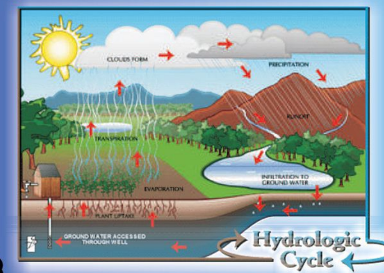
Issue No: 17& 18June& Dec., 2020

Hydrology for People™

जन साधारण के लिए जलविज्ञान अंक-17,18



Newsletter of National Institute of Hydrology, Roorkee (India)

राष्ट्रीय जलविज्ञान संस्थान रूड़की द्वारा प्रकाशित समाचार पत्र

From Director's Desk

From Director's Desk

Water is perhaps the most precious natural resource on the earth which is required for different purposes. The country received above normal rainfall in the year 2020, recording the second highest precipitation in the last 30 years. This blessing along with the infrastructures in the form of tanks, ponds, rooftop rainwater harvesting structures, check dams, etc. will certainly reduce the water scarcity and improve groundwater reserves, and in turn will support the country's goal towards food security.

The country also faced the Covid-19 pandemic and to restrict the spread of this pandemic, the government ordered a 21 days' lockdown on March 24, 2020, which was further extended till May 31. The restriction on economic activities along with spells of rain helped the rivers and water resources to rejuvenate and cleanse themselves. Improvement in water quality and quantity was observed in the rivers throughout the country. This clearly demonstrated the self cleansing capacity of the rivers and that increasing the treatment capacity and implementing strict regulatory laws can certainly help in reviving the water resources.

However, the Covid-19 pandemic has brought a new challenge for the water professionals in the form of increased usage of water for personal hygiene and water resources contamination by SARS-COV-2 through the waste water from the containment zones. Live SARS-CO-2 were detected in the stool samples and untreated wastewater, raising concerns regarding the spread of this virus through the water system considering the fact that approximately 60% of the untreated domestic wastewater is drained in the water resources. However, no case of pandemic spread through water system has been identified and is a relief for the drinking water utilities, but more research work is required in this area. Further, a proactive approach is required through better water management strategies to meet the post Covid-19 challenge and have sufficient clean water in order to provide for human consumption and to resume normal productive and commercial activities.

J V Tyagi

About National Institute of Hydrology

The National Institute of Hydrology (NIH), established in 1978 as an autonomous organization under Ministry of Water Resources (Government of India), is a premier R&D institute in the country to undertake, aid, promote and coordinate basic, applied and strategic research on all aspects of hydrology and water resources development. The Institute has its headquarters at Roorkee (Uttarakhand). To carry out field related research covering different regions of the country, the Institute has four Regional Centres located at Belagavi, Jammu, Kakinada and Bhopal, and two Centres for Flood Management Studies at Guwahati and Patna. The Institute has established state-of-art laboratory facilities in the areas of Nuclear Hydrology, Water Quality, Soil Water and Remote Sensing & GIS Applications.

The Institute acts as a centre of excellence for the transfer of technology, human resources development and institutional development in specialized areas of hydrology, and conducts user defined, demand-driven research through collaboration with relevant national and international organizations. The Institute vigorously pursues capacity development activities by organizing training programmes for field engineers, scientists, researchers and NGOs. The Institute has undertaken a number of internationally funded projects, including those from UNDP, USAID, UNESCO, The World Bank, The Netherlands, Sweden and European Union. The Institute is presently participating in the World Bank funded National Hydrology Project and National Mission for Sustaining the Himalayan Ecosystem (NMSHE) (GoI funded).

The Institute is actively pursuing the IEC and mass awareness activities and is contributing in 'Jal Shakti Abhiyan' of the Ministry of Jal Shakti (GoI). NIH hosts the Secretariats of Indian National Committee on Climate Change (INC-CC) and Indian National Committee for Intergovernmental Hydrological Programme of UNESCO (INC-IHP).

Thrust Areas

- Water Resources Planning and Management
- Ground Water Modeling and Management
- Flood and Drought Prediction and Management
- Snow and Glacier Melt Runoff Estimation
- Prediction of Discharge in Ungauged Basins
- Water Quality Assessment in specific areas
- Hydrology of Arid, Semi-arid, Coastal & Deltaic Zones
- Reservoir / Lake Sedimentation
- Impact of Climate Change on Water Resources
- Application of modern techniques to solve hydrological problems

Projects Solving Real Life Problems:

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

Attempts for assessing E-Flows in western Himalayan region have been mostly based on hydrological or hydraulic approaches with application of limited habitat preferences due to limited knowledge base hydrology-ecology relationships for the aquatic species of this region. In this connection, a study was carried out to develop habitat suitability curves for the aquatic species of western Himalayan streams using the available literature for the assessment of environmental flows using habitat simulation modelling.

In the present study, the data/information on biotic parameters (abundance of aquatic species) and influencing abiotic parameters (water depth & velocity and water quality parameters: water temperature, pH, DO, BOD, turbidity etc.) for the concurrent period have been compiled for 48 sites in the western Himalayan region. It was found from the literature that the keystone species for upper (>1500m), middle (500-1500m) and lower (< 500m) zones are Brown Trout, Snow Trout and Golden Mahseer respectively. Hence, the habitat suitability curves for these species have been developed through the specific module in the 'System for Environmental Flow Analysis (SEFA)' software utilizing the data/information available in the compiled literature (Fig. 1).

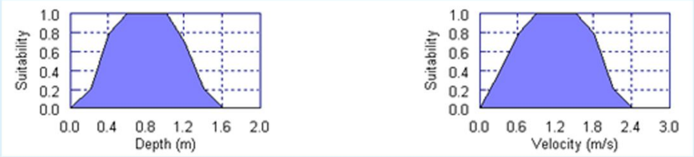


Fig. 1: Habitat suitability curves for Snow Trout

For habitat simulation modelling through SEFA, four sites have been selected viz. Joshimath (upper zone), Rudraprayag (middle zone) and Devprayag&Rishikesh (lower zone). Further, the developed habitat suitability curves alongwith discharge and cross-section data at these four sites have been used for the simulations through habitat simulation modelling exercise. The final modelling output is the Area Weighted Suitability (m2 of river bed/ m of reach length) which indicates the suitability of a particular discharge for the habitat sustenance. Further, AWS Duration analysis was also performed on monthly basis at these sites for the keystone species which provides the median, 90%, 75%, 25%, 10% and mean of AWS for the historical flow series (Fig. 2). Assuming that the environmental flows may be kept for maintaining the median or higher values of AWS for sustenance of keystone aquatic species, it was found that the recommended e-flows are falling in the range from 26.32 to 41.81 % of average monthly flows at Joshimath site, from 20.94 to 38.64% of average monthly flows at Rudraprayag site, from 23.67 to 33.81% of average monthly flows at Devprayag site (after confluence) and from 24.66 to 37.17% of average monthly flows at Rishikesh site.

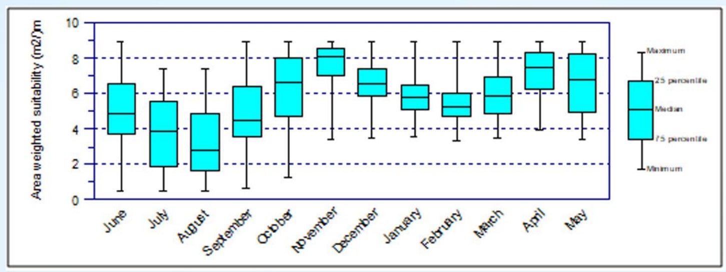


Fig. 2: AWS duration analysis for Snow Trout at Rudraprayag site

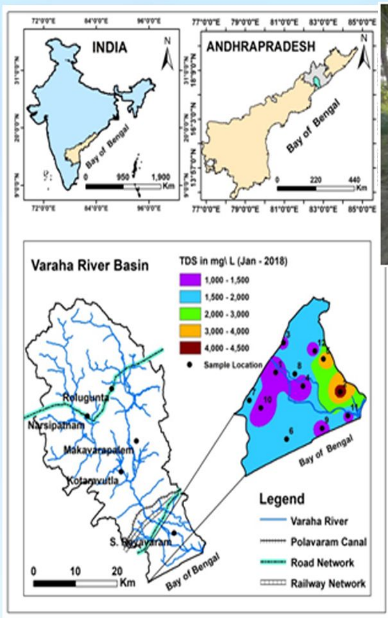
The habitat suitability varies significantly with respect to the species and location. The curves developed for this habitat simulation modelling exercise are based on the secondary literature available. The results may be different if we derive the site-specific habitat suitability curves. Habitat simulation modelling provides additional information in comparison to hydrodynamic modelling in terms of a number of optional management scenarios for the maintenance of different levels of habitat sustenance.

