee
46.	Dr .S.M.Pingale Scientist D	An integration of multiple hydro-meteorological variables for comprehensive drought characterization in the changing climate for central India	Mr. Ruchir Patidar, Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee

47.	Dr. Nitesh Patidar Scientist C	Ground Water Management in Changing Climate	Mr. Mayank Raturi Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee
48.	Dr. Nitesh Patidar Scientist C	Integrated surface-subsurface modelling for baseflow simulation	Mr. Prem Chand Department of Water Engineering and Management, School of Engineering and Technology, Central University of Jharkhand, Ranchi
49.	Dr. Pravin Rangrao Patil Scientist C	Rainfall Runoff and Sediment Yield Modeling of Gauged and Ungauged Catchments	Mr. Esmatullah Sangin, Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee
50.	Dr. Pravin Rangrao Patil Scientist C	NRCS-CN Inspired Modeling of Rainstorm-Generated Sediment Yield	Mr. Shafiq Ahmad Siddiqui, Civil Engineering Department, Graphic Era (Deemed to be University), Dehradun
M.E./M.TECH./M.Sc. THESIS GUIDANCE (COMPLETED IN 2022-23)			
1.	Dr. A.K. Lohani Scientist G	Hydrological and Hydrodynamic Modelling in Upper Kabini River Basin	Mr. Chandra Prakash, Department of Water Engineering and Management Central University of Jharkhand, Ranchi
2.	Dr. R.P. Pandey Scientist G and Dr. Rajesh Singh Scientist D	Impact of forest fire on soil chemical characteristics	Ms. Akanksha Maravi, M. Tech., Department of Farm Engineering, Institute of Agri. Sciences, Banaras Hindu University, Varanasi
3.	Dr. Y.R.S. Rao Scientist G	Assessment of Anthropogenic contaminants in around Kakinada smart city, Andhra Pradesh, India	Mr. K. Murali M.Tech. (Environmental Engg.), Department of Chemical Engineering, JNTU, Anantapur, Andhra Pradesh
4.	Dr. Surjeet Singh Scientist G	Assessment of Hydrogeochemistry & Arsenic Contamination in Groundwater of Ballia District, U.P., India	Mr. Achal Singh Patel, M. Tech. (Agricultural Engg.), Department of Farm Engineering, Institute of Agricultural Sciences, BHU, Varanasi
5.	Dr. M.K. Sharma Scientist F	Cloning, expression, purification and bioinformatics analysis of arsenite oxidase in Comamonastestosteroni KF1	Ms. Kunika Saraswat, M. Sc., Department of Bioscience and Biotechnology, Banasthali Vidyapith, Rajasthan

6.	Dr. M.K. Sharma Scientist F	Physiochemical Analysis and Determination of Pesticides in the Surface Water	Ms. Anoushka Anuj, M. Sc., Department of Chemistry, Kanya Gurukul Campus, Gurukula Kangri Vishwavidyalaya, Haridwar
7.	Dr. M.K. Sharma Scientist F	Gas Chromatography- Mass Spectrometry Analysis of Pesticidal Content in Waste Water	Ms. Chhavi Sharma, M. Sc., Department of Chemistry, Kanya Gurukul Campus, Gurukula Kangri Vishwavidyalaya, Haridwar
8.	Dr. M.K. Sharma Scientist F	Analysis of Pestcidal Residues in the Groundwater by Gas Chromatography-Mass Spectrometry	Ms. Himanshi Tyagi, M. Sc., Department of Chemistry, Kanya Gurukul Campus, Gurukula Kangri Vishwavidyalaya, Haridwar
9.	Dr. M.K. Sharma Scientist F	Groundwater Quality Analysis of Roorkee City, District Haridwar, Uttarakhand	Mr. Vaibhav Gehlot, BS-MS Integrated Program (Chemistry Major), Indian Institute of Science Education and Research (IISER), Mohali
10.	Dr. M.K. Sharma Scientist F	Groundwater Quality Analysis of Roorkee City, District Haridwar, Uttarakhand	Mr. Devesh Sharma, BS-MS Integrated Program (Chemistry Major), Indian Institute of Science Education and Research (IISER), Mohali
11.	Dr. M.K. Sharma Scientist F	Groundwater Quality Analysis of Roorkee City, District Haridwar, Uttarakhand	Mr. Deepak Kumar, BS-MS Integrated Program (Chemistry Major), Indian Institute of Science Education and Research (IISER), Mohali
12.	Dr. M.K. Sharma Scientist F	Characterization and Correlation Analysis of Groundwater Quality of Bikaner City, Rajasthan	Ms. Monika Kumari, M. Sc., Department of Environmental Science, Maharaja Ganga Singh University, Bikaner, Rajasthan
13.	Dr. M.K. Sharma Scientist F	Water Quality Study of Surface Water Bodies of Bikaner Area	Mr. Abhinav Kumar Singh Yadav, M. Sc., Department of Environmental Science, Maharaja Ganga Singh University, Bikaner, Rajasthan
14.	Dr. M.S. Rao Scientist F	Assessment of surface water and ground quality in Middle Ganga Basin of Uttar Pradesh, India	Ms. Anjana P.S., Department of Marine Geology and Geophysics, Cochin University of Science and Technology, Kochi, Kerala

15.	Dr. M.S. Rao Scientist F	Investigation of hydrological processes in the coastal zone of West Bengal, India	Mr. Aswin Joseph, Department of Marine Geology and Geophysics, Cochin University of Science and Technology, Kochi, Kerala
16.	Dr. M.S. Rao Scientist F	Impact of Lockdown/Unlock Interventions During the Pandemic COVID-19 on the Change in the Quality of Water and Air in the Coastal Districts of West Bengal	Ms. Sapna Baghel, Banasthali Vidyapith, Rajasthan
17.	Dr. M.S. Rao Scientist F	Effect of COVID-19 Epidemic on Change in the, Quality of Environment in State of UttarPradesh	Ms. Tanya Kapoor, Banasthali Vidyapith, Rajasthan
18.	Dr. V.S. Jeyakanthan Scientist F	Sedimentation Assessment of Nagarjuna Sagar Reservoir using Microwave Remote Sensing	Mr. D. Madhu Kumar JNTU College of Engineering, Kakinada
19.	Dr. Ravi Galkate Scientist F	Assessment of irrigation requirement for rabi season crops under canal command area of Kolar dam, Madhya Pradesh	Mr. Shivam Dwivedi, M. Tech., Department of Farm Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi
20.	Dr. T. Thomas Scientist F	Optimal Reservoir Operation of Barna Dam using NIH_ReSyp	Mr. Akash Jain, M. Tech., Department of Civil Engineering, Maulana Azad National Institute of Technology, Bhopal
21.	Dr. T. Thomas Scientist F	Groundwater Flow Modelling of Maleni Watershed using Visual MODFLOW	Mr. Anoop Dongre, M. Tech., Department of Farm Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi
22.	Dr. R.K. Jaiswal Scientist E	Estimation of Probable Maximum Precipitation in Betwa Basin under Projected Climate Change Scenario	Mr. Deepak Mishra, M. Tech., Department of Civil Engineering, Maulana Azad National Institute of Technology, Bhopal
23.	Dr. R.K. Jaiswal Scientist E	Assessment of Climate Change Impact on Irrigation Water Requirement in the Command of Ravi Shankar Sagar Reservoir of Chhattisgarh State	Ms. Snehil, M. Tech., Department of Soil and Water Engineering, Indira Gandhi Krishi Vishwavidyalaya, Raipur
24.	Dr. R.V. Kale Scientist E	Integrated ADCIRC-SWAN-HEC-RAS 2D Modeling Framework For Cyclonic Coastal Flood Inundation Mapping	Mr. Aman Tejaswi, School of Water Resources, Indian Institute of Technology, Kharagpur

25.	Dr. L.N. Thakural Scientist E	Analysis of River flow response with CMIP5 climate projection using SWAT in the Bina River Basin, Madhya Pradesh	Mr. Dheeraj Sonkar, M. Tech., Department of Farm Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi
26.	Dr. L.N. Thakural Scientist E	Identifying Groundwater Recharge Potential zones in Dehradun, Uttarakhand using Geospatial Techniques	Ms. Abhishikta Maria Susheel, M.Sc., Department of Marine Geology and Geophysics, Cochin University of Science and Technology, Kochi, Kerala
27.	Dr. L.N. Thakural Scientist E	Site Suitability Analysis for Groundwater recharge potential zones using geospatial techniques of Udham Singh Nagar, Uttarakhand, India	Mr. Manjar Alam, M.Sc., Interdisciplinary Department of Remote Sensing and GIS Applications, Aligarh Muslim University (AMU), Aligarh
28.	Dr. L.N. Thakural Scientist E	Geospatial and AHP- Based Identification of Potential Zones for Ground Water Recharge in Haridwar	Mr. Abdul Samad, M.Sc., Interdisciplinary Department of Remote Sensing and GIS Applications, Aligarh Muslim University (AMU), Aligarh
29.	Dr. Pradeep Kumar Scientist E	Effect of Forest Fire on Physical Characteristics of Soil and Hydrological Response in Madhya Pradesh	Ms. Nishtha Sharnagat, M. Tech. (Soil & Water Conservation Engg.), Department of Farm Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi
30.	Dr. Pradeep Kumar Scientist E	Effect of Forest Fire on Soil Physical Characteristics	Mr. Kamal Kumar, M. Tech. (Agricultural Engg.), Indira Gandhi Krishi Vishwavidyalaya, Raipur
31.	Dr. P.K. Singh Scientist E	Application of Water Accounting Plus (WA+) Framework for Estimation of Land And Water Productivity using Satellite Earth Observation Datasets of Gomti River Basin	Ms. Saptoparna Saha, MSc. (Geoinformatics), Department of Natural and Applied Sciences, TERI School of Advanced Studies, New Delhi
32.	Dr. P.K. Singh Scientist E	Assessment of soil erosion by RUSLE model using remote sensing and GIS - A case study of Ramganga Basin	Mr. Mushahid Ali, M.Sc., Interdisciplinary Department of Remote Sensing and GIS Applications, Aligarh Muslim University (AMU), Aligarh

33.	Dr. M.K. Nema Scientist E	Evaluation and Determination of Reliability on Advanced Neural Network Models for Prediction of Soil Moisture	Ms. Nagashree G.E., Department of Water Resources and Ocean Engineering, National Institute of Technology Surathkal, Karnataka
34.	Dr. M.K. Nema Scientist E	Groundwater Vulnerability and Potential Zone Mapping for Southern Districts of M.P Using Geospatial Techniques	Mr. Gaurav Mourya, Department of Agricultural Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi
35.	Dr. M.K. Nema Scientist E	Assessment of Runoff and Sediment Yield for Identification and Prioritization of Critical Sub-Watersheds of Hasdeo River Catchment	Ms. Anuradha Sahu, Department of Agricultural Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi
36.	Dr.Gopal Krishan Scientist D	Aquifer characterization and mapping of salinity affected areas of SW Punjab	Ms. Prakriti Gupta, M.Sc. Geoinformatics, TERI School of Advance Studies, New Delhi
37.	Dr.Gopal Krishan Scientist D	Mapping groundwater salinity coastal and inland-case study from Punjab	Mr .Amalraj Padikal, Department of Coastal Disaster Management, Pondicherry University, Port Blair Campus, Andaman and Nicobar Islands
38.	Dr.Gopal Krishan Scientist D	A study on Management solutions for groundwater salinity-An experiment under controlled conditions	Ms. Gayathri B.S., Department of Marine Geology and Geophysics, Cochin University of Science and Technology, Kochi, Kerala
39.	Dr.Gopal Krishan Scientist D	Groundwater and agriculture potential mapping of Mewat district, Haryana	Mr .Gokul Pradeep, Department of Geology, Cochin University of Science and Technology, Kochi, Kerala
40.	Dr.Gopal Krishan Scientist D	Groundwater potential mapping using remote sensing and GIS of Hoshiarpur district Punjab, India	Ms .Midhuna Prasad, Department of Geology, Cochin University of Science and Technology, Kochi, Kerala
41.	Dr.Gopal Krishan Scientist D	Groundwater behavior in multi-aquifers of Punjab	Ms. Srijita Ghosh, Department of Geology, Presidency University, Kolkata, West Bengal
42.	Dr. Rajesh Singh Scientist D	Evaluation of constructed wetland for chemical and bacterial removal	Ms. Shubha Dixit, M.Sc., Department of Bioscience and Biotechnology, Banasthali Vidyapith, Rajasthan

