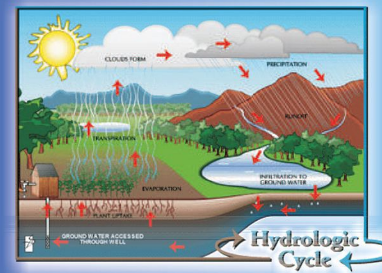
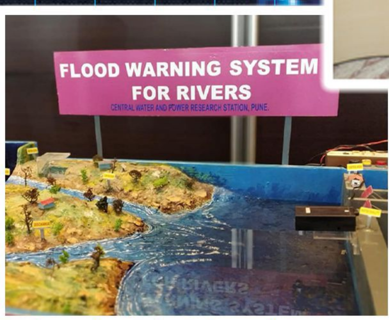
Issue No: 19 June, 2021

Hydrology for People™

जन साधारण के लिए जलविज्ञान अंक–19



Newsletter of National Institute of Hydrology, Roorkee (India)
राष्ट्रीय जलविज्ञान संस्थान रूड़की द्वारा प्रकाशित समाचार पत्र



From Director's Desk

From Director's Desk

In view of increase in population, urbanization and industrialization, the demand for water for meeting various requirements is increasing day by day. Sustainable development and management of water resources is one of the most challenging tasks to ensure adequate water for our present and future generations.

Traditionally, a river is regarded as the mother in our country because of its life giving and life sustaining capabilities. Over the years with the sustained efforts of our engineers, scientists, administrators, and planners, utilization of country's water resources has significantly improved. Construction of dams, canals, and irrigation systems has brought water to many of those areas where agriculture has been dependent only on the vagaries of rainfall. This has made it possible to raise two or more crops in a year; thus improving food production and self-sufficiency. In spite of the best efforts, still we are facing several difficulties in water sector. The per capita water availability is decreasing, ground water table is declining in certain areas and the problems of seawater intrusion are being faced in some of the coastal areas. The quality of surface and groundwater resources is also deteriorating because of increasing pollutant loads from various sources. There are numerous reports about the possible effects of climate change on water resources, particularly in respect of snowmelt and glacier melt.

The high variability in spatial and temporal distribution of rainfall is another reason for uneven availability of water resources in our country. In fact, some parts of the country face threat of drought, not necessarily due to deficiency of rainfall, but many times due to its uneven distribution. On the other hand, many parts of the country face the problem of floods. During recent years the number and scale of water related disasters, particularly floods and droughts have been increasing. These problems are further expected to aggravate with the phenomena of climate change. Therefore, mitigation and management of flood and drought have become a priority for saving lives of the people, alleviating poverty, ensuring socio economic progress, preserving our eco-systems and sustainable development.

I feel that sustainable development and efficient management of water resources is the key for economic growth and poverty alleviation. Suitable water harvesting measures and recharge of ground water, conjunctive use of surface and groundwater, cleaning and rejuvenation of rivers and other water bodies, recycling and reuse of waste water, water conservation at household level, enhancement of water use efficiency etc. are some of the possible solutions, which are required to be put in practice to alleviate water crisis.

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.

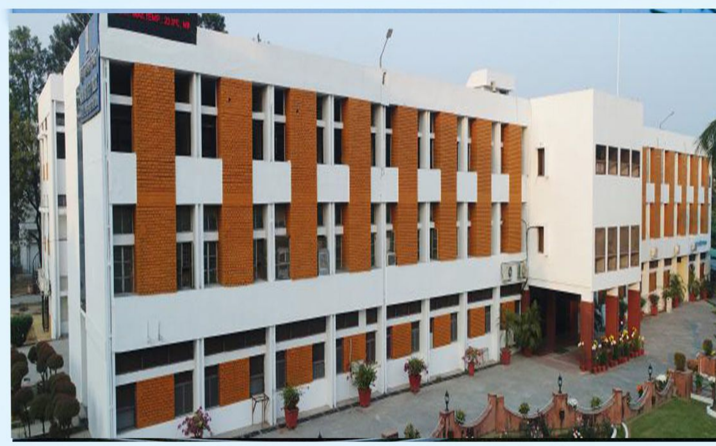
The Institute acts as a centre of excellence for the transfer of technology, human resources development and institutional development in specialized areas of hydrology, and conducts user defined, demand-driven research through collaboration with relevant national and international organizations.