2. River Bank Filtration (RBF) studies in coastal alluvium of Andhra Pradesh

The natural recharge to the groundwater from River Bank Filtration (RBF) is one of the possible solution for groundwater salinity problems in the coastal regions of India. To provide safe drinking water supply, lower reaches of Varahariver, Visakhapatnam district, Andhra

Pradesh is selected for RBF investigations where many coastal villages are facing high salinity in groundwater. The spatial distribution of groundwater TDS map at the lower reaches of the Varaha river basin is between 1000 −4500 mg/L. An integrated approach including hydro-geochemical studies, geophysical surveys, pumping tests and groundwater flow modeling techniques is adopted for establishing a RBF well on Varaha river bank. The geophysical surveys (ERT and VES) successfully delineated a river-aquifer interaction zone (low saline zone) with resistivity values of 14-24 Ohm.m. in the depth range of 7–15 m below the subsurface.

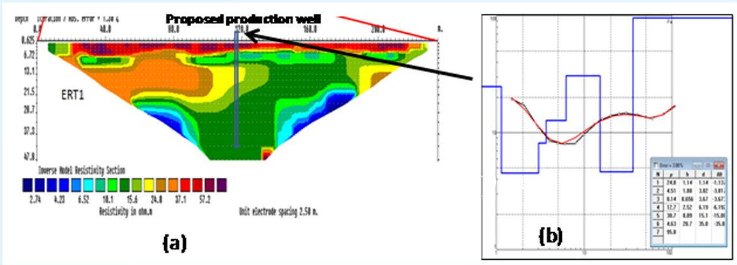
The RBF well is drilled at this zone on a riverbank by taking proper well construction methods. Based on the results obtained from ERT and VES surveys, the exploratory drilling work is carried out by employing the rotary drilling method and drilled the RBF well up to the depth of 35 m. To extract good quality of water from this desired coarse sand layer and also to arrest the vertical leaching in the subsurface, the Galvanized Iron (GI) pipe (diameter of 10 in.) at a length of 18 m is used and provided the angular slots (screening) between the depth of 7–13 m. Based on the water requirement from RBF well, the 5 Horse Power (HP) capacity submersible motor is installed. The pumping rate and aquifer properties (transmissivity and storativity) are estimated during pumping test (Transmissivity of 285 m2/day and storativity value of 0.03). The RBF water is analyzed and compared with the nearby groundwater (present water supply to the Vommavaram village) and Varaha river water. According to the major ion chemistry, physico-chemical parameters, trace elements and bacteriological characteristics, the newly established RBF well has qualified the conditions of all drinking water limits which indicate that the quality of extracted water is suitable for water supply. The recommended optimum pumping rates of RBF well is established using groundwater flow modeling technique. The optimum pumping rate of RBF well is recommended to be nearly 150 m3/day with 5h of pumping duration per day. This optimum pumping rate with recommended pumping rates and pumping time is crucial to tap good quality induced water from RBF well. It is also estimated that, if the water consumption is assumed to be 150 L per capita per day, the RBF well could able to provide safe drinking water for nearly 1000 persons (5 hour pumping per day) on the basis of safe pumping rate from RBF well.



The map of Varaha river basin and groundwater TDS in the lower reaches (May 2019)

A photograph showing Varaha river bank

A photograph showing drilling of RBF well



The figure showing (a) ERT profile and (b) VES results at RBF well

3. Peya Jal Suraksha - Development of Four Pilot Riverbank Filtration Demonstrating Schemes in Different Hydrogeological Settings for Sustainable Drinking Water Supply

River Bank Filtration (RBF) or simply, Bank Filtration (BF), as one of the alternate cost-effective natural treatment technologies for drinking water supply, has been a common practice in many European countries particularly, in urban and peri-urban areas, for more than a century.

India has a large potential for use of RBF/BF for sustainable qualitative and quantitative production of drinking water, particularly in the Indo-Gangetic-Brahmaputra alluvium areas, coastal alluvium tracts and scattered inland pockets in different states where surface water bodies are hydraulically connected to the adjoining aquifer, surface water source is perennial and aquifers have good soil pores. Currently, only a fraction of RBF potential is in use in India. There is a pressing need to explore possibility to upscale the RBF technology in feasible locations particularly, in rural and sub-urban areas where organized drinking water supplies coverage is yet to take place.

To upscale the RBF technology in different hydro-geological settings in India, four pilot demonstration schemes have been developed in different feasible locations particularly in the Gangetic basin with the support of Ministry of Jal Shakti, DoWR, RD&GR, Govt. of India aiming to demonstrate the effectiveness of the RBF technology to utility groups about its feasibility, effectiveness, protection against risk, etc. for sustainable safe drinking water supply in peri-urban and rural areas. These four sites include: one in Mathura and one in Agra in Uttar Pradesh on the bank of the Yamuna river; one in Barhara village of Ara district in Bihar on the bank of the Ganga river; and one in Vommavaram village of Visakhapatnam district in Andhra Pradesh on the bank of Varaha river. These sites were developed in two phases. Phase-I included investigations on baseline water quality, geophysical survey, exploratory drilling, identifying hydraulic connectivity between river and aquifer, identification of taping zone, lowering of tube well, well development, etc. Phase-II comprised of installation of pump, construction of pump house, electrical connection and fittings, pipeline laying and hydrant point installation, etc. including the performance evaluation of the RBF water.

The quality of water of these schemes is found better as compared to the BIS standards. These schemes shall be handed over to the respective state public water supply departments. These pilot sites are an attempt from NIH-Roorkee to demonstrate effectiveness of the technology as guiding scheme and helping the utility groups for upscaling.

Snapshot of a developed pilot demonstration RBF scheme at Mathura; Pump House and Stand Post.

4. Improving our understanding of aquifer systems of Sunderbans

The Indian Sundarbans, a UNESCO World Heritage site is home to 2.79 million people. Majority of the population live in acute poverty with marginal living conditions and depends on agriculture for its livelihood which offers limited livelihood potential for communities due to higher sodic salinity levels. This is accentuated by sea level rise and sea water intrusion and contamination of unconfined aquifers and agricultural lands. In recent times with increased crop demand, groundwater demand has also risen (fig. 1), as the limited rainfall fails to meet year round fresh water demand in the region. As a result, groundwater abstraction has become a regular practice, over abstraction often leads to severe water crisis during summer in the region.

In this context, a project was conceptualized and led by National Institute of Hydrology (NIH), Roorkee jointly with British Geological Survey (BGS) and Rajarhat PRASARI with funding from IUKWC to understand the aquifer system in the Sundarbans, by identifying the practicality of artificial aquifer recharge, and its potential contribution to aquifer sustainability and possible role in regional water security. The key aims of the pilot project were –

i) To generate a conceptualized model of artificial recharge with the community,

ii) Understanding communities fresh water demand/need for agriculture and

iii) Current problems with groundwater abstraction from the fresh water aquifers.