43.	Dr. Rajesh Singh Scientist D	Performance evaluation of deep horizontal constructed wetlands and its dynamics in Sub-tropical region	Mr. Chinmay Maithani, M.Tech., Department of Civil Engineering, NIT, Warangal, Telangana
44.	Dr. Rajesh Singh Scientist D	Evaluation of antibiotic resistance bacteria in constructed wetland	Ms. Astha Saini, M.Sc., Department of Microbiology, Gurukula Kangri Vishwavidyalaya, Haridwar
45.	Dr. Rajesh Singh Scientist D	Evaluation of antibiotic resistance bacteria in Upper Ganga Canal	Ms. Dimple, M.Sc., Department of Microbiology, Gurukula Kangri Vishwavidyalaya, Haridwar
46.	Dr. Rajesh Singh Scientist D	Appraisal of horizontal subsurface flow constructed wetland/or domestic wastewater treatment	Ms. Vaishali Saini, M.Sc., Department of Environmental Science and Engineering, J.C. Bose University of Science & Technology, YMCA, Faridabad
47.	Dr. Rajesh Singh Scientist D	Impact of forest fire on soil chemical characteristics	Ms. Sangeeta Korram, M.Tech., Faculty of Agricultural Engineering, Indira Gandhi Krishi Vishwavidyalaya, Raipur
48.	Dr. Vinay Kumar Tyagi Scientist D	Performance Evaluation of Landfill Mining Projects at Three Site in Haryana	Mr. Rajan Kalahans, Department of Civil Engineering, Indian Institute of Technology, Roorkee
49.	Dr. Vinay Kumar Tyagi Scientist D	Effect of FNA pretreatment on Wheat Straw Solubilization and Biomethanation	Mr. Phurba Thamang, Department of Civil Engeneering, Indian Institute of Technology, Roorkee
50.	Dr. P.K. Mishra Scientist D	Historical Trend Analysis of Rainfall and Temperature across Kerala State, India	Mr. Harikrishnan P.U., Faculty of Ocean Science and Technology, Kerala University of Fisheries and Ocean Studies, Kochi, Kerala
51.	Dr. Sunil Gurrapu Scientist D	Evaluation of land use/land cover changes using remote sensing data and GID tools: A case study of Amaravati, Andhra Pradesh	Mr. Jishnu V., M.Sc. in Disaster Management, Pondicherry University, Port Blair Campus, Andaman and Nicobar Islands
52.	Dr. Sunil Gurrapu Scientist D	Impact of climate change on the runoff of Brahmani River Basin	Ms. Subhra P. Khuntia, M. Tech. in Water Resources Engineering, NIT, Rourkela
53.	Dr. Sunil Gurrapu Scientist D	Integrated analysis of flood frequency and inundation mapping using HEC-RAS 6.2 in Pennar River Basin, India	Ms. Swagatika Sahu, M. Tech. in Water Resources Engineering, NIT, Rourkela
54.	Dr. Swapnali Barman Scientist D	Runoff simulation using SWAT model: A case study for the Baralia river Watershed	Ms. Leema Pathak NERIWALM, Tezpur

55.	Dr. Swapnali Barman Scientist D	Flood Inundation Mapping of Pagladiya River using HEC-RAS and GIS Tools	Er. Hrishikesh Barman Jorhat Engineering College, Assam
56.	Dr. Sanjay Kumar Sharma Scientist D	Prioritisation of Silsako watershed for its effective management	Ms. Meghna Sharma NERIWALM, Tezpur
57.	Ms .Anjali Scientist C	Modelling the Solute Migration through the Landfill Profile for Gazipur Landfill site, Delhi, India	Mr .Himanshu Jain, Department of Civil Engineering, NIT, Warangal
58.	Dr. D.S. Bisht Scientist C	Assessment of Rainwater Harvesting Potential using High-Resolution Sentinel Data and SCS-CN in Google Earth Engine	Mr. Tarun Agrawal, M. Tech., Department of Agricultural and Food Engineering, Indian Institute of Technology, Kharagpur
59.	Dr. Kalzang Chhoden Scientist C	Physico-chemical and Bacteriological Analyisis of Wastewater	Ms. Pratiksha, M.Sc., Department of Microbiology, Gurukula Kangri Vishwavidyalaya, Haridwar
60.	Dr. Kalzang Chhoden Scientist C	Bacteriological Assessment of Constructed Wetland for Wastewater Treatment	Ms. Parul, M.Sc., Department of Microbiology, Hemvati Nandan Bahuguna Garhwal University, Srinagar
M.E./M.TECH./M.Sc. THESIS GUIDANCE (ONGOING IN 2022-23)			
1.	Dr. A.K. Lohani Scientist G	Hydrological Modelling in Upper Narmada River Basin Using SWAT Model	Ms. Pallavi Chaudhary, Department of Water Resources Development and Management, Indian Institute of Technology, Roorkee
2.	Dr. M.K. Sharma Scientist F	Cloning, expression, purification and in-silicoanalysis of enzyme arsenite oxidase (homologue) from Comamonastestosteroni KF1	Ms. Astha Bisht, Department of Bioscience and Biotechnology, Banasthali Vidyapith, Jaipur, Rajasthan
3.	Dr. Rajesh Singh Scientist D	Nutrient Dynamics in Constructed Wetland Treating Domestic Wastewater	Mr. Sandeep Kumar, Department of Civil Engineering, Indian Institute of Technology, Roorkee
4.	Dr. Rajesh Singh Scientist D	Synthesis of Cu-Oxide nanoparticles and its application for removal of As from water	Ms. Priya Dimri, Department of Allied Sciences (Chemistry), Graphic Era Deemed to be University, Dehradun
5.	Dr. Rajesh Singh Scientist D	Synthesis of Cu-Oxide nanoparticles and its application for removal of U from water	Ms. Priya, Department of Allied Sciences (Chemistry), Graphic Era Deemed to be University, Dehradun

6.	Dr .Gopal Krishan Scientist D	Studies of ET changes using isotopes	Ms. Nikita Saini, Department of physics, Gurukula Kangri Vishwavidyalaya, Haridwar
7	Dr .Gopal Krishan Scientist D	ET partitioning using isotopes under controlled conditions	Ms. Himanshi, Department of physics, Gurukula Kangri Vishwavidyalaya, Haridwar
8.	Dr. Vinay Kumar Tyagi Scientist D	Thermal-alkali pretreatment of municipal solid water to enhance energy recovery	Ms. Anjali Anand, Department of Civil Engineering, Indian Institute of Technology, Roorkee
9.	Dr. Vinay Kumar Tyagi Scientist D	Performance evaluation of disinfection units of municipal wastewataer treatment plants in Ganga Basin	Mr. Yashwant Singh, Department of Civil Engineering, Indian Institute of Technology, Roorkee
10.	Dr. Vinay Kumar Tyagi Scientist D	Effect of thermal pretreatment of sewage sludge for enhancing biogas generation	Ms. Priyanshi Modi, Devi Ahilya University, Indore (MP)
11.	Dr. Vinay Kumar Tyagi Scientist D	Biomethanation of Thermal Pretreated Organic fraction of municipal solid waste and sewage sludge	Mr. Rahul Sharma, Department of Civil Engineering, Indian Institute of Technology, Roorkee
12.	Dr. Swapnali Barman Scientist D	Simulation of runoff using HEC-HMS for Pagladiya river basin	Ms. Himadri Baruah NERIWALM, Tezpur
13.	Dr. W.R Singh Scientist C	Hydrological Modeling in Puthimari watershed of Assam using HEC-HMS	Ms. Nayana Borah, Water Resource Engineering Department, NERIWALM, Tezpur

Awareness Activities

APPENDIX-XV

S. N.	ACTIVITY	DATE	VENUE
Activities Organized Under Aazadi Ka Amrit Mahotsav (Phase I&II)			
1.	Awareness activity on Water Conservation and use of GIS for college students	04.04.2022	HRRC, Belgavi
2.	Mass awareness campaign on Water and Environmental Issues Jointly organized by CFMS Patna and NWDA Patna	15.04.2022	Aastha Green City (residential complex), Patna
3.	Awareness Workshop on Water Conservation and Water Security	21-04-2022	Anand Swaroop Arya Saraswati Vidya Mandir, Roorkee
4.	Awareness and drawing competition on Water Conservation and Water Security	22.04.2022	Devi Public School, Dhadhera, Roorkee
5.	Awareness activity by RC Bhopal on Water Conservation and efficient irrigation Techniques	28.04.2022	Village Majhera, Naheryai Panchayat, Shamshabad, M. P.
6.	Outreach activity on Water Conservation & Water Security	04-05-2022	Govt. Upper Primary School, Jhabredi, Narsan Block, Dist.-Haridwar
7.	Awareness activity by RC Kakinada on Water and Environmental Issues	09.05.2022	ASD Womens Govt. Degree college and PR Govt. Degree College, Kakinada
8.	Awareness Workshop on Water Conservation and Water Security	19-05-2022	Rashtriya Inter College, Bhalasw Gaj, Bhagwanpur Block, Roorkee
9.	An Awareness activity on Water Conservation in Agricultural Field and in Village	25-05-2022	Bombarga Village in Belagavi Taluk, Belagavi
10.	Awareness Workshop on Save Water Save Life	28-05-2022	Govt. Inter College, Kunja Bahadurpur, Bhagwanpur Block, Roorkee
11.	Awareness Workshop on Water Conservation and Water Security	15-06-2022	Jal Vihar Colony, NIH, Roorkee
12.	Outreach activity on Water Conservation & Water Security for Anganwadi Staff & Rural Women	22-06-2022	Vill.- Puranpur, Bahadrabad Block, Dist.- Haridwar
13.	Mass awareness programme on Water Conservation and Efficient Irrigation Techniques	22-06-2022	Funda, Bhopal
14.	Mass awareness on Water Conservation and Water Security for Anganwadi Workers, GP Members, Govt. Officials, NGOs	14.07.2022	Khanpur Block, Haridwar

15.	IEC activity on Water Conservation and Water Security including painting competition, elocution, plantation drive	20-07-2022 to 22-07-2022	Govt. Girls Higher Secondary School, Shastri Nagar, Jammu
16.	Awareness Programme on Water Conservation & Water Security for the students of Class 11th and 12th	29-07-2022	National Kanya Inter College, Khanpur, Dist.- Haridwar
17.	An awareness programme on Water Conservation along with painting/speech competition	29-07-2022	Takshshila Higher Secondary School, Khurai, Dist.- Sagar, M.P.
18.	Awareness Workshop on Water Conservation and Water Security	03-08-2022	Methodist P.G. Girls Degree College, Roorkee
19.	Awareness Programme on Water Conservation and Water Security and a Drawing competition	10-08-2022	New Light Junior High School, Subashgarh, Jwalapur, Haridwar
20.	Awareness Programme on Water Conservation & Water Security for college students	12-08-2022	Chaman Lal Mahavidyalaya, Landhaura, Dist.- Haridwar
21.	IEC activity on Water Conservation and Water Security including quiz competition, painting competition, etc.	21-11-2022 to 28-11-2022	Govt. Girls Higher Secondary School, Satwari, Jammu
22.	Drawing competition on the theme Water and Conservation	29-11-2022	Changchari Jatiya Vidyalaya, Kamrup (R), Assam
23.	Drawing and speech competition	01-12-2022	Saraswati Vidya Mandir School, Bhopal
24.	Speech competition on the theme Water Conservation, Sanitation and Security for students	06-12-2022	CFMS, Patna
25.	Awareness activity on Water Conservation and Security	24-01-2023	M.S.N. Charities High School, Kakinada
26.	Drawing and essay writing competitions on Water Conservation Methods and Conserve Water and Secure Future	25-01-2023	DRC, NIH, Kakinada
27.	Drawing competition on Water Conservation	15-02-2023	Kannada Govt. High School, Hanuman Nagar, Belagavi
28.	Essay competition on Water Conservation	22-02-2023	Mahila Vidyalaya Mandal English Medium School, Belagavi
Activities organized under Swachh Bharat Mission (Swachhta Hi Sewa& Swachhta Pakhwada)			
1.	Awareness Programme on Swachhta and Water Conservation along with drawing competition and plantation	27-09-2022	U.P. School, Fatehpur Bhado, Muzaffarabad, Saharanpur, U.P.
2.	Celebration of Swachhta Hi Sewa programme	30-09-2022	Central India Hydrology Regional Centre, Bhopal