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 International 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. 'Basin Futures: Case study of Maner River Basin'

Basin Futures is an entry-level modeling tool that aims to support rapid and exploratory basin planning globally. It is developed by CSIRO, Australia and, the developers provided training for using this tool during April 2019 at ICID, New Delhi. Basin Futures is a lightweight cloud-based platform that brings together global and local datasets to support water planning. The system is designed to make large datasets accessible, make data analysis efficient, and empower decision-makers to understand their opportunities and constraints in managing their water resources. During the training program at ICID, Maner river basin was selected as a study area, are the right bank tributary of the Godavari, the largest of the peninsular rivers, and the third-largest in India. The basin lies in the Deccan plateau. The average annual rainfall of Maner is 932mm (CWC, 2017). The gauge-Discharge site of Maner basin is at Somanpalli, District-Karimnagar, State-Telangana (Fig. 1). The Manair River was highlighted in the news as 'Garbage polluting Manair river, as the shores are being polluted by dumping garbage generated from the town and other sources. Considering the situation in the river basin, four scenarios were set to study the impact on the water balance of basin, viz., 1. Ensuring environmental flow (EEF) in the basin, 2. Increase in irrigation potential (IIP) (incorporating proposed dam), 3. Impact of climate change (ICC) and 4. Population change scenario (PC).

The rainfall dataset from IMD and Global PET dataset were used while setting up Maner basin model in Basin Futures. The basin includes major irrigation projects like Lower Manair Dam (24.07TMC) and medium irrigation project-Upper Manair Dam (3.020TMC), while Mid Manair (20TMC) is under construction. Considering this, the basin was divided into three reaches as Upper Maner, Mid Maner, and Lower Maner (Fig.1). As per baseline results, the Bluewater scarcity index of the basin is of low stress (Fig. 2). The runoff contribution is highest from the lower reach of the basin (Fig. 2). The mean annual outflow was lower in the scenarios of ensuring environmental flow and an outflow was lower in the scenarios of ensuring environmental flow and an increase in irrigation potential. While the outflow was more in the case of population change scenario which may be due to an increase in the urban area. The demands of mean annual evapotranspiration remained the same for all scenarios.

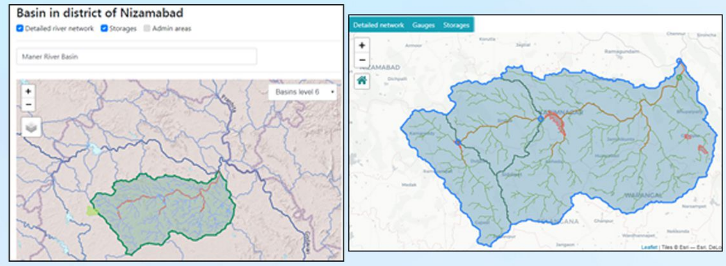


Fig. 1 Location of Maner river basin and model setup in Basin future

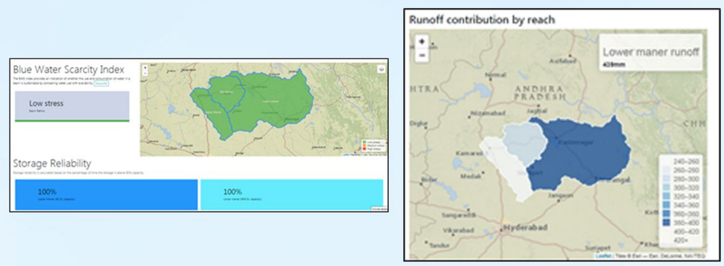


Fig. 2 Bluewater scarcity Index and runoff contribution of reaches in Maner basin

Parameter	Baseline result	Ensuring environmental flow in the basin	Increase in irrigation potential	Impact of climate change	Population change (PC)
Mean annual outflow (GL)	4379	4355	4339	4379	4433
Mean annual ET (mm)	1781	1781	1781	1781	1781

2. Assessment of Vulnerability to Climate Change in Chhattisgarh

Climate-induced variability intensifies the vulnerability of the rural areas and limits the household's ability to deal and cope up with risks, shocks, and stresses. Vulnerability assessment is, therefore, considered a useful tool for planning climate change adaptation and risk management strategies in water-challenged areas. In this study, two Livelihood Vulnerability index approaches were adopted – the composite index approach and the IPCC approach. The two approaches have been tailored as per the local factors of vulnerability and the assessment is used in suggesting water resources planning. Utilizing the methodology of LVI-IPCC assessment, vulnerable blocks of Jashpur and Kanker districts were identified while, a composite index approach was used to assess the vulnerable village of IWMP-14, IWMP-15, and IWMP-16 of Kanker district. The study area is shown in Fig.1. The block and village level classification was used to assess the vulnerability of people, livelihood, and ecosystem to climate change, using primary and secondary data, to identify highly vulnerable block/villages. The LVI–IPCC approach was used to reflect the vulnerability based on 43 environmental and socio-economic sub-indicators, through IPCC-identified components: exposure, sensitivity, and adaptive capacity. It was found that Manora block of Jashpur district and Antagarh block of Kanker district were the most vulnerable among the blocks under assessment (Fig.1).