To achieve its aims, main activities undertaken are given below:

• Socio-hydrological survey – using stratified sampling based on the Central Ground Water Board (CGWB) well data

- Identification of Water crisis in agriculture through field survey & result triangulation through community workshops
- Collection of rainfall data, pump testing, soil-lithology data from the field
- Water level monitoring (pre and post monsoon) and validating with the community
- Developing simulated ASR model feeding the bservation data

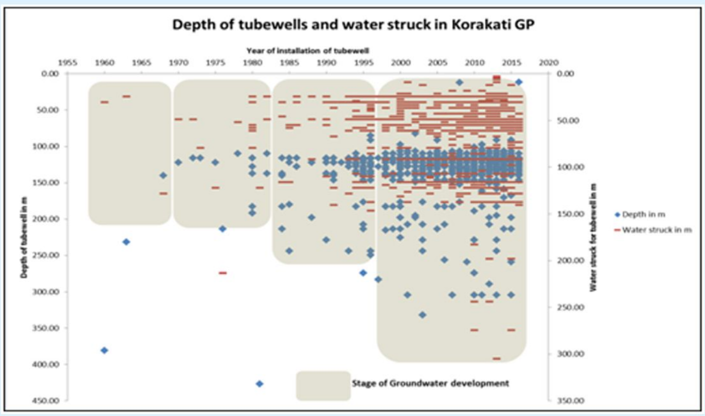


Fig. 1. Year wise progress in the depth of tube wells in the study area

Lithology data was collected and validated the same through participatory aquifer storage and recovery (ASR) system to run solute-transport groundwater modelling; required to predict how stored water will migrate over time, given different conditions and how saline aquifer properties will affect the quality of stored water. It has been well-demonstrated, by model that ASR systems can provide very large volumes of storage at a lesser cost than other options in Indian Sunderbans. The challenges moving forward are to field test the success of ASR systems, optimize system performance, and set expectations appropriately.

Stakeholders, including the society need to be involved since inception of such a water conservation measure. This will not only facilitate adhoc participation but also generate awareness on using water in an efficient manner amongst the users. Frequent training and skill building amongst the society to monitor, manage and maintain the artificial recharge system, data platform and water sharing platform would be key to ensure smooth and long term functioning of the system for a sustainable future.

Fig. 2. Participatory groundwater management workshop

With the research output of the project the next phase of field experiment was designed with the following objectives - i) Field testing of the model Aquifer Storage and Recovery (ASR) system in the saline aquifers of Indian Sunderbans, ii) Impact measurement of ASR in two different context through Ground water modelling, iii) Monitoring of the water quality parameters of the ASR water throughout the year, iv) Capacitating local cadres to facilitate water conservation in the islands of Indian Sunderbans and v) Dissemination of research outcome with the community and vi) Facilitating policy makers to use the research outcomes.

5. Development of water allocation plan of watershed in Kanker district Chhattisgarh

The objectives of the study are to model the different components of hydrological process and to evolve water allocation plan for various uses by scenario analysis for micro watersheds in Kanker Districts, Chhattisgarh.The WEAP model was setup for micro watersheds IWMP14, IWMP15 and IWMP16 using the climate data such as rainfallreference evapotranspiration for crops, population data and livestock details, area under different crops, priority for supply from DPR, crop coefficient, etc. The catchment area of IWMP 14, IWMP15 and IWMP 16 are 66.73, 46.56 and 41.80 sqkm respectively. The base year for current accounts (reference scenario) used for IMWP14, IWMP15 and IWMP16 are 2011, 2015 and 2009 respectively. The input for IWMP16 have been taken from global climate dataset attached with WEAP model. The annual demand for domestic, livestock and agricultural and unmet demand for the reference scenario for the period from 2011 to 2021 for IWMP14, 2015 to 2025 for IWMP15, 2010 to 2050 for IWMP16 have been computed with the input data. The schematic diagram of the model setup for IWMP 14, 15 and 16 are

66.73, 46.56 and 41.80 sqkm respectively. The base year for current accounts (reference scenario) used for IMWP14, IWMP15 and IWMP16 are 2011, 2015 and 2009 respectively. The input for IWMP16 have been taken from global climate dataset attached with WEAP model. The annual demand for domestic, livestock and agricultural and unmet demand for the reference scenario for the period from 2011 to 2021 for IWMP14, 2015 to 2025 for IWMP15, 2010 to 2050 for IWMP16 have been computed with the input data. The schematic diagram of the model setup for IWMP 14, 15 and 16 are given in Figures 1 through 3.

Fig. 1 Schematic diagram for IWMP 14

Fig. 2 Schematic diagram for IWMP 15

Fig. 3 Schematic diagram for IWMP 16

The scenario analysis carried out for IWMP14 are low population growth, high population growth and supply augmentation. The scenario analysis carried out for IWMP15 are population growth rate at 0.9%, 1.0%, 1.1%, 1.2% and 1.3 %. The scenario analysis carried for IWMP16 are population growth, decrease or increase in groundwater recharge, construction of surface water storage structures. The demand and unmet demand for the scenarios are computed and analyzed for the demand met by the way of considering the supply augmentation. The annual water demand and unmet demand for population growth scenario for IWMP 14 are given in Figures 4 and 5.

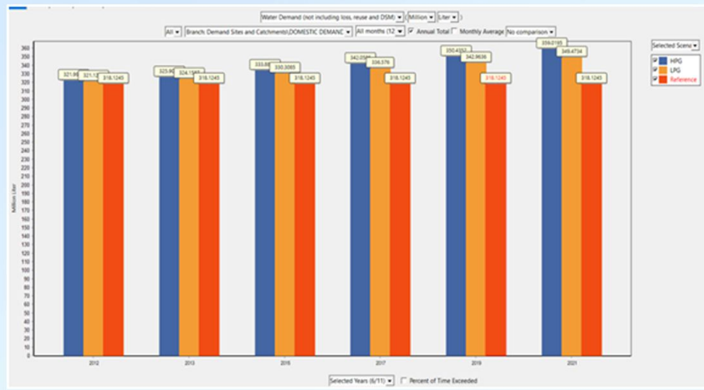


Fig. 4 Annual water demand, Population growth scenario for IWMP14

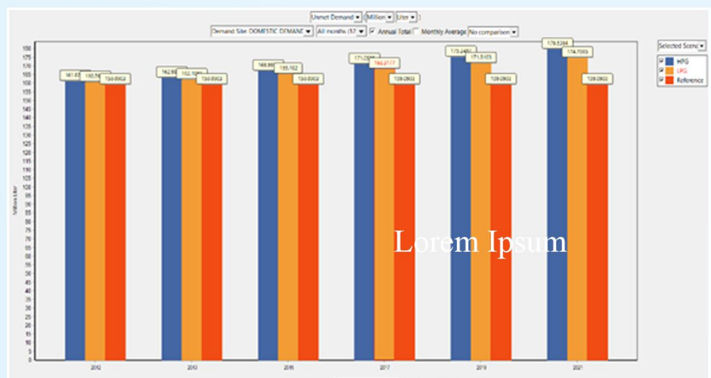


Fig. 5 Annual unmet water demand, Population growth scenario for IMP14

It can be clearly seen that population growth is going to create water stress in the region if the current water supply is not altered. The unmet water demand with population growth scenario changes by 20-30 million litres as compared to the baseline scenario.The annual water demand and unmet demand for population growth scenario at 1.3 % for IWMP 15 are given in figures 6 to 7

Fig. 6 Demand for the scenario of population growth rate at 1.3 % per annum

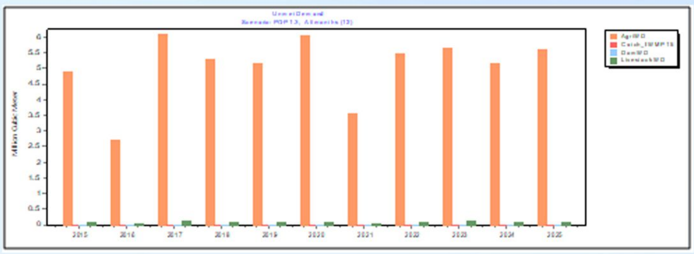


Fig. 7 Unmet demand for the scenario of population growth rate at 1.3 % per annum

It can be clearly seen that the domestic water demand is met even at the population growth rate at 1.3 % per annum. The unmet demand for agriculture varies from 2.7 Mm3 to 6.10 Mm3 for the period from 2015 to 2025. The unmet demand for livestock varies from 0.07 Mm3 to 0.13 Mm3 for the period from 2015 to 2025. The annual unmet water demand for 2 % growth rate in Groundwater recharge for IWMP 16 is given in figure 8. It can be seen that unmet demands for IWMP16 are expected to be very less by the year 2050.