3.	Cleaning activities and mass awareness programs under Swachhta Pakhwada	15-03-2023 to 31-03-2023	Boat club ponds premises, DRC, NIH, Kakinada
4.	Cleaning activity and mass awareness programme under Swachhta Pakhwada	16-03-2023 to 31-03-2023	I&FC Complex, Satwari, Jammu
5.	Swachhta Pakhwada Activities (Swachh-Anubhag/Parisar/Neer/ Paryavaran/Jalashay)	16-03-2023 to 31-03-2023	CFMS, Patna
6.	Cleaning of Tawi Ghat under Swachhta Pakhwada	22-03-2023	Tawi Ghat, Bikram Chowk, Jammu
7.	Awareness programme for students and teachers on Swachhata, Water Conservation and Plantation	24-03-2023	CFMS, Patna
8.	Awareness Programme on the water conservation	24-03-2023	KPS, Imlikheda, Dist.- Haridwar
9.	Drawing competition under Swachhta Pakhwada	26-03-2023	Anand Academy, Guwahati
10.	Cleaning of Lakshmi Narayan Ghat and Solani Park under Swachhta Pakhwada	27-03-2023	Lakshmi Narayan Ghat and Solani Park, Roorkee
11.	Motivational Programme on Swachh Jal Evam Swachh Parayvaran	28-03-2023	Govt. Primary School, Kishanpur, Roorkee
12.	Tree plantation and mass awareness programme under Swachhta Pakhwada	28-03-2023	Govt. Model Middle School, Satwari, Jammu
13.	Celebration of Swachhta Pakhwada	28-03-2023	Central India Hydrology Regional Centre, Bhopal
14.	Drawing competition on Swachhta and Hygiene	29-03-2023	Upper Primary School, Kachrai, Saharanpur, U.P.
15.	Painting and speech competition under Swachhta Pakhwada	30-03-2023	Govt. Model Middle School, Satwari, Jammu
16.	Celebration of Swachhta Pakhwada	30-03-2023	HRRC, Belagavi
17.	Workshop for Women on the theme Sashakt Nari, Swasth Bharat aiming cleanliness, sanitation, and water conservation	31-03-2023	JalTarang Auditorium, NIH, Roorkee
Activities organized under Poshan Pakhwada			
1.	Workshop for sensitizing women on Techniques of Water Conservation, Management and Rainwater Harvesting	30-09-2022	Jeevan Jyoti Inter College, Mewar Kalan, Roorkee, Haridwar
Participation in Exhibitions			
1.	Exhibition on Rise in Uttarakhand-2022	07-07-2022 to 09-07-2022	Dehradun

2.	9th Indian National Exhibition-Cum Fair 2022-23	04-08-2022 to 08-08-2022	Kolkata, West Bengal
3.	Exhibition on Aspiring Haryana - 2022	28-07-2022 to 30-07-2022	Hisar, Haryana
4.	Jaipur Expo- 2022	22-09-2022 to 24-09-2022	Jaipur, Rajasthan
5.	7th India Water Week- 2022 on the theme Water Security for Sustainable Development with Equity	01-11-2022 to 05-11-2022	India Expo Centre, Greater Noida
6.	Exhibition on Vision Rajasthan- 2022	01-11.2022 to 03.11.2022	Sirohi, Rajasthan
7.	108th Indian Science Congress/Exibition	03-01-2023 to 07-01-2023	Rashtrasant Tukadoji Maharaj Nagpur Univ., Nagpur
8.	G20 Summit and Exhibition	27-3-23 to 29.3.2023	Gandhinagar, Gujarat
Other activities			
1.	Awareness talk on Rainwater Harvesting and Water Resources Management	08-07-2022	All India Radio studio, Jammu
2.	Community Interaction Water Awareness programme organized during the Jal Shakti Abhiyan- 2022	08-07-2022	Bagheshwar, Uttarakhand
3.	Awareness Programme for the B. Tech (Civil) students of Roorkee Institute of Technology, Roorkee	29-11-2022	NIH, Roorkee
4.	Mass awareness programme on Application of Mobile Applicationfor farmers	28-12-2022	Basai, Saipau, Dist.- Dholpur, Rajasthan
5.	Mass awareness programme on Application of Mobile Applicationfor farmers	29-12-2022	Nabab, Saipau, Dist.- Dholpur, Rajasthan
6.	Outreach activity on Water Conservation & Water Security	07-02-2023	Govt. Upper Primary School, Bandera Tanda, Tehsil- Roorkee
7.	Outreach activity on Water Conservation & Water Security	09-02-2023	Govt. Upper Primary School, Noorpur Pal Basti, Tehsil- Roorkee
8.	Outreach activity on Water Conservation & Water Security	14-02-2023	Govt. Inter College, Daulatpur, Tehsil- Roorkee

Audited Statement of Accounts 2022-23

APPENDIX-XVI

Manoj Mohan & Associates
Chartered Accountants Since 1999

AUDITOR'S REPORT

To
The Director,
National Institute of Hydrology,
Roorkee

We have audited the Balance Sheet, the Income & Expenditure Account and the Receipts & Payments Account for "**National Institute of Hydrology, Roorkee**", for Scheme, Non- Scheme and NHP Projects as on 31st March, 2023. These financial statements are responsibility of the management. Our responsibility is to express an opinion on these financial statements based on our audit.

We conducted our audit in accordance with the auditing standards generally accepted in India. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosure in the financial statement. An audit also includes assessing the accounting principles used by management, as well as evaluating the overall financial statement presentation, we believe that our audit provides a reasonable basis for our opinion.

1. We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purpose of our audit.

2. In our opinion, proper books of accounts have been kept by Management so far as it appears from our examination of the books

3. Management is responsible for preparation of financial statements for the financial year 2022-23 and is also responsible for maintenance of accounting records in accordance with generally accepted accounting principles in India.

4. The Balance Sheet and Income and Expenditure Account dealt with by the report are in agreement with the books of account.

Manoj Mohan & Associates is a
MSME Registered & ISO 9001 - 2015 Certified CA Firm
H.O.: F 18A Sector 27 Noida 201301 UP INDIA
mma.ca@rediff.com www.mmaca.org
+91 120 4314155; 2556515

5. In our opinion, and to the best of our information and according to the explanation given to us, the said accounts exhibit a true and fair view:

a. In the case of the Balance Sheet, of the state of affairs of the Organization as at March 31, 2023.
b. In the case of Income & Expenditure account, of the surplus for the year ended on that date.
c. In the case of Receipts & payment account, for the year ended on that date.

For Manoj Mohan & Associates
Chartered Accountants
FRN: 009195C

CA (Dr.) Manoj Kumar Agrawal
Managing Partner
M.No.: 076980

Place: Roorkee
Date: 12/09/2023

UDIN: 23076980BGVQIO2279

UTILISATION CERTIFICATE

Certified that the National Institute of Hydrology, Roorkee has utilised the Grants-in-aid detailed hereunder during the Financial Year 2022-23 and the same has been verified with reference to accounting records maintained by the Institute and has been found to be correct:

(Amount in Rupees)

PARTICULARS	Scheme	Non-Scheme	NHP	TOTAL
Opening Balance as per UC GFR 12-A				-
a) at NIH Headquarters including R.C	97,52,559	1,55,974	50,07,597	1,49,16,130
b) LC with SBI	-	-	1,05,13,690	1,05,13,690
c) Interest to be deposited	2,51,073	6,36,693	1,91,695	10,79,461
c) Unadjusted Advance	21,260	4,73,51,944	40,01,343	5,13,74,547
d) Unadjusted Liablity	-	-	(10,47,754)	(10,47,754)
TOTAL (A)	**1,00,24,892**	**4,81,44,611**	**1,86,66,571**	**7,68,36,074**
Prior Period CPWD Advances	3,62,58,533	-	-	3,62,58,533
Grants-in-aid received from MOWR, New Delhi	10,00,00,000	45,80,00,000	5,28,93,684	61,08,93,684
Interest Received	10,47,927	6,14,856	3,15,221	19,78,004
TOTAL (B)	**13,73,06,460**	**45,86,14,856**	**5,32,08,905**	**64,91,30,221**
Interest Deposited	2,51,073	6,36,693	2,38,108	11,25,874
TOTAL C=(A+B-Int. Deposited)	**14,70,80,279**	**50,61,22,774**	**7,16,37,368**	**72,48,40,421**
Establishment, Office & Other Expenses	3,19,29,086	46,07,17,190	2,28,28,714	51,54,74,989
Capital Expenditure	2,17,62,326	-	1,28,60,434	3,46,22,760
Net Provision for Leave Encashment		(1,82,89,385)		(1,82,89,385)
Net Provision for Gratuity (Less)		(1,28,79,981)		(1,28,79,981)
TOTAL D	**5,36,91,412**	**42,95,47,824**	**3,56,89,148**	**51,89,28,383**
TOTAL E = (C-D)	**9,33,88,867**	**7,65,74,950**	**3,59,48,220**	**20,59,12,038**
Closing Balance (as on 31.03.2023)				
a) at NIH Headquarters	89,01,144	2,14,05,917	1,56,71,217	4,59,78,278
b) at R.C. Belgaum	17,001	1	-	17,001
c) at R.C. Guwahati	16,017	941	-	16,957
d) at R.C. Jammu	4,999	-	-	4,999
e) at R.C. Kakinada	1,786	34,630	-	36,416
f) at R.C. Patna	10,713	400	-	11,113
g) at R.C. Sagar/Bhopal	3,152	1,567	-	4,719
h) LC with SBI	-	-	-	-
i) Interest to be deposited	10,47,927	6,14,856	3,15,221	19,78,004
j) Unadjusted Advances	9,91,781	82,16,638	24,40,115	1,16,48,534
k) Work in Progress	8,23,94,348	4,63,00,000		12,86,94,348
k) Less:Unadjusted Liabilities	-	-	(12,22,017)	(12,22,017)
TOTAL (a to k)	**9,33,88,867**	**7,65,74,949**	**1,72,04,536**	**18,71,68,353**

Note: (1) ₹2,12,55,153.00 lapsed on 31/03/2023 in Non-Scheme(TSA A/c)PFMS
(2) ₹ 1,46,86,116.00 lapsed on 31/03/2023 in NHP(Sub Agency A/c) PFMS

FOR NATIONAL INSTITUTE OF HYDROLOGY

FOR MANOJ MOHAN & ASSOCIATES
FIRM REG. NO. : 009195C
CHARTERED ACCOUNTANTS

12/9/23
(SURYA KANT)
FINANCE OFFICER
वित्त अधिकारी/Finance Officer
राष्ट्रीय जलविज्ञान संस्थान
National Institute of Hydrology
रुड़की/Roorkee

12/9/23
(SUDHIR KUMAR)
DIRECTOR
डॉ. सुधीर कुमार/Dr. Sudhir Kumar
निदेशक/Director
राष्ट्रीय जलविज्ञान संस्थान
National Institute of Hydrology
रुड़की/Roorkee-247 667

CA (Dr.) MANOJ KUMAR AGRAWAL
PARTNER
M. No.076980

PLACE: ROORKEE
DATE: 12/09/2023

NATIONAL INSTITUTE OF HYDROLOGY (SCHEME & NON SCHEME), ROORKEE

BALANCE SHEET AS ON 31.03.2023

(Amount in Rupees)

PARTICULARS	SCH.	SCHEME	NON-SCHEME	NHP	TOTAL	PREV. YEAR
Capital Fund And Liabilities						
Corpus/Capital Fund	1	33,59,33,810.30	(29,38,22,667)		4,21,11,143.30	-
Reserve & Surplus	2	5,61,65,709	-	3,08,45,678	8,70,11,388	13,48,42,213
Earmarked/Endowment Funds	3	10,99,205	-	1,72,04,536	1,83,03,741	-
Secured Loans And Borrowings	4	-	-	-	-	-
Unsecured Loans And Borrowings	5	-	-	-	-	-
Deferred Credit Liabilities	6	-	-	-	-	-
Current Liabilities And Provisions	7	31,07,010	37,51,24,746	9,06,796	37,91,38,553	35,37,58,078
Total		**39,63,05,735**	**8,13,02,079**	**4,89,57,011**	**52,65,64,825**	**48,86,00,291**
Assets						
Plant, Property & Equipment	8	34,91,74,760	4,63,00,000	3,08,45,678	42,63,20,438	40,80,22,759
Investments - From Earmarked/Endowment Funds	9	-	-	-	-	-
Investments - Others	10	-	-	-	-	-
Current Assets, Loans, Advances Etc.	11	4,71,30,975	3,50,02,080	1,81,11,333	10,02,44,388	8,05,77,532
Miscellaneous Expenditure		-	-	-	-	-
(To The Extent Not Written Off Or Adjusted)		-	-	-	-	-
Total		**39,63,05,735**	**8,13,02,079**	**4,89,57,011**	**52,65,64,825**	**48,86,00,291**
Significant Accounting Policies	23	-	-	-	-	

FOR NATIONAL INSTITUTE OF HYDROLOGY

12/9/23

(SURYA KANT)
FINANCE OFFICER
वित्त अधिकारी/Finance Officer
राष्ट्रीय जलविज्ञान संस्थान
National Institute of Hydrology
रुड़की/Roorkee