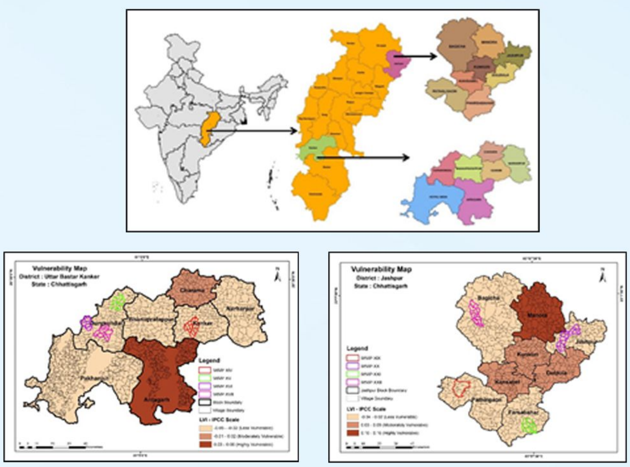
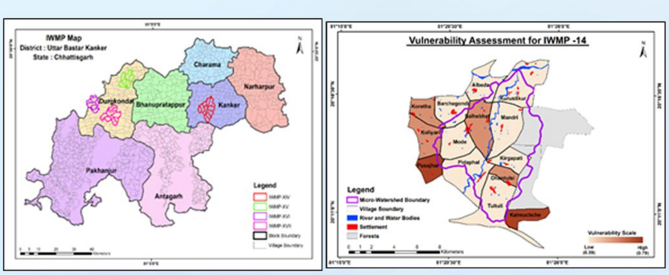


Fig. 1 Block-wise vulnerability assessment results in Kanker and Jashpur districts.

Also, it was observed that Kalmuchche (IWMP-14), Gudphel (IWMP-15), and Otekatta (IWMP-16) (Fig. 2) were most vulnerable to future climate change. The findings helped in suggesting sector-specific as well as overall drought management and adaptation strategies to cope up with climate change.



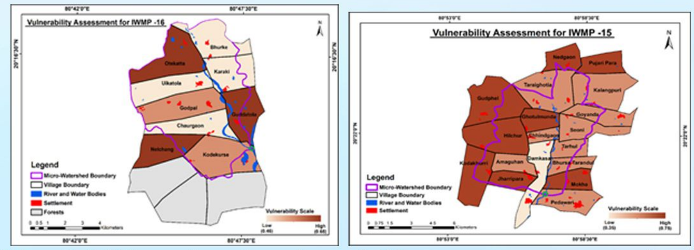


Fig. 2 Village level vulnerability assessment results in IWMP-14, IWMP-15 and IWMP-16 of Kanker district.

3. Environmental Assessment of Aquatic Ecosystem of Upper Ganga Basin

The objectives of this study included i) To study ecology, biodiversity and water quality of Upper Ganga Basin ii) To study in-stream reactions and sediment dynamics of Upper Ganga Basin iii) To assess environmental flows in critical stretches of River Ganga. To meet these objectives, monthly regular monitoring at 15 sites of Upper Ganga Basin was carried out for water quality assessment and selected eight zones were monitored on quarterly basis for aquatic biodiversity assessment. The findings of the study revealed that

i) All analysed water quality parameters are well within permissible limits of river water quality, except COD and TSS. COD is high at lower reaches of River Ganga (below 1200 m) which may be attributed to anthropogenic pollution. TSS is high at all the locations and decreases from higher elevation to lower elevation because sediments get deposited due to geomorphology of the river. Carbonate weathering is a major source of dissolved ions in the surface water of the study area and hydro-chemistry is also controlled by dissolution of rock forming minerals. Dissolved metal concentrations of Fe, Mn, Cu, Cr, Ni, Zn, Pb, and Cd in water samples of Upper Ganga Basin are well within acceptable limit of river water, except dissolved iron.