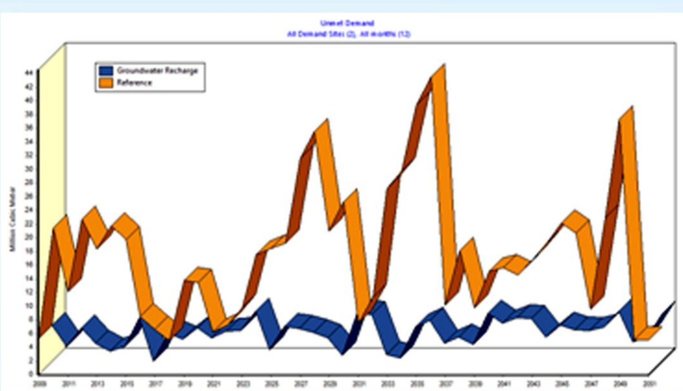


Fig. 8 Annual Variation in Unmet Water Demands (2009-2050) With 2% Growth Rate in Groundwater Recharge

6. Catchment scale evaluation of cold-arid cryospheric system Hydrology, Ganglass catchment, Ladakh

Cold-arid region of the Himalaya located beyond the Great Himalayan range is one of the three major hydrologic regimes of the Himalaya. Owing to the harsh climate and limited water resources, these areas are sparsely populated. Studies on the hydrology of these areas are also limited, due to the perceived limited contribution of these areas to the downstream discharge of major rivers. However, these limited water resources of the area are sustaining the livelihood of the local population with a unique and rich cultural heritage. Hence, gaining better knowledge of the system has become imperative for managing the scarce water resources of the region, especially under the manifestations of the changing climate.

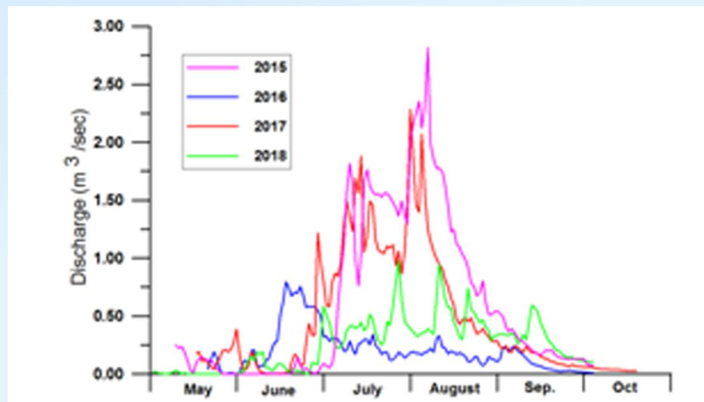
The low lands experiencing significant precipitation have limited significance of the mountain runoff while desert low lands almost completely dependent on the mountain water resources. This holds true for local mountain- valley system with drier valley bottom fed by the melt water from the cryospheric sources along the high mountain ranges. Therefore, cryospheric resources of the cold-arid region could acquire higher value as compared to the similar resources in the wet monsoon regions of the Himalaya.

Cold-arid regions of the country are part of the upper Indus basin having a glacier cover of about 29119 km2 constituting more than 75% of the Indian glacier reserve. Paradoxically, this region remains as water scarce and water stressed region owing to very little precipitation occurrence over the large part, especially along the valley bottom region. One of the key water resources management challenge in this region is caused by the topographical constraints.

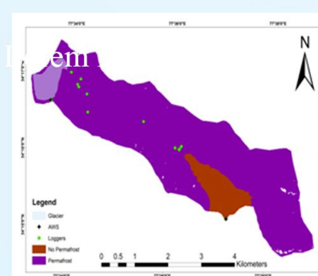
Hydrology of the cold arid region is characterised by its steep hydrological gradients supported by steep precipitation and temperature gradients. Runoff data during 2015 to 2018 period at 4700 m a.s.l. showed high inter-annual uncertainty of timing and amount of discharge from the cryosphere catchment. For three years, seasonal increase in runoff is observed after mid-June. Two of these years were wet years having high amount of snow in the catchment in the month of June which is followed by high discharge during July and August months. Overall, 2016 and 2018 experienced low snow in the catchment and 2015 and 2017 experienced high snow. On an average, low snow years recorded more than 50% less runoff as compared to high snow years. Some extraordinary years like in 2016, the total annual runoff is as low as 35% of the high snow year runoff. This inter- annual variability in runoff is manifested in the seasonal runoff variation as well. During high snow years July, August runoff constituted 90-82% of summer runoff while during low snow years this range between 45 to 70%. This imply that the discharge during May-June months are higher during low snow years. This shows that the uncertainty in water availability in the cod-arid system is very high than it counterparts in other cryospheric systems in the Himalaya. Water usage optimisation and developmental programmes in the region should consider this aspect of high inter-annual and seasonal runoff variability while designing the programmes. Persistent higher electrical conductivity in stream water during the low snow years suggest ground ice melt component in the stream flow. This suggest that permafrost could be a critical cryospheric component in the regional hydrology of the cold-arid system. Moreover, permafrost thaw has implications in disaster occurrence and infrastructure projects in the high elevation regions such as roads and bridges.

Considering the significance of permafrost, some maiden investigation permafrost is carried out. At 4700 m a.s.l. summer sub-zero conditions are not encountered at deeper layers (0.4 to 2.0 °C) suggesting no permafrost at this elevation. At 4900 m as.l. summer sub-zero conditions are modelled at 10 meter below the ground surface and estimated to be ranging from -10 to -0.2 °C and suggested to have permafrost. All the sites above this elevation have summer sub-zero soil and classified as permafrost areas. Spatial extent of permafrost in the study catchment is estimated using two statistical models and both show comparable permafrost extent in the catchment with a mean aerial extent of 14.7 km2 covering 95% of the catchment above 4700 m a.s.l. This suggest that the permafrost cover in the catchment could be ~ 22 times of the glacier area. The simulated active layer thickness (ALT) at the study sites above 4900 m a.s.l. ranges from 0.1 to 4.2 m.

The lower elevations have higher active layer thickness and identified to be the potential areas of ground ice melt component in the stream water. The estimated Mean Annual Air Temperature (MAAT) for probable permafrost locations range between -4.1 to -8.9 °C. This work proposes to extend the cryosphere boundaries of the cold-arid Himalaya to significantly lower elevations up to 4900 m a.s.l. for the first time by including the permafrost zone below the glacier area. Considering the comparatively large extend of permafrost areas in this region, further studies are required to establish the regional extend, characteristics and implications of permafrost in the Ladakh region.



Significant Inter-annual variations in water availability is the biggest stress factor in the cold-arid system water management.



Research team at 5600 m a.s.l. during the permafrost field campaign

Modelling exercise show around 95% of the Upper Ganglass catchment, Leh having permafrost underneath. The study established permafrost as a critical missing component in the cryospheric system studies in the Upper Indus basin.