(SUDHIR KUMAR)
DIRECTOR
डॉ. सुधीर कुमार/Dr. Sudhir Kumar
निदेशक/Director
राष्ट्रीय जलविज्ञान संस्थान
National Institute of Hydrology
रुड़की/Roorkee-247 667

FOR MANOJ MOHAN & ASSOCIATES
FIRM REG. NO. : 009195C
CHARTERED ACCOUNTANTS

CA (Dr.) MANOJ KUMAR AGRAWAL
PARTNER
M. No.076980

PLACE: ROORKEE
DATE: 12/09/2023

2

NATIONAL INSTITUTE OF HYDROLOGY, ROORKEE
RECEIPT AND PAYMENT ACCOUNTS FOR THE YEAR ENDING 31ST MARCH, 2023

(Amount in Rupees)

Receipts	Current Year				Previous Year	Payments	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total			Scheme	Non-Scheme	NHP	Total	
1. OPENING BALANCE						**1. EST. EXPENSES**					
With HQ	2,44,86,784	1,68,78,544	51,99,292	4,65,64,620	2,67,74,493	(a) Pay & Allowances	-	21,01,82,759	-	21,01,82,759	15,22,109
Opening Balance with RCs	1,92,256	14,554	-	2,06,810	1,21,269	(b) Medical	-	67,52,245	-	67,52,245	43,83,089
LC with SBI				-	1,17,94,949	(c) Leave Travel Expenses	-	15,52,452	-	15,52,452	33,79,464
2. GRANTS RECEIVED						(d) Bonus	-	-	-	-	
(a) From MOWR, Govt. of India	10,00,00,000	45,80,00,000	3,41,50,000	59,21,50,000	53,39,00,000	(e) Employer's Contribution	-	1,19,37,440	-	1,19,37,440	1,30,04,790
(b) From R&D Activity(MOWR)	61,68,776			61,68,776	-	(f) Honorarium & Others	3,69,250	1,38,200	2,93,445	8,00,895	5,55,700
Less: Grant Lapse in TSA & NHP on 31.3.2023	-	(2,12,55,153)	(1,46,86,116)	(3,59,41,269)	-	(g) NPS Contribution	-	1,36,35,086	-	1,36,35,086	1,21,17,217
				-		(h)CPF Cont.	-	3,18,76,705	-	3,18,76,705	2,34,960
3. INTEREST RECEIVED				-		(i) Leave Encashment(LTC)	-	16,92,158	-	16,92,158	9,55,698
(a) On Bank Accounts/other	10,47,416	19,37,646	80,645	30,65,707	8,06,730	(j) Gratuity	-	4,48,28,215	-	4,48,28,215	2,02,24,343
(b) On Advances	511	70,010	-	70,521	-	(k) Wages	1,31,39,593	4,71,84,485	1,71,40,423	7,74,64,501	7,36,23,005
(c) On CPF Balances	-	1,56,00,000	-	1,56,00,000	-	(l) Cont. towards Shortfall in Intt.	-	-	-	-	96,59,946
(d) Interest received on FDR	-		2,34,199	4,19,223	-	(m) Leave Encashment (Retirement)	-	3,29,64,331	-	3,29,64,331	1,50,85,323
(e) Payble to Bharatkosh		1,85,024				(n) GSCA	-	24,84,124	-	24,84,124	-
4. RECOV. OF ADVANCES						(o) CGSA	-	44,500	-	44,500	-
(a) From Employees	-	-	-	-	-	(p) Court Attachment	-	1,75,000	-	1,75,000	-
(b) From Firms	3,91,305	22,858	28,293	4,42,456	-	(q) GSLI	-	29,45,283	-	29,45,283	-
(c) For Construction	-	-	-	-	65,46,916	(r) LIC	-	5,03,434	-	5,03,434	-
(d) Deptt. Advance	2,50,316	28,437	77,675	3,56,428		(s) Recreation Club	-	40,980	-	40,980	-
(e) Advance to CPWD Dehradun	6,43,984	-	-	6,43,984	-	(t) Society	-	91,99,632	-	91,99,632	-
(f) Advance to LC Margin	-	-	6,77,284	6,77,284	-	(u) SHFL	-	1,28,145	-	1,28,145	-
(i) LTC Advance	40,000	8,41,071	-	8,81,071	-						
(k) From RC Belgaun	7,158	15,976	-	23,134	-	**2. CAPITAL EXPENSES**					
(l) TA advance	1,98,365	1,92,000	1,28,513	5,18,878	-	(a) Furniture & Fixture	3,97,479	-	4,39,686	8,37,165	7,18,564
(m) Medical Advance	-	8,33,749	-	8,33,749	-	(b)Computer	27,47,614	-	1,18,763	28,66,377	91,01,509
5. OTHER RECEIPT				-		(c) Library Books/Journals	80,80,658	-	-	80,80,658	68,54,186
(a) Misc. Receipt	26,615	2,54,136	29,153	3,09,904	14,61,036	(d) Equipment	-	-	-	-	1,49,44,626
(b) Sale of old Assets	30,046	-	6,230	36,276	-	(e) Electric Fixture & Fittings				-	1,40,652
(c) Licence Fee	-	3,90,660	32,186	4,22,846	2,25,244	(f) Office Equipment	18,15,764		5,400	18,21,164	18,41,132
(f) Tender cost		10,000		10,000	7,000	(g) Software	6,43,195			6,43,195	7,44,909
(g) Deposits received by NIH	2,10,500	1,19,000	2,17,000	5,46,500	900	(h) Lab & Field Equipment	74,81,529		8,58,416	83,39,945	-
(h) Water Testing	-	2,01,400	-	2,01,400	29,49,500	**3. OFFICE EXPENSES**				-	
(i)Registration fee training Course	-	20,600	-	20,600	12,750	(a) Publication of Tech. Reports	6,89,142	-	-	6,89,142	8,25,258
(j) Receipts from RTI	-	70	-	70	140	(b) Workshop/Training	39,170	2,070	11,34,379	11,75,619	16,55,239
(k) Guesthouse Receipts	7,450	20,28,679	-	20,36,129	8,80,900	(c) Other Office Expenses	-	19,13,060	-	19,13,060	3,40,78,216
(l) Sale of Scrap	105	2,99,448	-	2,99,553	1,95,387	(d) Maintenance	1,71,200	1,37,53,734	-	1,39,24,934	1,10,83,689
(m) Application Fees	-	1,35,800	-	1,35,800	-	(e) Payment to Bharat Kosh (IMD Pune)	-	1,85,024	-	1,85,024	
(n) Income Tax Refunded (Prior period)	-	18,85,660	-	18,85,660	-	(f) Liveries	-	1,40,000	-	1,40,000	1,60,000
(o) Mandays	-	33,20,026	-	33,20,026	-	(g) Water Testing	-	-	-	-	66,04,932
(p) Overhead Charge Income	-	25,500	-	25,500	-	(h) Stationery & printing	4,33,784	69,080	-	5,02,864	-
(q) Penalty	-	-	377	377	-	(i) POL	5,40,696	6,85,170	-	12,25,866	-
						(j) Advertisement	12,123	2,22,852	8,562	2,43,537	-
6. INCREASE IN LIABILITIES						(k) Bank Charges	7,882	1,000	7,093	15,975	-
(a) For Taxation	99,273	60,91,555	1,42,853	63,33,681	78,360	(l) Elec/Water & Gen Expense	-	66,57,283	-	66,57,283	-
(b) Deposits	-	-	-	-	76,550	(m) Field Expense	1,65,711	31,342	10,53,133	12,50,186	-
(c) Others	-	-	-	-	33,824	(n) Hospitality Expense	3,47,235	38,880	-	3,86,115	-
(d) EMD	-	-	-	-	1,93,559	(o) Misc Expense	12,44,455	42,956	84,309	13,71,720	-
(e) Retention Money Witheld	25,000	-	-	25,000	-	(p) Postage Expense	1,313	-	-	1,313	-
(f) NPS	-	83,22,800	-	83,22,800	-	(q) Rent, rate & Taxes	3,16,282	14,27,532	-	17,43,814	-

Page 3

SCHEDULE - 1 : CORPUS/CAPITAL FUND

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
Balance as at the beginning of the year Corpus/Capital Fund	-	-	-	-	-
Add/(Deletion) : during the year	(2,71,95,177)	48,35,095	-	(2,23,60,082)	-
Add/(Deletion) : Transferred from General Reserve	36,31,28,987	(29,86,57,762)	-	6,44,71,225	
Total	**33,59,33,810**	**(29,38,22,667)**	-	**4,21,11,143**	-

SCHEDULE - 2 : RESERVES AND SURPLUS

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
1. Capital Reserve :					
As per last Account	-	-	4,33,56,112	4,33,56,112	-
Addition during the year	6,00,00,000	-	-	6,00,00,000	-
Less: Deductions during the year	(38,34,291)	-	1,25,10,434	86,76,143	-
Total	**5,61,65,709**	-	**3,08,45,678**	**8,70,11,388**	-
2. Revaluation Reserve :					
As per last Account	-	-	-	-	-
Addition during the year	-	-	-	-	-
Less: Deductions during the year	-	-	-	-	-
3. Special Reserve :					
As per last Account	-	-	-	-	-
Addition during the year	-	-	-	-	-
Less: Deductions during the year	-	-	-	-	-
4. General Reserve :					
As per last Account	36,31,28,987	(27,74,02,609)	-	8,57,26,378	10,51,50,443
Addition during the year	-	-	-	-	3,62,96,702
Less: Deductions during the year (Prior Period Item)	-	-	-	-	(66,04,932)
Less: Grant Lapse in TSA A/c on 31.3.2023	-	(2,12,55,153)	-	(2,12,55,153)	-
Less: Transferred to Corpus/Capital Fund	36,31,28,987	(29,86,57,762)	-	6,44,71,225	-
Total	**5,61,65,709**	-	**3,08,45,678**	**8,70,11,388**	**13,48,42,213**

6

SCHEDULE - 3 : EARMARKED/ENDOWMENT FUNDS

(Amount in Rupees)

Particulars	Current Year					Previous Year
	Scheme		Non-Scheme	NHP	Total	
	R&D Activity(MOWR)	NWM				
a) Opening Balance of the Funds	-		-	4,91,15,836	4,91,15,836	-
- Less: Prior period Item				(3,04,49,265)	(3,04,49,265)	
TOTAL				**1,86,66,571**	**1,86,66,571**	
b) Addition to the Funds:						
I. Grants	61,68,776	-	-	3,41,50,000	4,03,18,776	-
ii. Income from Investments made on account of funds	-	-	-	-	-	-
iii. Other additions (Interest)	-	-	-	3,15,221	3,15,221	-
iv. Less: Grant Lapse on SA A/c on 31/03/2023				-		
v. Less: Interest Deposited				(2,38,108)	(2,38,108)	
TOTAL (a+b)	**61,68,776**	-	-	**5,28,93,684**	**5,90,62,460**	-
c) Utilisation/Expenditure towards objectives of funds						
I. Capital Expenditure						
- Fixed Assets	-	-	-	1,28,60,434	1,28,60,434	-
- Others	50,69,571	-	-	-	50,69,571	-
Total	**50,69,571**	-	-	**1,28,60,434**	**1,79,30,005**	-
ii. Revene Expenditure						
- Honorarium	-	-	-	2,93,445	2,93,445	-
- Wages	-	-	-	1,71,40,423	1,71,40,423	-
- Advertisement				8,562	8,562	
- Training course/Workshop	-	-	-	12,58,071	12,58,071	-
- Proffessional Fees	-	-	-	2,12,754	2,12,754	
- TA to non Official	-	-	-	34,032	34,032	
-Travelling Expenses	-	-	-	84,309	84,309	
- Field expenses	-	-	-	21,61,759	21,61,759	
-Contingency	-	-	-	11,33,092	11,33,092	
- Bank Charges	-	-	-	41,454	41,454	
- Consumables	-	-	-	7,093	7,093	
- Misc. Expense	-	-	-	4,53,720	4,53,720	
- Interest paid to bharatkosh				-		
Total	-	-	-	**2,28,28,714**	**2,28,28,714**	-
TOTAL (c)	**50,69,571**	-	-	**3,56,89,148**	**4,07,58,719**	-
NET BALANCE AS AT THE YEAR - END (a+b-c)	**10,99,205**	-	-	**1,72,04,536**	**1,83,03,741**	-

Notes

1) Disclosures shall be made under relevant heads based on conditions attaching to the grants.