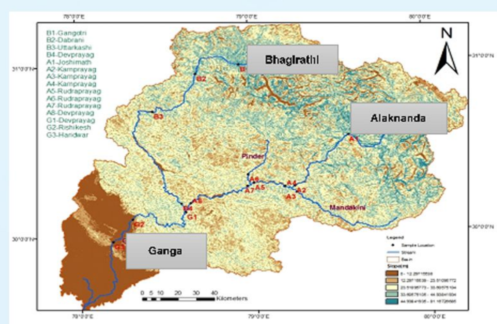
ii) Chemical mass balance approach accounts >30-50% contribution for almost all constituents from uncharacterised sources (NPS) in the stretch of River Alaknanda of Upper Ganga System during the months of November to February, which may be attributed to intense agricultural activities during the winter months particularly cereals and vegetables along with the runoff due to winter rains/ snowmelt coming from the landscape.

iii) The sediments existing at the bottom of water column play a major role in pollution scheme of the river systems. Sediment concentrations provide a better evaluation of the degree and the extent of contamination in the aquatic environment. Higher ranges of iron followed by copper and manganese in the bed sediment of the study area are observed which might have principally originated from lithogenic sources and traces from anthropogenic sources. Enrichment Factor value was calculated for different metals and highest was observed for Mn, followed by Cu, Cr, Ni, Pb, Cd and Zn, which illustrates that all these elements vary from unpolluted to very smaller enrichmnent. The general trend for relative mobility is observed to be Fe>Mn>Cu>Cd>Pb>Cr>Ni>Zn.

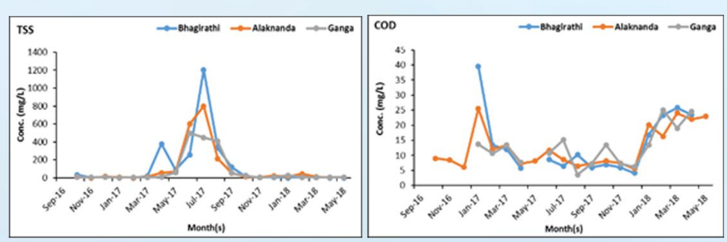
iv) The adsorption of metal ions on sediments plays an important role in controlling metal pollution. The pH is the most important parameter in controlling metal ion adsorption. The adsorption of metal ions increases with increasing adsorbent doses and decreases with adsorbent particle size. The Kinetic data suggest that the adsorption of metal ions on bed sediments is an endothermic process, which is spontaneous at low temperature. Adsorption of lead is higher as compared to cadmium and nickel on the both size fractions of bed sediments of river Bhagirathi, Alaknanda and Ganga.

v) Most common biotic species in the Upper Ganga Basin are phytoplanktons, zooplanktons, macro-benthos and fishes. Phytoplanktons are decreasing towards lower elevations while zooplanktons and macro-benthos are increasing at lower elevations.Drastic change observed in biotic community in all the observed three seasons. Winter and early summer seasons favour better growth of Biotic species. Biodiversity Indices indicate that status of diversity varies from medium to maximum and river water is clean to slightly polluted. Higher BOD observed during summer season in upper Ganga basin due to high temperature that favours microbial activity. Physico-chemical parameters concentration of water showed that river water was under good quality condition i.e. good for aquatic biodiversity growth and survival. The keystone species for upper (>1500m), middle (500-1500m) and lower (<500m) zones are Brown Trout, Snow Trout and Golden Mahseer respectively.

vi) The habitat suitability curves for the keystone species were developed which may be used for the habitat simulation modelling with more detailed data. The final modelling output of the habitat simulation modelling is the Area Weighted Suitability (m2/m of reach length) which indicates the suitability of a particular discharge for the habitat sustenance. Based on the variability of AWS for the historical flow variability, AWS duration analysis may be carried out in the SEFA software which may further be used for selecting a particular level of AWS for providing reasonable habitat for different seasons. 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 21.30 to 27.91% of average monthly flows at Uttarkashi, from 21.47 to 29.71% of average monthly flows at Devprayag site on Bhagirathi river, 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.



Map showing sampling sites for Water Quality Assessment



Temporal variation of TSS and COD in the water of river Bhagirathi, river Alaknanda and river Ganga

Water Quality Analysis in the laboratory

Water Qulaity Montoring in the field

4. Groundwater Quality Assessment with Special Reference to Sulphate Contamination in Bemetara District, Chhattisgarh and Suggesting Ameliorative Measures”