7. Hydrological Processes and Characterization of Lesser Himalayan Catchments

The Himalayan basins are very critical to the water security of the northern Indian plains. Himalaya is also a data-sparse region leading to lack of in-depth understanding of the various physical processes. The scanty availability of hydro-meteorological database is further accelerating the complexity to understand the Himalayan hydrology and its interaction with other processes such as orographic forcing. Thorough understanding of the coupling between surface hydrologic systems and the overlying atmospheric systemunder orographic moisture flow is essential to address this question. NIH Roorkee established an experimental research station with state-of-the-art instrumentation with a long-term research framework, at the lesser Himalayan region to gain an understanding of these issues. This research station is aimed to produce baseline data of weather and hydrology of the lesser Himalayan mountains leading to a better understanding of climate-hydrology interaction under changing climate of the region. Since the Himalayan tributaries play an essential role in maintaining the hydrologic regime of the Ganges River; sustained research from this experimental station will help in managing the water resources of Himalayan tributaries of Ganges River under the climate change scenario. The proposed project deals mainly with the hydrological measurements and actual field experiments on one of the direct tributary of River Ganga, viz. Henval. The primary objective of the study is to develop a predictive understanding of the watershed and ecosystems respond to changes in climate and land use with the establishment of a hydro-climatic monitoring facility in lesser Himalayas. Estimation of evapotranspiration (ET) by different methods like RS/SEBAL, FAO56 and actual field measurements and the study of the various water balance components in the watershed were the other objectives of the project.

Henval is a small lesser Himalayan hilly watershed of Henvalriver up to Devnagar, Chamba (TehriGarhwal), Uttarakhand located in the vicinity of Tehri reservoir. The total area under study is 102 km2 approximately (26 km2 forested catchment and 76 km2 of main Henval) with an elevation range of 1000-2676 m. The forest is the principal land-cover feature of both the catchments. However, Henval catchment is having considerable coverage of agricultural and fallow land, which represent the more human interventions in the catchment. Henval is also a source of drinking water for 87 nearby villages. This stream is being pumped 24x7 by the state authorities at its outlet at Devnagar, Chamba, TehriGarhwal (UK).

Since 2015, a lot of instrumentation has been done at the Henval watershed under the project such as automatic weather stations, automatic water level recorder, soil monitoring stations, eddy covariance flux towers, etc. (Fig. 1). Discharge is an essential component and process of the hydrological cycle. One broad-crested rectangular weir has been constructed to measure the discharge at the outlet of Henval (Fig. 2).All the instrumentation envisaged towards establishing a classical hydro-meteorological field observatory in the Lesser Himalayan environment has been completed in this first phase of the Project-Henval. This first phase of the study was focused on monitoring evapotranspiration (ET) by using the latest available technology of eddy covariance tower and ET modelling for the lesser Himalayan region. The ET estimated using the energy balance method from the flux tower was compared with the ET estimated by using the other methods like Penman-Monteith equation, remote sensing/ SEBAL, and Pan. Remote sensing-based evapotranspiration estimation method Surface Energy Balance Algorithm for Land (SEBAL) is being tested for the experimental catchment.

Mapping Evapotranspiration at high Resolution with Internalized Calibration (METRIC) is a remote sensing-based model similar to SEBAL was also attempted for the Henval catchment. It estimates ET as a residual of the surface energy balance to produce ET information over a larger area of interest. One of the latest and direct measurement technique of ET, namely Eddy Covariance (EC) flux analysis was also carried out to estimate the actual ET.

The catchment response to the various hydro-climatic forcing within the lesser Himalayan catchment was evaluated by the water balance study done through the hydrological modelling using Soil and Water

Assessment Tool (SWAT) model. The modelling results show that the model is underestimating the flows; this may be attributed to the slow hydrological response of the catchment as well as fine-tuning of the model parameters. The results can be improved by incorporating the catchment specific data such as intensive soil parametrization. These need to be done in order to achieve better model efficacy. The main focus of the project was to establish a state-of-art field hydro-meteorological observatory and ET estimations with various empirical methods and actual field measurements. In the next phase, the main focus shall be on the hydrological modelling and studies of the interaction between the various observed variables.

Fig. 1. The Automatic Weather Station (AWS) installed at Henvalwatershed near Nagini Village and Kanataal Village, TehriGarhwal (Uttarakhand)

Fig. 2. Construction of compound rectangular weir and installation of AWLR over the Henval stream

8. NIH_Basin – A WINDOWS based model for water resource assessment in a river basin

In the recent past, a spatially distributed model was developed at NIH to assess various components of the hydrological cycle (actual evapo-transpiration, overland flow, groundwater recharge, and residual soil water content) in a river basin. The model incorporates spatial attributes of land-use, soil type, rainfall, evapo-transpiration, physiographic characteristics, cropping pattern, irrigation development, groundwater conditions, river network and hydraulic structures in a river basin. The objective of this study was to carry out a number of modifications in the model methodology and develop a WINDOWS interface (named as NIH_Basin – NIH_Basin-Simulation) for easy application by the user groups. Model limitations that have been addressed include: i) specification of EAC tables or corresponding relationships for various storage structures, ii) rule-curve based operation of reservoirs for analysis of different operation policies, iii) option of hydropower simulation in the basin, iv) continuous long-term simulation, and v) simplified representation of groundwater simulation.

The option of EAC specification for a reservoir has been added. For reservoirs with non-availability of EAC table, the approach suggested by J. Mohammadzadeh-Habiliet. al (2009) for approximating the EAC relationships has been incorporated. Rule-curve based approach has been added for simulating operation of reservoirs as per specified operation policy. The option of hydropower simulation has been added. Model now works in two modes: a) monthly mode (in which simulation is carried out at daily time step for a month and spatial recharge and discharge pattern are externally used to find revised water table in the basin using groundwater simulation model, say MODFLOW, and revised groundwater table is used for subsequent month), and b) continuous mode (in which the simulation is carried out at daily time step for the complete period for which hydro-meteorological data are available). In continuous mode, grid-wise pumping and recharge estimations are accumulated over each sub-basin for a month and then divided by the specific yield (Sy) of sub-basin to convert water withdrawal/recharge volume to change in groundwater level in the sub-basin. This avoids the necessity of detailed groundwater simulation at monthly interval which makes the analysis at basin scale too cumbersome. For each sub-basin, initial and intermittent average groundwater depth is computed from data of a large number of observation wells with irregular observations and a procedure, defined by DHI, Denmark during DSS (P) development under HP-II has been programmed and added as a module in the software.

In WINDOWS interface of the model, various data input forms have been developed. Four important modules of the software include: a) Database preparation, b) GIS analysis, c) Model execution, and d) Results. The "Database Preparation" module includes user-interactive forms for entry of general, attribute and temporal data of hydrological variables. In the "GIS Analysis" module, free domain GIS (ILWIS system) has been linked for creating and processing geo-spatial data. This module also contains provisions for converting raster data to ASCII format. In the "Model Execution" module, various sub-models are executed in order to simulate basin hydrology. In "Results" module, it is possible to view spatial and temporal hydrological results for different sub-basins, gauging sites, and hydraulic structures. The model study can help water resources departments and river basin authorities in analyzing the spatial and temporal water availability and demands for different purpose in the river basin. It can also help in assessing the impact of various natural and anthropogenic activities on various components of the hydrological cycle at basin scale. The model can also be used to: a) visualize effect of land use change, cropping pattern and water use efficiency change, climate change (in terms of rainfall distribution, temperature, humidity etc.), and population/industrial/irrigation growth on basin water resources, and b) analyze various management options like inter-basin transfer of water, development of new water resources projects etc.

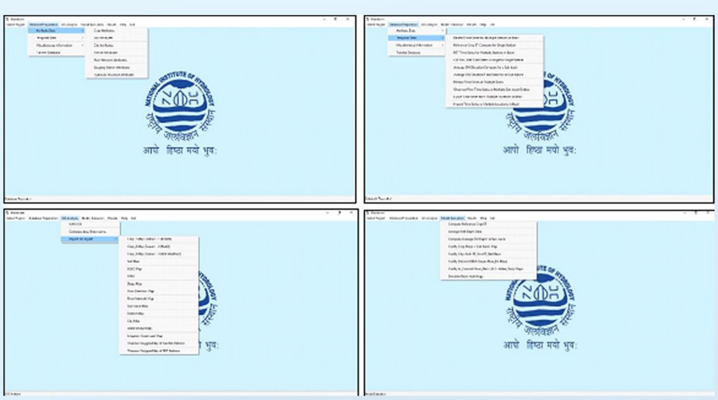


Figure – 1: Main working screen of NIH_Basin showing different attribute, temporal, GIS, & executable files

Outreach Activities-

Awareness campaign for water conservation continued even during the Corona period and made students aware of water conservation and its need Both in real and virtual mode.