2) Scheme Funds received froim the Central/State Governments are to be shown as separate Funds and not to be mixed up with any other Funds

SCHEDULE - 4 : SECURED LOANS AND BORROWINGS :

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
1. Central Government					
2. State Government (Specify)					
3. Financial Institutions					
(a) Term Loans					
(b) Interest accrued and due					
4. Banks :					
(a) Term Loans			NIL		
- Interest accrued and due					
(b) Other Loans (specify)					
- Interest accrued and due					
5. Other Institutions and Agencies					
6. Debentures and Bonds					
7. Other (Specify)					
Total					

Note : Amounts due within one year

8

SCHEDULE - 5 : UNSECURED LOANS AND BORROWINGS :

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
1. Central Government					
2. State Government (Specify)					
3. Financial Institutions					
4. Banks :					
(a) Term Loans			NIL		
(b) Other Loans (specify)					
5. Other Institutions and Agencies					
6. Debentures and Bonds					
7. Fixed Deposits					
8. Others (Specify)					
Total					

Note: Amounts due within one year

SCHEDULE - 6 : DEFERRED CREDIT LIABILITIES :

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
(a) Acceptances secured by hypothecation of capital equipment and other assets			NIL		
(b) Others					
Total					

Note: Amounts due within one year

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SCHEDULE - 7 : CURRENT LIABILITIES AND PROVISIONS :

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
A. CURRENT LIABILITIES :					
1. Sundry Creditors :					
(a) For Capital Goods (As per List 'I')	-	-	-	-	-
(b) Others	-	-	-	-	-
2. Deposit Received	10,57,078	25,350	6,19,251	17,01,679	16,91,512
3. Outstanding Expenses (As per List 'II')	22,718	24,71,380	53,503	25,47,601	22,06,973
4. Earnest Money Deposit	3,12,450	(5,000)	1,93,559	5,01,009	7,86,509
5. Retention Money witheld	7,66,950	83,928	-	8,50,878	8,70,878
6. Payable to CPF	-		-	-	-
7. Employees Contribution to COVID Fund	-	42,575	-	42,575	42,575
8. R&D Support Fund	-	9,052	-	9,052	-
Total (A)	**21,59,196**	**26,27,285**	**8,66,313**	**56,52,794**	**55,98,447**
B. PROVISIONS :					
1. For Taxation (As per List 'III')	(1,00,113)	(2,44,920)	3,168	(3,41,865)	2,56,405
2. Gratuity	-	20,68,98,179	-	20,68,98,179	19,40,18,198
3. Superannuation/Pension	-		-	-	-
4. Accumulated Leave Encashment	-	16,51,79,346	-	16,51,79,346	14,68,89,961
5. Trade Warranties/Claim	-		-	-	-
6. Others (Specify)(as per list 'IV')	10,47,927	6,64,856	37,315	17,50,098	69,95,066
Total (B)	**9,47,814**	**37,24,97,461**	**40,483**	**37,34,85,758**	**34,81,59,630**
Total (A+B)	**31,07,010**	**37,51,24,746**	**9,06,796**	**37,91,38,553**	**35,37,58,077**

Annexures to Schedule - 7

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
List-'I' CAPITAL	-	-	-		
Library Journals	-	-	-	-	-
Library Books	-	-	-	-	-
Furniture & Fixture	-	-	-	-	-
Lab. & Field Equipment	-	-	-	-	-
Computer & Peripherals	-	-	-	-	-
Buildings	-	-	-	-	-
Communication	-	-	-	-	-
Auxilliary Equipment	-	-	-	-	-
Office Equipment	-	-	-	-	-
Stationary Payable	-	-	-	-	-
Software	-	-	-	-	-
Total	-	-	-	-	-

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Annexures to Schedule - 7

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
List-'II'					
(a) ESTABLISHMENT				-	
Dearness Allowances (DA (Arrear)	-	-	-	-	-
Salary	-	-	-	-	-
NPS Payable	-	-	-	-	-
Medical Claims	-	-	-	-	-
DA Arrear		4,548	-	-	-
HRA Payable	-	-	403	403	403
Leave Salary & Pension Contribution	-	-	-	-	-
Employer's contribution to CPF	-	-	-	-	-
Intt. On Employee's own Subscription	-	-	-	-	-
Intt. On Employer's Contribution	-	-	-	-	-
Special Pay	-	-	-	-	-
Washing Allowance	-	-	-	-	-
CSIR Contribution	-	-	-	-	-
Travelling Allowance	-	-	-	-	-
T.A. Claims (Foreign)	-	-	-	-	-
Wages	-	-	-	-	1,58,354
RTF Payable	-	-	-	-	-
Incremental Arrears Payable	-	-	-	-	-
Professional Allowance	-	-	-	-	-
Honorarium Payable	-	-	-	-	-
Total (a)	-	**4,548**	**403**	**4,951**	**1,58,757**
				-	-
(b) OFFICE EXPENSES				-	-
Elect/Water charges & Running cost of DG Set	-	-	-	-	2,79,502
Rimb Membership Fes	-	-	-	-	-
Seminar And Confrence	-	-	-	-	-
SAP	-	-	-	-	-
Training Course	-	-	-	-	-
Postage Exp.	-	-	-	-	-
Telephone	-	-	-	-	-
Other Charges	-	-	-	-	-
Advertisement	-	-	-	-	-
Rent, Rates & Taxes	-	-	-	-	-
Hospitility Exp.	-	-	-	-	-
Running cost of Computer/Lab.	-	-	-	-	-
T.A. to Non-officials	-	-	-	-	-
Travellig Exp	-	-	-	-	-
Professional & Other Services	-	-	53,100	53,100	53,100
Newspapers/Periodicals	-	-	-	-	-
Printing of Technical Report	-	-	-	-	-
Field Exp.	-	-	-	-	-
Misc. Expenses	-	-	-	-	-
Professional Fees Payable	-	-	-	-	-
Audit Fees Payable	22,718		-	22,718	22,718
Printing & Stationery	-	-	-	-	-
Contingency	-	-	-	-	-
Conveyance Payble		-	-	-	-
Chemical & Glassware	-		-	-	-
Leave Travel Claim		-	-	-	-
P.O.L.	-	-	-	-	-
Total (b)	**22,718**	-	**53,100**	**75,818**	**3,55,320**
				-	

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(c) MAINTENANCE					
Furniture & Fixture	-	-	-	-	-
electric &fixture	-	-	-	-	-
Computer Centre	-	-	-	-	-
Communication System	-	-	-	-	-
Buildings & Bulk Services	-	-	-	-	-
Office Equipment	-	-	-	-	-
DG Set	-	-	-	-	-
Lab Equipment	-	-	-	-	-
Vehicle	-	-	-	-	-
Library Books	-	-	-	-	-
Generator Set	-	-	-	-	-
Total (c)	-	-	-	-	-
					-
(d) RECOVERIES FROM SALARY	-	-	-	-	-
Benovalent Fund	-	8,700	-	8,700	8,700
House Rent (IIT Roorkee)	-	(1,890)	-	(1,890)	(3,010)
Elect. Charges (IIT Roorkee)	-	(2,098)	-	(2,098)	(10,261)
C.P.F. Recovery	-	(1,55,654)	-	(1,55,654)	(1,55,654)
NIH GSLI	-	-	-	-	266
NPS Recovery	-	(14,46,104)	-	(14,46,104)	2,14,127
NPS Hold	-	17,99,081	-	17,99,081	12,04,912
Court Attachment	-		-	-	-
Recreation Club	-	8,130	-	8,130	-
NIH Society	-	1,500	-	1,500	1,500
SHFL of NIH Employees	-	-	-	-	-
GSCA Pension Scheme	-	2,48,400	-	2,48,400	-
Licence Fee of HQ	-	9,07,946	-	9,07,946	4,32,316
CGSA	-	44,500	-	44,500	-
GSLI	-	10,54,321	-	10,54,321	-
Total (d)	-	**24,66,832**	-	**24,66,832**	**16,92,896**
Total (a)+(b)+(c)+(d)	**22,718**	**24,71,380**	**53,503**	**25,47,601**	**22,06,973**
	-	-	-	-	
List-'III'	-	-	-	-	
Income Tax of Employees	(9,525)	15,100	(400)	5,175	1,06,200
Income Tax of Firms	(84,345)	(1,09,004)	3,568	(1,89,781)	1,56,036
TDS on GST	(9,216)	(96,491)	-	(1,05,707)	-
GST	2,973	(54,525)	-	(51,552)	(5,831)
Total (e)	**(1,00,113)**	**(2,44,920)**	**3,168**	**(3,41,865)**	**2,56,405**
LIST-'IV'					
Rajbala w/o S K Yadav (Retained for exp)	-	50,000	-	50,000	50,000
Licence Fee	-	-	-	-	-
Other Misc. Receipts	-	-	33,193	33,193	4,040
Consultancy Department			-	-	
Interest Payable to Bharathkosh	10,47,927	6,14,856	-	16,62,783	2,62,067
Payable to Firm	-	-	-	-	-
M/s. Agilant Technologies pvt ltd.	-	-	-	-	-
Penalty Charges	-	-	4,122	4,122	4,122
Total (f)	**10,47,927**	**6,64,856**	**37,315**	**17,50,098**	**3,20,229**

NATIONAL INSTITUTE OF HYDROLOGY, ROORKEE
SCHEME

SCHEDULE-8 : PROPERTY, PLANT & EQUIPMENT (Previous Years Assets)

(Amount in Rupees)

Descriptions	GROSS BLOCK					DEPRECIATION					NET BLOCK	
	Cost/valuation as at 31.3.22	Additions during the year		Deductions during the year	Cost/valuation as at 31.3.23	Rate of Depreciation	At the beginning of the year	On Addittions during the year	For the Year	Value as on 31-Mar-23	As on 31-Mar-23	As on 31-Mar-22
		Before 30-Sep-22	After 30-Sep-22									
A. PROPERTY, PLANT & EQUIPMENT												
Furniture & Fixture	2,97,55,486	-	4,62,376	-	3,02,17,862	10%	1,93,01,621	23,119	10,45,387	2,03,70,127	98,47,736	1,04,53,865
Library Books	80,59,065	94,392	2,85,844	-	84,39,301	40%	77,32,501	94,926	1,30,626	79,58,052	4,81,249	3,26,564
Library Journals	6,78,01,221	-	77,00,422	-	7,55,01,643	40%	5,52,99,728	15,40,084	50,00,597	6,18,40,409	1,36,61,234	1,25,01,493
Maps & Imagery	1,04,73,808	-	-	-	1,04,73,808	15%	83,23,385	-	3,22,563	86,45,948	18,27,859	21,50,422
Lab & Field Equipment	21,81,82,407	62,85,594	11,95,935	-	22,56,63,936	15%	15,75,14,167	10,32,534	91,00,236	16,76,46,937	5,80,16,999	6,06,68,240
Auxiliary Equipments	52,56,029	-	-	-	52,56,029	15%	50,61,206	-	29,223	50,90,429	1,65,600	1,94,823
Communications System	11,89,708	-	-	-	11,89,708	15%	9,70,085	-	32,944	10,03,029	1,86,679	2,19,623
Vehicle	93,76,579	-	-	-	93,76,579	15%	78,59,635	-	2,27,542	80,87,177	12,89,402	15,16,944
Office Equipment	4,06,68,365	1,45,121	16,70,643	-	4,24,84,129	15%	3,14,10,133	1,47,066	13,88,735	3,29,45,934	95,38,194	92,58,232
Computer & Peripherals	11,52,12,595	14,62,021	12,81,835	-	11,79,56,451	40%	11,10,49,099	8,41,175	16,65,398	11,35,55,673	44,00,778	41,63,496
Building/Civil Construction	33,28,86,497	-	4,11,32,247	-	37,40,18,744	10%	19,89,42,454	26,747	1,54,24,269	21,43,93,470	15,96,25,273	13,39,44,042
Electrical Fixture & Fittings	62,23,158	-	-	-	62,23,158	10%	36,64,528	-	2,55,863	39,20,391	23,02,766	25,58,629
Land for Colony	17,43,991	-	-	-	17,43,991	0%	-	-	-	-	17,43,991	17,43,991
Land Purchase for Office(Belg	8,75,180	-	-	-	8,75,180	0%	-	-	-	-	8,75,180	8,75,180
Fiber Hut	3,32,950	-	-	-	3,32,950	15%	2,67,400	-	9,832	2,77,232	55,717	65,549
Generator Set	88,56,011	-	-	-	88,56,011	15%	66,20,749	-	3,35,289	69,56,038	18,99,974	22,35,263
	-	-	-	-	-		-	-	-	-	-	-
B. INTANGIBLE ASSETS	-	-	-	-	-		-	-	-	-	-	-
Software	10,76,447	-	6,43,195	-	17,19,642	40%	4,97,740	1,28,639	2,31,483	8,57,862	8,61,781	5,78,708
TOTAL	**85,79,69,496**	**79,87,128**	**5,43,72,497**	**-**	**92,03,29,121**	-	**61,45,14,431**	**38,34,291**	**3,51,99,987**	**65,35,48,709**	**26,67,80,412**	**24,34,55,065**
Capital Work in Progress	8,77,72,016	0	3,58,63,615	4,12,41,283	8,23,94,348		0.00	-		-	8,23,94,348	87772016.00
TOTAL	**94,57,41,512**	**79,87,128**	**9,02,36,112**	**4,12,41,283**	**1,00,27,23,469**	-	**61,45,14,431**	**38,34,291**	**3,51,99,987**	**65,35,48,709**	**34,91,74,760**	**33,12,27,081**

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NATIONAL INSTITUTE OF HYDROLOGY, ROORKEE
NON SCHEME

SCHEDULE-8 : PROPERTY, PLANT & EQUIPMENT

(Amount in Rupees)

	GROSS BLOCK						DEPRECIATION				NET BLOCK	
Descriptions	Cost as on 31-Mar-22	Additions		Deletions during the year	Addition from Consultancy Projects/ Sponsored Research	Cost as on 31-Mar-23	Rate of Depreciation	At the beginning of the year	For the Year	Value as on 31-Mar-23	As on 31-Mar-23	As on 31-Mar-22
		Before 30-Sep-22	After 30-Sep-22		As on 31-Mar-23							
A. PROPERTY, PLANT & EQUIPMENT												
Building/Civil Construction												
	-	-	-	-	-	-		-	-	-	-	-
TOTAL	-	-	-	-	-	-		-	-	-	-	-
Capital Work in Progress	4,63,00,000		-			-				0.00	4,63,00,000	4,63,00,000
TOTAL	4,63,00,000	-	-	-	-	-	-	-	-	-	4,63,00,000	4,63,00,000

SCHEDULE-8 : PROPERTY, PLANT & EQUIPMENT

(Amount in Rupees)

Descriptions	GROSS BLOCK					DEPRECIATION				NET BLOCK	
	Cost as on 1-Apr-22	Before 30-Sep-22	After 30-Sep-22	Deletions during the year	Cost as on 31-Mar-23	Rate of Depreciation	At the beginning of the year	For the Year	Value as on 31-Mar-23	As on 31-Mar-23	As on 31-Mar-22
A. PROPERTY, PLANT & EQUIPMENT											
Civil Work	44,49,891			-	44,49,891	10%	14,20,164	4,44,989	18,65,153	25,84,738	30,29,727
Computer & Machinery	1,65,98,095	66,230	46,303	-	1,67,10,628	40%	74,11,367	66,74,991	1,40,86,358	26,24,270	91,86,728
Office Equipment	97,69,448	24,539	5,400	-	97,99,387	15%	33,02,514	14,69,503	47,72,017	50,27,370	64,66,934
Lab Equipment	1,86,39,964	8,58,416		-	1,94,98,380	15%	70,89,883	29,24,757	1,00,14,640	94,83,740	1,15,50,081
Furniture & Fixture	3,76,350		4,39,686	-	8,16,036	10%	1,52,588	59,619	2,12,208	6,03,828	2,23,762
Car Parking (Kakinada)	-	12,91,000			12,91,000	10%	-	1,29,100	1,29,100	11,61,900	
Equipment (LC)			98,36,406		98,36,406	15%	-	7,37,730	7,37,730	90,98,676	
Water Quality Lab (Kakinada)		79,700			79,700	10%	-	7,970	7,970	71,730	
B. INTANGIBLE ASSETS					-			-	-	-	
Software	48,058		2,12,754	-	2,60,812	40%	9,612	61,774	71,386	1,89,426	38,446
TOTAL	**4,98,81,806**	**23,19,885**	**1,05,40,549**	-	**6,27,42,240**		**1,93,86,128**	**1,25,10,434**	**3,18,96,562**	**3,08,45,678**	**3,04,95,678**

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SCHEDULE - 9 : INVESTMENTS FROM EARMARKED/ENDOWMENT FUNDS

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
1. In Government Securities	NIL				
2. Other approved Securities					
3. Shares					
4. Debentures and Bonds					
5. Subsidiaries and Joint Ventures					
6. Other (to be specified)					
Total					

SCHEDULE - 10 : INVESTMENTS - OTHERS

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
1. In Government Securities	-	-	-	-	-
2. Other approved Securities	-	-	-	-	-
3. Shares	-	-	-	-	-
4. Debentures and Bond	-	-	-	-	-
5. Subsidiaries and Joint Ventures	-	-	-	-	-
6. Others (to be specified)	-	-	-	-	-
Total	-	-	-	-	

SCHEDULE - 11 : CURRENT ASSETS, LOANS, ADVANCES ETC.

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
A. CURRENT ASSETS :					
1. Inventories :					
a) Stores and Spares	-	-	-	-	-
2. Sundry Debtors :	-	-	-	-	-
a) Debts Outstanding for a period exceeding six months	-	-	-	-	-
b) Others	2,41,900	-	-	2,41,900	2,41,900
3. Cash balances in hand (including cheques/drafts and imprest)	-	-	-	-	-
a) Imprest with Officers	-	-	-	-	-
4. Bank Balances :	-	-	-	-	-
a) With Scheduled Banks:	-	-	-	-	-
- On Savings Bank Accounts at	-	-		-	
Headquarter	2,05,66,806	2,51,41,527	1,56,71,217	6,13,79,551	4,65,64,620
Cash & Bank Balance with Regional Centre (As per List 'I')	53,667	37,538	-	91,205	2,06,810
LC with IOB	-	-	-	-	-
LC with SBI	-	-	-	-	1,05,13,690
Total (A)	**2,08,62,373**	**2,51,79,066**	**1,56,71,217**	**6,17,12,656**	**5,75,27,020**
				-	
B. LOANS, ADVANCES AND OTHER ASSETS				-	
1. Loans				-	
a) Staff (as per list 'II')	3,10,598	18,29,495	-	21,40,093	19,89,452
b) Others - Departmental Advances (as per list 'III')	6,25,573	15,678	2,54,348	8,95,599	5,92,901
2. Advances and other amounts recoverable in cash or in kind or for value to be received:					
a) Staff Imprest A/c	37,777	-	-	37,777	33,777
b) Advances to Firms	1,42,49,206	77,62,439	21,85,767	2,41,97,412	1,92,75,759
c) Advances for Constructions (As per list 'IV')	1,04,17,830	-	-	1,04,17,830	1,45,630
d) Advance to Govt. Institutions	-	-	-	-	-
e) Amt. tranf. To National Conference	-	-	-	-	-
d) Pre-paid Expenses (As per list 'V')	-	-	-	-	-
e) Deposits (As per list 'VI')	6,27,618	2,15,401	-	8,43,019	8,43,019
f) Central Ground Water Board , Faridabad	-	-	-	-	
g) Receivable from Plan	-	-	-	-	-
Total (B)	**2,62,68,602**	**98,23,013**	**24,40,115**	**3,85,31,730**	**2,28,80,538**
				-	
Total (A+B)	**4,71,30,975**	**3,50,02,079**	**1,81,11,332**	**10,02,44,386**	**8,04,07,558**

Annexures to Schedule - 11

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
List 'I' Cash & Bank Balance with Regional Centre					
RC Belgaum	17,001	1	-	17,001	12,613
RC Guwahati	16,017	941	-	16,957	37,340
RC Jammu	4,999	-	-	4,999	15,190
RC Kakinada	1,786	34,630	-	36,416	21,604
RC Patna	10,713	400	-	11,113	56,085
RC Bhopal	3,152	1,567	-	4,719	63,979
Total	**53,667**	**37,538**	-	**91,205**	**2,06,810**
List 'II' Staff					
Fan Advance	-	-	-	-	-
Festival Advance	-	525	-	525	525
Scooter/Car Advance	-	-	-	-	-
Court Attachment	-	-	-	-	-
Cycle Advance	-	7,429	-	7,429	7,429
House Building Advance	-	(125)	-	(125)	(125)
Interest Accrued on House Building Advance	-	12,10,320	-	12,10,320	12,97,580
Medical Advance	-	2,65,751	-	2,65,751	-
L.T.C. Advance	1,18,936	1,57,561	-	2,76,497	2,91,157
T.A. Advance	1,91,658	7,380	-	1,99,038	3,92,886
Recoverable from Salary	-	-	-	-	-
CPF Recoverable	-	1,80,654	-	1,80,654	-
Total	**3,10,598**	**18,29,495**	-	**21,40,093**	**19,89,452**
List 'III' Others - Departmental Advances					
Departmental Advances	6,25,573	15,678	2,54,348	8,95,599	5,92,901
Advaces to Divisional Head	-	-	-	-	-
Advance to RC Belgav				-	
Total	**6,25,573**	**15,678**	**2,54,348**	**8,95,599**	**5,92,901**
				-	
List 'IV' Advances for Constructions				-	
EE, CPWD, Kakinada	1,45,630	-	-	1,45,630	1,45,630
EE, CPWD, Patna	1,02,72,200	-	-	1,02,72,200	
EE, CPWD, Dehradun	3,52,19,631	4,63,00,000	-	8,15,19,631	
NPCC Dehradun	-	-	-	-	-
Less: Capital WIP	(3,52,19,631)	(4,63,00,000)		(8,15,19,631)	
Total	**1,04,17,830**	-	-	**1,04,17,830**	**1,45,630**

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List 'V' Pre-paid Expenses					
Particulars	**Current Year**				**Previous Year**
	Scheme	**Non-Scheme**	**NHP**	**Total**	
Telephone Exps.	-	-	-	-	-
Maint. Of Office Equipment	-	-	-	-	-
Library Journal	-	-	-	-	-
Rent, Rates & Taxes	-	-	-	-	-
Maint. Of Communication	-	-	-	-	-
Electricity & Water Charges	-	-	-	-	-
Total	-	-	-	-	
List 'VI' Deposits					
Security Deposits for Gas Cylinders	3,300	350	-	3,650	3,650
Security Deposits With UPCL Roorkee	2,65,030	1,95,392	-	4,60,422	2,65,030
Deposits to UPSEB for Sub-Station	-	8,480	-	8,480	8,480
SDO (Telegraph) for Telephones	13,840	10,649	-	24,489	24,489
Security Deposits for Telephones at RC Belgaum	21,100	-	-	21,100	21,100
D.G.M. Telecom for Telephones at Guwahati	10,000	-	-	10,000	10,000
Deepti Gas Agency, Guwahati	500	530	-	1,030	1,030
Accounts Officer (Tel), Jammu	2,880	-	-	2,880	2,880
Accounts Officer (Tel.), Patna	16,950	-	-	16,950	16,950
Accounts Officer (Tel.), Kakinada	11,710	-	-	11,710	11,710
SDO (Tel), Sagar	12,000	-	-	12,000	12,000
R.C. Sagar	7,604	-	-	7,604	7,604
A.P. State Elect. Board, Kakinada	87,220	-	-	87,220	87,220
Accounts Officer (Tel.) Roorkee	5,600	-	-	5,600	5,600
Deposits made by NIH to outside Parties	16,970	-	-	16,970	2,12,362
Security deposit from Gangotri project	25,000	-	-	25,000	25,000
E.E. UPCL, Roorkee for staff colony	1,26,714	-	-	1,26,714	1,26,714
BSNL, Kakinada	1,200	-	-	1,200	1,200
Total	**6,27,618**	**2,15,401**	-	**8,43,019**	**8,43,019**

SCHEDULE - 12 : INCOME FROM SALES/SERVICES

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
1) Income from Sales	-	-	-	-	
(a) Sale of Scraps	105	2,99,448	-	2,99,553	1,95,387
2) Income from Services					
(a) Water Testing Charges	-	2,01,400	-	2,01,400	4,49,500
(b) Guest House Receipts	7,450	20,08,938	-	20,16,388	8,80,900
(c) Sale of Tender Documents	-	10,000	-	10,000	7,000
(d) Licence fee	-		-	-	-
(e) Income from RTI	-	70	-	70	140
(d) Others	511			511	-
Total	**8,066**	**25,19,856**	-	**25,27,922**	**15,32,927**

SCHEDULE - 13 : GRANTS/SUBSIDIES

(Irrevocable Grants & Subsidies Received)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
1) Grant from MOWR, Govt. of India	4,00,00,000	45,80,00,000		49,80,00,000	53,39,00,000
Total	**4,00,00,000**	**45,80,00,000**	-	**49,80,00,000**	**53,39,00,000**

SCHEDULE - 14 : FEES/SUBSCRIPTIONS

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
1) Entrance Fees			NIL		
2) Annual Fees/Subscriptions					
3) Seminar/Program Fees					
4) Consultancy Fees					
5) Others (Specify)					
Total					

SCHEDULE - 15 : INCOME FROM INVESTMENTS

(Income on Investment from Earmarked/Endowment Funds transferred to Funds)

(Amount in Rupees)

	INVESTMENT FROM EARMARKED FUND				
	Scheme	NON-Scheme	NHP	TOTAL	PREV. YEAR
1) Interest			NIL		
a) On Govt.Securities					
b) Other Bonds/Debentures					
2) Dividends					
a) On Shares					
b) On Mutual Fund Securities					
3) Rents					
4) Others (Specify)					
TOTAL					
TRANSFERRED TO EARMARKED/ENDOWMENT FUNDS					

	INVESTMENT FROM OTHER FUND				
	Scheme	NON-Scheme	NHP	TOTAL	PREV. YEAR
1) Interest			NIL		
a) On Govt.Securities					
b) Other Bonds/Debentures					
2) Dividends					
a) On Shares					
b) On Mutual Fund Securities					
3) Rents					
4) Others (Specify)					
TOTAL					
TRANSFERRED TO EARMARKED/ENDOWMENT FUNDS					

SCHEDULE - 16 : INCOME FROM OTHER SOURCES

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
1) Seminar, Courses and Workshops	-	-	-	-	-
2) Registration fee for training course	-	20,600	-	20,600	12,750
Total	-	**20,600**	-	**20,600**	**12,750**

SCHEDULE - 17 : INTEREST EARNED

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
1) On Fixed Deposits with Scheduled Bank					-
2) On Savings Accounts					8,56,576
3) On T A Advance					
4) on NIH P.F. balances					-
5) Interest accrued on the house building advances			NIL		-
6) Interest accrued on scooter advance					-
7) Interest on Intt. Bearing Advance					-
8) Interest accrued on Security with UPFCL RKE					
9) Interest on Leave Travel Claim					1,438
Total					**8,58,014**

Note : Tax deducted at source to be indicated.