The Research Management and Outreach Division has informed students about the importance of water conservation in two schools and a college. Apart from this, students were also introduced to Mascot Hydro. In this program, the Head of Division and Scientist, Dr. V.C. Goyal highlighted the need for water conservation to the students, history of water conservation, spiritual and economic importance of this subject and need of water conservation to secure our future. In this series of programs, Er. Omkar Singh Scientist F, Dr. A. R. Senthil Kumar Scientist F, Mr. Digambar Singh Scientist C, Delivered their respective lectures.

On 29th September, Webinar was organized on the subject of water conservation in Kendriya Vidyalaya No.1, Roorkee in which information was given about water conservation and addressee were made to students to be ready as a JAL YODHAAS for future.

बच्चों को जलयोद्धा के रूप में तैयार करें

वेबिनार

रुड़की | हमारे संवाददाता

Apart from this, every student was given guidance to always be ready to work collectively to revive the ponds in every village town.

In this sequence, awareness was given on the subject of water conservation on 12 November 2020 at Government Inter College, Roorkee with 55 students and as a part of awareness campaign the program is also repeated for Government High School, Sohalpur, Haridwar on 18 November 2020.

Visit of School Children at NIH Labs

Webinar: Water Security in the Himalayas

National Institute of Hydrology (NIH), Roorkee under the aegis of Indian National Committee for Intergovernmental Hydrological Programme (INC-IHP) had organized a webinar on 09 th September, 2020 on "Water Security in the Himalaya" covering various aspects like hydrology, snow, glaciers and permafrost, cloudbursts, conservation of springs, and vulnerability and water security. The convener of the webinar was Dr. V.C. Goyal, Scientist-'G', who is also the Member-Secretary of INC-IHP. The co-convener of the session was Dr. Renoj J. Thayyen, Scientist- 'E' of NIH. The webinar was broadcasted through Cisco Webex platform as well as Facebook live at NIH and at Department of WR,RD&GR, Mnistry of Jal Shakti, Government of India. It was joined by nearly 1,100 enthusiasts

At the outset of the webinar, a short film entitled "Save Himalaya to Save Our Future" was featured. The film was about 10 minute's duration and was produced by the RMO Division of NIH. first presentation of the webinar, Dr. Sanjay Kumar Jain talked about "Snow, Glacier and GLOF studies in the Himalaya". The second presentation of the webinar was delivered by Dr. M.K. Goel on the topic "Hydrology of Upper Ganga basin (UGB) in climate change perspective".The third and important presentation of this webinar was delivered by Dr. Renoj J. Thayyen on the topic "Emerging insights on cloudbursts and permafrost in the IHR". Subsequently, Dr. Soban Singh Rawat discussed the topic "Springs Conservation for Water Security in the Western Himalaya". The second last lecture of the webinar was delivered by Dr. P.K. Mishra on the topic "Vulnerability Assessment in the Upper Ganga basin".The last and important presentation of this webinar was delivered by Dr. V.C. Goyal on the topic "Water Security and Environmental Carrying Capacity in the Himalaya". He started his presentation with the slide showing issues related to water security in India as described in National Water Policy.

Training courses/Workshop/Conference attended by Scientist/ Scientific Staff during Jan– Dec., 2020

S.No.	Name of Course	Period	Organised by
1.	Drafting in Disciplinary Matters	Jan. 6-7, 2020	ISTM, New Delhi
2.	Data to Decisions: Big Data Analytics for Water, Environment and Natural Resources Management	Jan.6-10, 2020	Water Resource Department, Govt. of Gujarat
3.	Roadmap for Mission to Action with Climate Integration: Jal-Jivan-Hariyali	Feb. 14, 2020	AranyaBhavan, Patna
4.	Training on Hydrometry techniques using non-contact measurement under National Hydrology Project (NHP)	Feb. 17-21, 2020	IIT, Roorkee
5.	Weekly Webinar Series “Water Challenges during and post COVID-19”	May 7-28, 2020	International Centre for Clean Water (IICW) and IIT, Chennai
6.	Webinar on ‘Look beyond what you can with IR imaging’	May 8, 2020	Perkin Elmer
7.	Participated in National Webinar on “Natural Resources and their management strategies in post corona period-Global and National Challenges”,	May 8, 2020	SAIT, Indore
8.	e-learning training course on Advance technologies in water and waste water management	May 18-19, 2020	Water Digest
9.	Attended a Webinar on ‘Self-Reliant India: Aspirations & Opportunities’	May 24, 2020	Alumni Association of JNU
10.	Attended a Panel Discussion webhosted by Water Digest with the theme, “Water Post Covid-Paving a Future and Protecting the Resource”	May 27, 2020	Hon. Minister & Secretary, Ministry of Jal Shakti
11.	Hands on Virtual Training on Water Budgeting in Google Earth Engine (GEE)!	June 24 – July 1, 2020	World Bank
12.	Online e-office training	June 24-25, 2020	NIC, Centre, New Delhi at NIH, Roorkee
13.	Online training programme titled “Groundwater modelling using visual MODFLOW” under NHP	July 6-10, 2020	NIH, Roorkee
14.	Virtual training course on “Hydrological Modelling using HEC-RAS and HEC-HMS” under NHP	July 13-17, 2020	NIH, Roorkee
15.	Attended online “STATCRAFT demonstration”	July 13, 2020	NIH, Roorkee
16.	Training Workshop (Webinar) on the topic “Applications of Image processing”	July 14-18, 2020	St.Joesph’s College of Engineering, Chennai, Tamilnadu
17.	Attended webinar on ‘Water Future and Cities’	July 15, 2020	UNESCO-NIUA-NamamiGange
18.	Attended webinar HALMA – A Jan Andolan:	July 17, 2020	NWM

	Fighting water crisis through local traditions as part of 15th Water Talk		
19.	Online training programme on 'Rainwater Harvesting and Management'	July 14-18, 2020	TERI School of Advanced Studies, New Delhi
20.	Webinar on "Cloudburst and Flood"	July 21, 2020	NIDM in collaboration with IMD
21.	Webinar on '3Rs of Water Conservation – Reduce, Reuse and Recycle'	July 22, 2020	FICCI in association with National Water Mission, DoWR, RD & GR, Ministry of Jal Shakti
22.	Webinar session on GeoHECRAS software	July 31, 2020	Trinetrix Technologies Private Limited
23.	Online training course on RS Applications in Agricultural Water Management	August 03-07, 2020	Indian Institute of Remote Sensing (ISRO) Dehradun
24.	Webinar on Part 1- Introduction to SAR Data	Aug.4, 2020	NASA EOSDIS Communications Team
25.	Online Training Programme on "Climate Change, Landslides and Safe Hill Area Development"	Aug. 5–7, 2020	NIDM in collaboration with DrRaghunandan Singh ToliaUttarakhand Academy of Administration, Nainital, Uttarakhand
26.	Webinar on Part 2- Applications of SAR Data in GIS Environments	Aug. 06, 2020	NASA EOSDIS Communications Team
27.	National Web- Conference on 'Technological Approaches for Resource Conservation and Management for Environmental Sustainability' (TARCMES)	August 16 & 17, 2020	ANRCM, Lucknow
28.	Purpose oriented training through distance learning on "project hydrology"	Aug. 17-28, 2020	National Water Academy & Regional Training Centre of WMO, Pune
29.	Training program on Purpose Oriented Training Through Distance Learning On Project Hydrology	Aug. 17-28, 2020	NWA Pune
30.	Training programme on Design flood estimation for gauged and ungauged catchment	Aug. 17–21, 2020	IIT Roorkee
31.	16th Water Talk on 'Each One Jal Rakshak –	Aug. 21, 2020	National Water