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SCHEDULE 18 : OTHER INCOME

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
1) Profit on Sale/disposal of Assets :	-	-	-	-	
2) Miscellaneous Income					
a) Misc. Receipt	26,615	2,54,536		2,81,151	13,95,236
b) Licence Fee R.C	-	19,480	-	19,480	1,03,687
c) Application Fees	-	1,35,800	-	1,35,800	66,400
d) Workshop	-	-	-	-	-
3) Income from Overhead Charges	-	25,500	-	25,500	-
4) Income from hindi Snghoshthi	-	-	-	-	-
5) Refund of Income Tax	-	-	-	-	-
6) Mandays	-	33,20,026	-	33,20,026	-
Total	**26,615**	**37,55,342**	**-**	**37,81,957**	**15,65,323**

SCHEDULE 20 : ESTABLISHMENT EXPENSES

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
(a) Pay & Allowances (Annexure 1)	-	24,98,23,302	-	24,98,23,302	23,46,13,666
(b) Bonus	-	-	-	-	-
(c) Medical	-	68,42,245	-	68,42,245	43,83,089
(d) Leave Salary & Pension Contribution	-	-	-	-	-
(e) Employer's Contribution CPF	-	1,19,37,440	-	1,19,37,440	1,30,04,790
+Contribution towards shortfall in Intt. On CPF (Annexure 2)	-	-	-	-	96,59,946
(f) Honorarium & Others	3,75,650	1,83,700		5,59,350	5,98,620
(g) Leave Encashment	-	5,12,53,716	-	5,12,53,716	2,91,20,731
(h) Leave Travel Expenses	-	19,56,630	-	19,56,630	33,49,968
(i) Wages	1,31,52,693	4,78,75,624		6,10,28,317	7,28,25,863
(j) NPS Contribution	-	15,51,071	-	15,51,071	76,38,377
(k) Gratuity	-	5,77,08,196	-	5,77,08,196	2,89,16,718
(l) Leave Encashment LTC	-	16,92,159	-	16,92,159	
Total	**1,35,28,343**	**43,08,24,083**	**-**	**44,43,52,426**	**40,41,11,768**

(Annexure 1 to SCHEDULE 20)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
(a) Basic Pay	-	4,11,07,583	-	4,11,07,583	16,72,76,010
(b) Dearness Allowances	-	1,64,39,089	-	1,64,39,089	4,34,79,568
(c) House Rent Allowances	-	34,59,409	-	34,59,409	1,31,94,293
(d) Overtime Allowances	-	-	-	-	-
(e) P.C. Allowances	-	-	-	-	11,82,499
(f) Special Duty Allowances	-	1,53,210	-	1,53,210	4,40,300
(g) Transport Allowances	-	19,01,195	-	19,01,195	74,18,636
(h) Washing Allowances	-	-	-	-	-
(i) Special Pay	-	2,100	-	2,100	8,400
(j) Deputation Allowance	-	39,240	-	39,240	1,55,960
(k) Reimb. Of Tuition Fees	-	15,28,900	-	15,28,900	14,58,000
Total	-	**6,46,30,726**	-	**6,46,30,726**	**23,46,13,666**
Add: Salary		18,51,92,576	-	18,51,92,576	-
Total	-	**24,98,23,302**	-	**24,98,23,302**	**23,46,13,666**

(Annexure 2 to SCHEDULE 20)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
Interest on					
(a) On CPF on Employees own subscription	-	-	-	-	-
(b) On CPF on Employer's contribution	-	-		-	96,59,946
Total (a+b)	-	-	-	-	**96,59,946**
(c) Less : Interest Received on CPF Investments	-	-		-	-
Total (a+b-c)	-	-	-	-	**96,59,946**

SCHEDULE 19 : INCREASE/(DECREASE) IN STOCK OF FINISHED GOODS & WORK IN PROGRESS

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
a) Closing Stock					
Finished Goods					
Work in Progress			NIL		
b) Less: Opening Stock					
Finished Goods					
Work-in-Progress					
Net Increase/ (Decrease) (a-b)					

SCHEDULE - 21 : OTHER ADMINISTRATIVE EXPENSES ETC.

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
OFFICE EXPENSES :					
(1) Elect./Water charges & Generator Running Cost	1,76,166	69,47,004	-	71,23,170	69,84,515
(2) Stationery & Printing	6,29,288	92,513	-	7,21,801	6,86,331
(3) Postage	83,408	121	-	83,529	1,28,801
(4) Telephone	58,933	14,16,007	-	14,74,940	15,84,995
(5) Rent, Rates & Taxes	3,78,559	21,03,376	-	24,81,935	19,83,532
(6) Liveries	-	1,40,000	-	1,40,000	1,60,000
(7) Hospitality Expenses	4,28,558	1,00,839	-	5,29,397	4,91,712
(8) Advertisement	12,123	2,22,852	-	2,34,975	4,28,176
(9) Running cost of Lab./Computer	2,22,576	2,41,674	-	4,64,250	28,06,052
(10) Publication (Printing of Tech. Reports)	6,97,586	-	-	6,97,586	8,26,100
(11) Training Courses/Workshops	60,170	21,570	-	81,740	5,66,360
(12) Seminar & Conference	18,25,774	17,240	-	18,43,014	10,70,342
(13) Conveyance Charge	27,735	2,550	-	30,285	13,374
(14) Payment for Professional & Other Services	8,27,534	45,674	-	8,73,208	1,38,36,857
(15) T.A. to Candidates	-	6,502	-	6,502	25,32,214
(16) T.A. to Non-Officials	85,781	69,499	-	1,55,280	1,39,676
(17) T.A. To Foreign	-	-	-	-	-
(18) Newspapers/Periodicals	8,117	7,42,987	-	7,51,104	6,61,348
(19) Misc. Expense	1715891.50	92,839	-	18,08,731	4,39,468
(20) Travelling Expenses	4,93,285	15,15,155	-	20,08,440	15,40,097
(21) Field expenses	61,27,520	32,189	-	61,59,709	12,57,893
(22) Contingency	15,05,906	8,32,361	-	23,38,267	12,30,394
(23) Bank Charges	9,904	1,000	-	10,904	3,320
(24) Consumables	6,20,502	-	-	6,20,502	8,30,072
(25) Office Expenses	-	-	-	-	5,12,338
(26) Leave Travel Claim	-	-	-	-	-
(27) Audit Fees	-	-	-	-	22,718
(28) Overhead Charges	-	-	-	-	-
(29) Sample Analysis	-	-	-	-	-
(30) Consultancy Service/ Training courses fee	-	-	-	-	1,07,600
(31) Rejnuvenation of Village Ponds	-	-	-	-	-
(32) Aazadi Ka Amrit Mahotsav	1,42,250	11,952	-	1,54,202	-
(33)Other Charges	-	-	-	-	80,587
(34) Swachta Action Plan	1,30,420	6,884	-	1,37,304	-
(35)Experimental Charges	-	-	-	-	1,14,172
(36)Chemical & glassware (R&D)	13,08,195	-	-	13,08,195	3,66,191
(37) Wages	-	-	-	-	-
(38) Water Testing	-	-	-	-	-
(39) Meeting	12,288	-	-	12,288	-
(40) POL	5,58,096	6,51,199	-	12,09,295	2,78,868
Total (a)	**1,81,46,565**	**1,53,13,987**	-	**3,34,60,552**	**4,16,84,103**

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MAINTENANCE EXPENSES					
(1) Lab./Workshop Equipment	-	10,78,372	-	10,78,372	6,90,255
(2) Communications	-	3,18,817	-	3,18,817	14,48,133
(3) Generator Set	1,74,458	6,87,579	-	8,62,037	1,47,974
(4) Computer Peripherals	-	16,19,117	-	16,19,117	19,77,747
(5) Buildings & Bulk Services		86,67,470	-	86,67,470	50,37,484
(6) Office Equipment	6,740	14,76,513	-	14,83,253	15,93,031
(7) Furniture & Fixture	-	2,28,209	-	2,28,209	550
(8) Vehicle	72,980	3,03,543	-	3,76,523	9,00,402
(9) Library Books		1,99,500	-	1,99,500	-
(10) Other Auxilary Equipments	-	-	-	-	1,99,613
Total (b)	**2,54,178**	**1,45,79,120**	-	**1,48,33,298**	**1,19,95,189**
				-	
Total (a+b)	**1,84,00,743**	**2,98,93,107**	-	**4,82,93,850**	**5,36,79,292**

SCHEDULE - 22 : EXPENDITURE ON GRANTS, SUBSIDIES ETC.

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
(a) Grants given to Institutions/Organisations			NIL		
(b) Subsidies given to Institutions/Organisations					
Total					

SCHEDULE - 23 : Interest

(Amount in Rupees)

Particulars	Current Year				Previous Year
	Scheme	Non-Scheme	NHP	Total	
(a) On Fixed Loans			NIL		
(b) On Other Loans (including Bank Charges)					
(c) Others (specify)					
Total					

National Institute of Hydrology, Roorkee
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Schedule24

SIGNIICANT ACCOUNTING POLICIES FORMING A PART OF BALANCE SHEET AS AT MARCH 31ST2023 AND INCOME & EXPENDITURE ACCOUNT AND RECEIPTS &PAYMENTS ACCOUNT FOR THE YEAR ENDED MARCH 31ST2023.

1. ACCOUNTING CONVENTION

The Financial Statement have been prepared under the historical cost convention, on the accrual basis of accounting and in accordance with generally accepted accounting principles.

2. REVENUE RECOGNITION

All income and expenditure item having material bearing on the financial statement are recognized on accrual basis.

3. FIXED ASSETS

i. Fixed Assets are stated as cost less accumulated depreciation.
ii. Fixed Assets are stated at cost of acquisition inclusive of all incidental expenses related thereto.

4. DEPRECIATION

i. Depreciation on fixed assets has been provided on written down value methods in accordance with the rates prescribed in the income tax Rules 1962.
ii. In respect of addition to deduction from fixed assets is less than a period of 180 days, then rate of depreciation has been applied for 50% of the actual rate.

5. RETIREMENT AND DISPOSAL OF ASSETS

Profits on sale of assets are accounted for on completion of sale thereof.

6. GOVERNMENT GRANTS

i. Grants in respect of specific fixed assets as required are shown as a deduction from the cost of the related assets.
ii. Government grants are accounted on realization basis.

7. RETIREMENT BENEFITS

i. The cost of providing benefit, i.e., gratuity is determined by the NIH, as per the rules applicable to the Center Government employees.
ii. Other Long Term Employees Benefits viz., Leave Encashment is recognized as in expenses in the Income & Expenditure account and when it accrues. The liability is determined by the NIH, as per the rules applicable to the Central Government employees.
iii. Payments to Contributory Provident Fund are charges as in expenses as they fall due.

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Schedule 25: CONTIGENT LIABILITIES & NOTES ON ACCOUNTS

1. As per the requirements of the Comptroller & Auditor General of India, the excess of Income over Expenditure/Expenditure over Income have been transferred to Corpus/Capital Fund instead of earlier practice of NIH to transfer in General reserve.
2. As per the requirements of the Comptroller & Auditor General of India, the capital grant received is shown under Capital Fund with depreciation as deduction instead of earlier practice of NIH to include the Grant in income and depreciation as expense.
3. The details of R&D Activity(MOWR) under Schedule 3 are as follows:-

S. no	Name of Agency	Fund Received	Expenditure	Balance
1	Center for Environment & Development Study, Jaipur	140,000	139,004	996
2	IIT Roorkee (NWM)	1,245,006	1,140,586	104,420
3	Indian Association of Soil & Water Conservationists, Dehradun	210,000	205,030	4,970
4	Navsari Agricultural University, Navsari Gujarat	210,000	210,000	-
5	VyaktiVikas Kendra India	210,000		210,000
6	Karunya Institute of Technology and Sciences, Coimbatore	140,000		140,000
7	IIT Kharagpur	350,000	259,896	90,104
8	Indian Society of Agriculture Engineers- New Delhi	350,000	350,000	-
9	Centre For Ecology Development And Research Dehradun	1,500,000	1,500,000	-
10	AFRI Jodhpur	185,782	185,782	-
11	SP college, Sirohi	208,600		208,600
12	PEC University of Technology, Chandigarh	350,000	350,000	-
13	Centre for Water Resources Development and Management, Kerala	200,000	164,885	35,115
14	Centre for Water Resources Development and Management, Kerala	214,388	214,388	-
15	RashtrasantTukdojiMaharaj, Nagpur, University	350,000	350,000	-
16	JNTUH College of Engineering Hyderabad	305,000		305,000
	TOTAL	**6,168,776**	**5,069,571**	**1,099,205**

4. As per the requirements of the Comptroller & Auditor General of India, the details of Grants & expenditure of NHP are shown under Schedule 3, instead of earlier practice of NIH to treat Grant as Income and expenditure in Income & Expenditure A/c.
5. The receipts of Interest by NIH in any form that is payable to bharatkosh has been treated as current liability instead of earlier practice of NIH to treat it as an interest income.
6. The Journal Vouchers for the Regional Centers are prepared on March 31st, 2023 at Head Office, NIH, Roorkee. In the case of acquisition of fixed assets, we have taken the actual purchase date for calculation of depreciation.
7. The amount of provision of Gratuity and Leave Encashment are as follows:-

PARTICULARS	GRATUITY	LEAVE ENCASHMENT
Opening balance as on 01.04.2022	**19,40,18,198**	**14,68,89,961**
Less: Paid during the Year	4,48,28,215	3,29,64,331
Add: Provision made for the Year	5,77,08,196	5,12,53,716
Closing balance as on 31.03.2023	**20,68,98,179**	**16,51,79,788**

8. Physical Stock Verification reports for all branches for the Financial Year 2022-23 have been received and no material discrepancy have been reported in them.
9. Advance due to and due from parties are subject to confirmation and these balances are shown as appearing in the books of accounts as on March 31st, 2023.
10. The Institute has obtained the exemption certificate from Income Tax department under Income Tax Act Section (12AA). The Institute has also obtained the exemption certificate from Income Tax Department under section 35(1) on 15.05.2017.
11. Last year figures have been regrouped and rearranged in order to make comparison meaningful.
12. Schedules 1 to 25 are annexed to and form an integral part of the Balance sheet as at 31.03.2023 and the Income and Expenditure Account for the year ended on that date.

FOR NATIONAL INSTITUTE OF HYDROLOGY, ROORKEE

12/9/23

(SURYA KANT)
FINANCE OFFICER

वित्त अधिकारी/Finance Officer
राष्ट्रीय जलविज्ञान संस्थान
National Institute of Hydrology
रुड़की/Roorkee

(SUDHIR KUMAR)
DIRECTOR

डॉ. सुधीर कुमार/Dr. Sudhir Kumar
निदेशक/Director
राष्ट्रीय जलविज्ञान संस्थान
National Institute of Hydrology
रुड़की/Roorkee-247 667

FOR MANOJ MOHAN & ASSOCIATES
FIRM REG.NO.:009195C
CHARTERED ACCOUNTANTS

CA (Dr.) MANOJ KUMAR AGRAWAL
MANAGING PARTNER
M.NO.: 076980

APPENDIX-XVII

Separate Audit Report of Comptroller and Auditor General of India for the year 2022-23

Separate Audit Report of the Comptroller & Auditor General of India on the Accounts of National Institute of Hydrology (NIH), Roorkee, Uttarakhand for the year ended 31 March 2023

1. We have audited the Consolidated Financial Statement of Scheme, Non-Scheme, NHP, Consultancy, Sponsored Project, Training Courses, R&D Support Fund, Welfare Fund & NMSHE of the National Institute of Hydrology (NIH), Roorkee, Uttarakhand as at 31 March 2023 and the Income & Expenditure Accounts and Receipt & Payment Accounts for the year ended on that date under Section 20 (1) of the Comptroller & Auditor General's (Duties, Power and Conditions of Service) Act 1971. These financial statements are the responsibility of Autonomous Body's Management. Our Responsibility is to express an opinion on these financial statements based on our audit.

2. This Separate Audit Report contains the comments of the Comptroller & Auditor General of India (CAG) on the accounting treatment only with regard to classification, conformity with the best accounting practices, accounting standards and disclosure norms, etc. of National Institute of Hydrology (NIH), Roorkee, Uttarakhand. Audit observation on financial transactions with regards to compliance with the Laws, Rules and regulations (Propriety and Regularity) and efficiency-cum-performance aspects, etc. if any, are reported through Inspection Reports/CAG's Audit Reports separately.

3. We have conducted our audit in accordance with auditing standards generally accepted in India. These standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatements. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of financial statements. We believe that our audit provides a reasonable basis for our opinion.

4. Based on our audit, we report that:

(i) We have obtained all the information and explanations, which to the best of our knowledge and belief were necessary for the purpose of our audit.

(ii) The Balance Sheet, Income and Expenditure Account and Receipt and Payment Accounts dealt with by this report are drawn up in the format as prescribed by the Ministry of Finance Government of India unless otherwise mentioned.

(iii) In our opinion, proper books of accounts and other relevant records have been maintained by National Institute of Hydrology (NIH), Roorkee, Uttarakhand in so far as it appears from our examination of such books.

(iv) We further report that:

A. General

A.1 The revised Consolidated Accounts of NIH Roorkee for the year 2022-23 revealed that:

- The Schedule 8 (Plant, Property & Equipments) of Consolidated Balance Sheet was not prepared in approved format of Accounts. Only a summary of WDV of Fixed Assets acquired from various funds was exhibited. Thus, the Gross Block, Addition, Deletion and Depreciation for the year and corresponding figures of previous year were not available for information and comparison.

- The Significant Accounting Policy, Notes to Accounts and Contingents Liabilities were not found attached with Consolidated Final Accounts of NIH for the F.Y. 2022-23.

A.2 The Final Account of FY 2021-22 was laid in the Parliament without final C&AG comments, instead the Draft Separate Audit Report (DSAR) was published in Annual Report.

A.3 Property, Plant & Equipment (Schedule 8) – Rs. 4556.76 lakh

An engineering work "Construction of Car Parking Shed at Deltaic Regional Centre, Kakinada" and "Renovation with Modern Platform in water quality laboratory for NIH Kakinada" from the fund of NHP and "Construction of Building/Civil works' of Scheme Fund were completed and put to use during the FY 2016-17 to 2019-20 at a gross value of Rs. 13,70,700/- and Rs. 4,11,32,247/- respectively. However, NIH, Roorkee wrongly booked the same in the current year (2022-23) in the NHP and Scheme fund.

Since the works were completed and put to use before the current year i.e. 2022-23, the depreciation as per the prescribed rate in Accounting Standard (AS)10 had to be charged. Impact of undercharging of depreciation could not be ascertained.

B. Revision of Accounts

The Institute, on the basis of audit observations, has revised the accounts. The impact of revision on consolidated financial statements is that the Assets & Liabilities increased by Rs. 42.37 crore and Surplus carried to Corpus/Capital Fund increased by Rs. 5.60 crore.

C. Grants-in-aid

Against the total contribution/grants of Rs. 70.61 crore (Rs.59.22 crore received during the year, Rs. 7.68 crore for previous year balance and Rs. 3.71 crore as other advances), the Board had incurred a net expenditure of Rs. 51.89 crore during the year 2022-23 leaving unspent grant balance of Rs. 18.72 crore.

D. Management letter

Deficiencies which have not been included in the audit report will be/have been brought to the notice of the Board through a Management Letter issued separately for remedial/corrective action.

(v) Subject to our observations in the preceding paragraphs, we report that the Balance Sheet, Income and Expenditure Account and Receipt and Payment Account dealt with by this report are in agreement with the books of accounts.

(vi) In our opinion and to the best of our information and according to the explanations given to us, the said financial statement read together with the Accounting Polices and Notes on Accounts, and subject to the significant matters stated above and other matters mentioned in Annexure to this Audit Report give a true and fair view in conformity with accounting principles generally accepted in India.

a. *In so far it relates to the Balance Sheet of the state of affairs of the NIH, Roorkee, as at 31 March 2023 and*

b. *In so far as it relates to the Income and Expenditure Account of the surplus for the year ended on that date.*

For and on behalf of C&AG of India

Place: New Delhi
Date: 08 /02/2024

08/02/2024

(Sandeep Lall)
Director General of Audit
Agriculture Food & Water Resources

Annexure

I. Adequacy of Internal Audit System:

The Internal Audit of National Institute of Hydrology (NIH) Roorkee, Uttarakhand for the year 2022-23 was not conducted.

II. Adequacy of Internal control system:

Assets Register were not maintained properly in NIH and furnished to Audit.

III. System of Physical Verification of assets:

(i) The Management has conducted only physical verification of 'Tools and Plant' for the year 2022-23.

(ii) Physical Verification (PV) have not been conducted of all Regional/ Division/ Lab/ Unit Offices during the F. Y. 2022-23.

IV. System of Physical Verification of inventory

The Management has conducted the physical verification of inventory, and a combined Physical Verification Report is created for inventory and Tools & Plant for the year 2022-23.

V. Regularity in payment of statutory dues:

There were no outstanding statutory liabilities as on 31.03.2023.

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NATIONAL INSTITUTE OF HYDROLOGY

MAJOR LABORATORY CAPABILITIES

HYDROLOGICAL INSTRUMENTATION

- Collection, transmission and processing of Hydrometeorological.
- Design & development of Hydrometeorological instruments and data acquisition system.
- Flow/discharge measurement
- Infiltration rate measurement
- Measurement of water level in wells
- Water sampling fro rivers, lakes etc.

NUCLEAR HYDROLOGY

- C^{14}/H^{3} dating of ground water
- Sediment dating using Cs^{137}/Pb^{210}
- Discharge of rivers
- Groundwater velocity measurement
- Leakage/seepage detection from dam/reservoir
- Recharge to ground water
- Soil moisture measurement
- Stable isotopic measurements (D, C^{13}, N^{15}, O^{16}, S^{34})
- Identification of recharge source & zones

REMOTE SENSING APPLICATIONS AND GIS

- Visual and digital image processing
- Ground water zonation mapping
- Food plain mapping
- Land use mapping
- Soil erosion and sedimentation studies
- Snow cover mapping
- Salinity and water logging mapping

CENTRE OF EXCELLENCE FOR ADVANCED GROUNDWATER RESEARCH

- Groundwater quantity and quality modeling
- Integrated catchment modeling
- Unsaturated zone modeling
- Spatial & statistical analysis of groundwater data
- Geological characterizing
- 3D contouring
- Water quality characterization

SOIL-WATER

- Determination of soil moisture characteristic curves (0.1 to 15 bar)
- Determination of soil suction (0 to 0.85 bar)
- In-situ soil mosture measurement
- Premeability measurement
- Particle size analysis of soil
- Infiltration rate measurement
- Soil density measurement

WATER QUALITY

- Analysis of organic carbon, inorganic carbon, total carbon
- Analysis of pesticides & organic compounds
- Bacteriological analysis
- Digestion of BOD & COD samples
- Field measurement of pH, conductivity, and anions
- Analysis of trace elements.

SNOW AND GLACIER

- Stremflow measurement in high altitute region analysis of snow cover
- Degree-day factors for snow and ice melt
- Assessment of suspended sediment concentration
- Modelling of stream flow and snow fed rivers
- Hydrological investigations on glaciers

FACILITIES AT REGIONAL CENTRES

- Hydrological modelling & analysis
- Digital image processing and GIS
- Groundwater exploration
- Hydrometerology
- Remote sensing application Soil Moisture measurement
- Soil sampling & analysis
- Water quality

Contact :

Director,

NATIONAL INSTITUTE OF HYDROLOGY

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आपो हिष्टा मयोभुवः