	Care for Water, Work for water and be like water'		Mission (MoWR, RD&GR), New Delhi
32.	Webinar during World Water Week on "Facing the climate emergency: effectively leveraging science, governance and diplomacy" as virtual session during World Water Week 2020 theme: "Water and Climate Change: Accelerating Action" at Sweden	Aug 24, 2020	IUCN SIDA, GWH, GEF
33.	Webinar during World Water Week on "The Internet of Water – Intelligent Water Management System" as virtual session during World Water Week 2020 theme: "Water and Climate Change: Accelerating Action" at Sweden	Aug 25, 2020	Antea Group, Enable, Join for Water, Internet of Water Flanders and SIDA
34.	Webinar on "Institutional Digital Repository of publications output of National Institute of Hydrology	Aug. 27, 2020	NIH, Roorkee
35.	नरकासहरिद्वारद्वाराआयोजितई-हिन्दीकार्यशालामेप्रतिभागी	Sept. 15, 2020	नरकासहरिद्वार
36.	Webinar of expert lectures on Global Water Security	Sept. 10, 2020	Working group of International Association of Hydraulics Research
37.	Training program (virtual mode) on "Hydrological Modelling using SWAT"	Sept. 21-25, 2020	NIH Roorkee
38.	online training course on "Certified Peer Reviewer Course"	Sept. 29, 2020	organised and evaluated by Elsevier
39.	Training session on India-WRIS	Sept. 18, 2020	organised by NHP
40.	Online Training Programme "Climate change: Challenges and Response (CCCR)' for Woman Scientist	Oct. 5-9, 2020	Lal Bhadur Shastri National academy of Administration, Mussoorie.
41.	Online Training Course titled "Data Processing for Water Quality"	Oct. 5-9, 2020	NIH Roorkee
42.	Webinar on "Improving Research Integrity: Managing and Sharing Research Data"	Oct. 6, 2020	John Wiley and Sons
43.	Online Training Programme on "Urban Water Management"	Oct 08-09, 2020.	Water Digest, Gurgoan
44.	Training workshop on MIKE Hydro Basin Training under DSS(PM)	Oct. 12-16, 2020	NIH, Belgavi
45.	Training on "Application of Water Accounting Plus (WA+) Tool for Water Resources Management" under NHP	Oct.16-20, 2020	NIH Roorkee
46.	Hydrological modelling using HEC-HMS and HEC-RAS under NHP	Oct 19-23, 2020	NIH Roorkee
47.	Webinar on "The Research Grant Applications Guide"	Oct. 22, 2020	John Wiley and Sons
48.	Online training course on "Data Science with Python"	Nov. 4-22, 2020	National Innovation

49.	Application of Water Accounting Plus (WA +) Tool for Water Resources Management	Nov.16-20, 2020	NIH Roorkee
50.	Web seminar on "Early Warning and Communication	Nov.17, 2020	NIDM, New Delhi
51.	Online Training Programme on "Basic Training on Disaster Management"	Nov. 18-20, 2020	NIDM in collaboration with ONGC, IPSHEM, Goa
52.	Webinar on "Importance of 2D cell size for accurate hydraulic modelling".	Nov.18, 2020	Australian Water School
53.	Webinar on "A Clinician's Perspective: Collaboration in Research and its Impact"	Nov.24, 2020	John Wiley and Sons

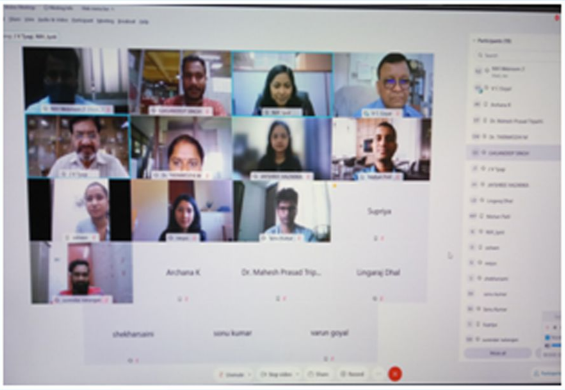
Training Course/ Workshop organised during Jan. –Dec., 2020

SN	ACTIVITIES	PERIOD	VENUE
1.	Training Course on "Hydrodynamic Modelling of a River System"	Jan. 6-8, 2020	Jalandhar
2.	Training Course on "Advance Hydrology" under NHP	Jan. 6-10, 2020	SIHFW, Jaipur (Rajasthan)
3.	Training Course on DGPS for students from Department of Civil Engg., GLA University, Mathura (UP)	Jan. 20-23, 2020	NIH, Roorkee
4.	Brainstorming Session on Hydrologic Modelling for Water Resources Management. Under the ongoing UKCEH Project	Jan. 30, 2020	PICU, WALMI, Bhopal
5.	International Webinar on Sunderbans-The case of Water, Water Everywhere But Not A Drop to Drink'?	Feb. 4, 2020	NIH, Roorkee
6.	Training Course on "Hydrology for Water and Sanitation Programmes" for engineers of PHED, Rajasthan	Feb. 11-14, 2020	NIH, Roorkee
7.	One Day Workshop on "Impact of Untreated Sewage water on Shallow groundwater Quality and its Remedies", organised at DRC, Kakinada	Feb. 20, 2020	Kakinada
8.	Hydrology and Water Resources Management of Cascade of Tanks System Under Climatic Uncertainty (For officers of Dept. Of Irrigation and Dept. of Agrarian Development, Sri Lanka	Feb. 17-21, 2020	New Delhi
9.	Seminar on "Application of Climate Change Science in Water Resource Management in Western Canada"	Feb. 24, 2020	NIH, Roorkee
10.	Seminar on "Sediment and water quality modeling with HYPE: a journey around the world."	Feb. 25, 2020	NIH, Roorkee
11.	International conference 'Roorkee Water Conclave' on "Hydrological Aspects of Climate Change", jointly organized with Indian Institute of Hydrology (IIT)	Feb. 26–28, 2020	NIH, Roorkee
12.	Training Course on "Hydrological Modelling Using HEC RAS and HEC-HMS" under NHP	Mar. 2-6, 2020	Hyderabad
13.	Training course on 'Machine Learning for Remote Sensing Data Classification'	June 1, 2020	Conducted by IIRS, Dehradun

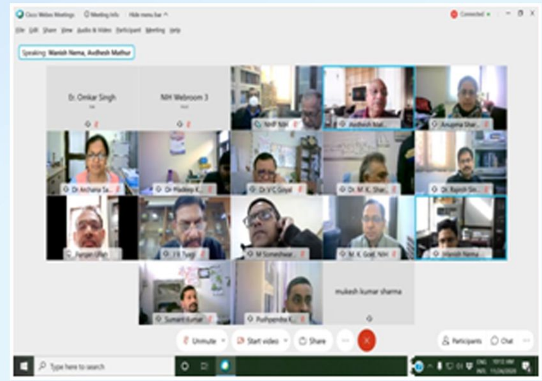
14.	Training course on 'GW Modelling using Visual MODFLOW' under NHP	July 6-10, 2020	NIH, Roorkee
15.	Training course on 'Hydrological Modelling Using HEC HMS and HEC RAS' under NHP	July 13-17, 2020	NIH, Roorkee In VC mode
16.	Workshop on DSS (PM) under NHP	Aug.24, 2020	NIH, Roorkee
17.	Training Programme on "Remote Sensing Application in Agricultural Water Management"	Aug. 3-7, 2020	Conducted by IIRS, Dehradun
18.	Online Training Programme on "Hydrological Modeling using SWAT"	Aug. 21-25, 2020	NIH, Roorkee
19.	Webinar on "Hydrology of Upper Ganga basin in climate change perspective" organized on the occasion of Himalaya Day	Sept.9, 2020	NIH, Roorkee and IHP of UNESCO
20.	Online Training Programme on "Understanding of Coastal ocean processes using RS and Numerical Modeling"	Sept. 21-25, 2020	IIRS Dehradun
21.	Online Google Earth Engine Workshop	Sept. 18, 2020	NIH Roorkee
22.	Online DSS(PM) workshop	Sept. 25, 2020	NIH Roorkee
23.	5-day Online Training Course titled "Data Processing for Water Quality"	Oct. 5-9, 2020	NIH, Roorkee
24.	Online Hydroinformatics Workshop under NHP	Oct 9, 2020	NIH Roorkee
25.	Online Training on "Mike Hydro Basin" under NHP	Oct.12-16, 2020	NIH Roorkee
26.	Training on 'Hydrological &Hydroclimatic Modelling using HEC-HMS & HEC-RAS'	Oct. 19-23, 2020	RC, Bhopal
27.	Conducting of Mandatory Level-II training for Senior Research Assistants (SRAs) of CWC	Oct.19-22, 2020	NIH Roorkee
28.	Online Training on "Hydrological Modelling Using HEC-HMS and HEC-RAS" under NHP	Oct. 19-23, 2020	NIH Roorkee
29.	Online Training on Automation Script of GEE and GIS under NHP	Oct 21, 2020	NIH Roorkee
30.	Online Workshop/Meeting on "DSS(PM)" under NHP	Oct. 29, 2020	NIH Roorkee
31.	Virtual Training course on "Water security for resilience to deal with disasters and outbreaks"	Nov.2-6, 2020	NIH, Roorkee
32.	Online Training Course titled "Data Processing for Water Quality" (Phase II)	Nov.2-6, 2020	NIH, Roorkee
33.	"Application of Water Accounting Plus (WA+) Tool for Water Resources Management" under NH	Nov.16-21, 2020	NIH Roorkee
34.	Online Training Course on 'Assessment of Reservoir Sedimentation Usin Geo-Spatial Technique and QGIS" under NHP	Nov.19-20, 2020	DRC, Kakinada
35.	Online Training Programme on 'Advanced Hydrology' under NHP	Nov.23-27, 2020	NIH Roorkee

Training course on 'Hydrology & Water Resources Management of Cascade of Tanks System under Climatic Uncertainty during Feb.17-21, 2020 at New Delhi

Project meeting 'Sustaining Himalayan Water Resources in a changing Climate (SusHi-Wat) during Feb.24-25, NIH, Roorkeea



Training course on "Water security for resilience to deal with disasters and outbreaks" 02-06 Nov., 2020 under INC-IHP.



2nd ISO Surveillance Audit Nov.24, 2020

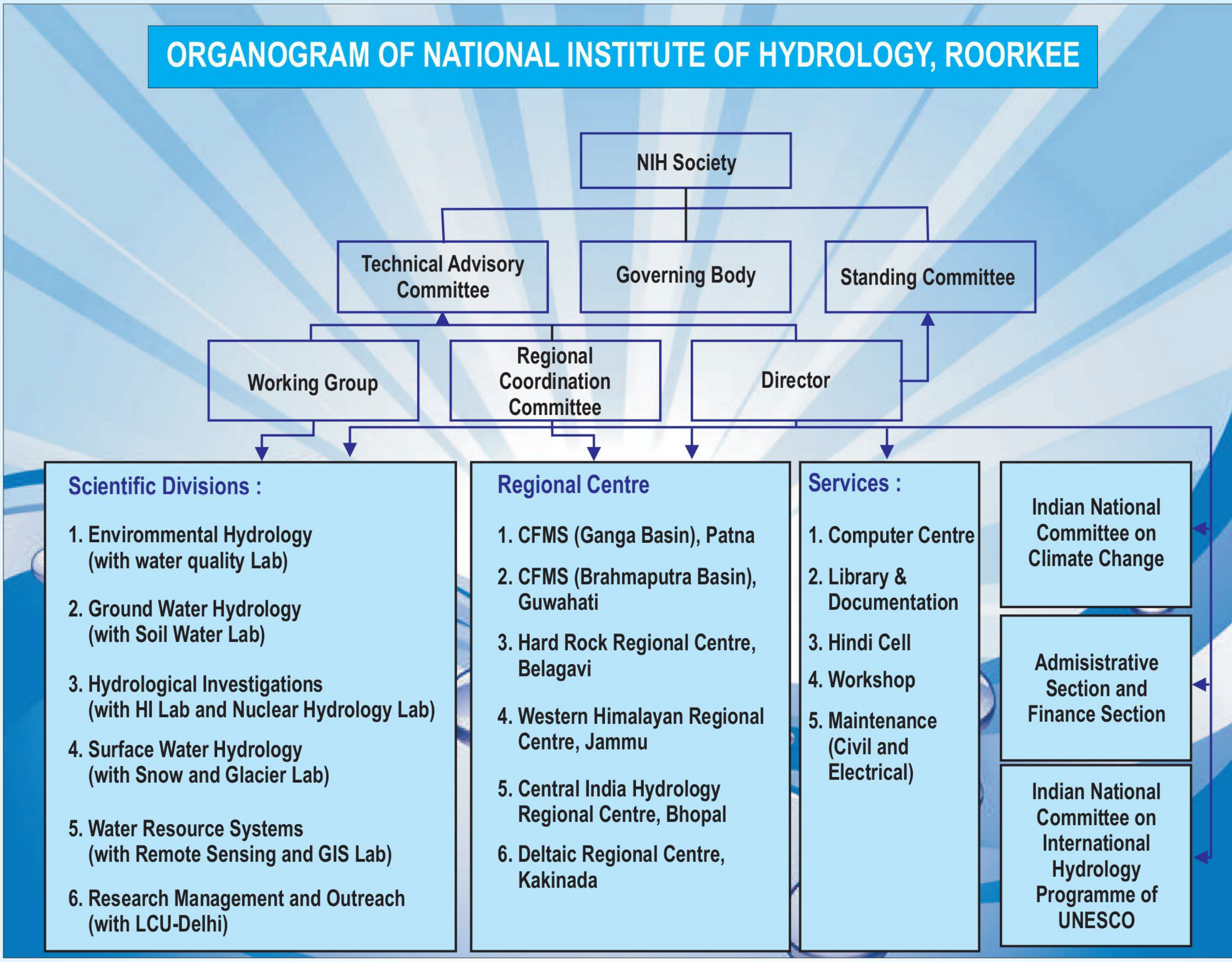
Visit of Secretary Sh. U.P. Singh, Ministry of Jal Shakti, DoWR, RD & GR at NIH, Roorkee

Well said about water

Water is life and clean water means health.	Audrey Hepburn
Water is the driving force of all nature.	Leonardo da Vinci
Water used to be fresh, pure and drinkable, now the water has lots of focal matter and bacteria.	Claudine Sierra
In one drop of water are found all the secrets of all the oceans.	Khalil Gibran

Hindi Glossary for Hydrological terms

Actual Evapotranspiration	वास्तविक वाष्पोत्सर्जन	Cloud Seeding	मेघ बीजन	Float Gauge	प्लवप्र मापी
Antecedent Precipitation Index	पूर्ववर्ती वर्षण सूचकांक	Compound Hydrograph	संयुक्त जलालेख	Geyser	उष्णोत्स
Basin Recharge	जल संग्रह क्षेत्र पुनःपूरण	Detention Storage	अवरोध संचयन	Initial Abstraction	प्रारम्भिक अपाहरण
Channel Routing	वाहिका अभिगमन	Deterministic	निधारणात्मक पध्दति	Percolation	अंतःस्रवण



Editor
Dr V C Goyal, Head, Research Management & Outreach Division
Assistance by
Sri Rajesh Agrawal, SRA & Varun Goyal RP(S)

We Will Appreciate Your Guest Articles!
You can share your knowledge with others on topics highlighting 'water resources for community benefits' by contributing an article to the Guest Article Column.
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