Groundwater is one of the most important sources for drinking water supply in the state of Chhattisagrh. The groundwater of Bemetara district is affected by sulphate contamination reported by Public Health Engineering Department, Durg. A purpose driven study titled “Groundwater quality assessment with special reference to sulphate contamination in Bemetara district, Chhattisgarh and suggesting ameliorative measures” was awarded in collaboration with Water Resources Department (WRD), Raipur, Govt. of Chhattisgarh and Central ground Water Board, NCCR, Raipur under National Hydrology Project for a period of 3 years duration in September 2017 with the objectives to evaluate the qroundwater quality and to identify the degraded ground water quality zones and possible sources of pollution and identify specific parameters not conforming to drinking/ & irrigation water quality standards, to investigate the important geochemical processes responsible for the groundwater contamination and to suggest ameliorative measures to restore the quality and sustainable use of groundwater for drinking/ & irrigation purpose by using Flow and Transport and investigating the hydro-geology of the area.. Collaborating agency WRD, Raipur suggested to focus on Maniyari shell formation region to track the problem in real sense. Therefore, study area is extended from district Bemetara to Maniyari shell formation region.

Findings:

(i) Seventy two ground water samples were collected each during pre- and post-monsoon easons in the year 2018-19 and 2019-20 and analysed for various physico-chemical parameters and heavy metals concentrations. Spatial distribution maps were prepared to identify degraded water quality zones, possible sources of pollution and specific parameters not conforming to drinking/ & irrigation water quality standards.

(ii) The hydro-chemical data was analyzed with reference to BIS and WHO standards, ionic relationships were studied, hydrochemical facies were determined and water types identified.

(iii) BIS Standards for drinking water have been violated for physico-chemical parameters viz; TDS, Total hardness, Calcium, Magnesium, Sulphate and Nitrate and metal concentrations viz; Fe, Mn, Pb, Cd and As by the groundwater of few locations of the study area. The quality of the ground water varies from place to place with the depth of water table.

(iv) The suitability of ground water for irrigation purpose has been evaluated based on salinity, Sodium Adsorption Ration (SAR) and Residual Sodium Carbonate (RSC) and found to be fit for irrigation.

(v) An attempt has also been made to classify the ground water on the basis of different classification schemes, viz., Piper trilinear diagram, Chadha’s diagram, U.S. Salinity Laboratory. Majority of the samples of the study area belong to Ca-Mg-Cl-SO_4 or Ca-Mg-CO_3-HCO_3 hydrochemical facies and fall under water types C3-S1 followed by C2-S1. The C3-S1 type water (high salinity and low SAR) cannot be used on soils with restricted drainage.

(vi) Hydrochemistry of groundwater of the study area is controlled by precipitation induced chemical weathering along with dissolution of rock forming minerals. Carbonate weathering is a major source of dissolved ions in the groundwater of the study area. Reverse ion exchange process controls the chemistry of groundwater of the region.

(vii) The source of sulphate in the groundwater of the study area may be $CaSO_4$ i.e. Gypsum as evident from relationship between Ca and SO_4 ($r^2 > 0.8$), present in shell formations.

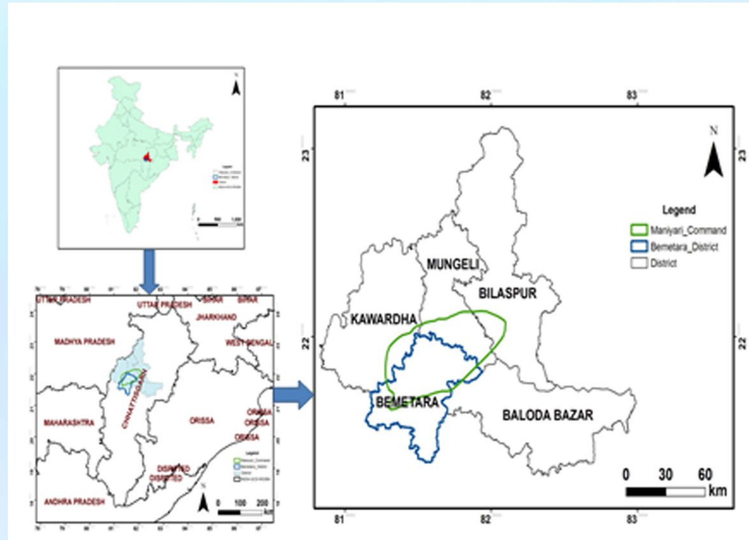
(viii) Most of the ground waters falls between poor to good type as per Water Quality Index.

(ix) Groundwater flow of the study area was simulated using transient flow model MODFLOW. Surface water hydrological features are considered as the boundary.The vertical discretization of 4-layers represents the formations as top layer having characteristics of aquitard, followed by an unconfined aquifer, then again an aquitard followed by confined aquifer of variable thickness. The model was calibrated and validated satisfactorily. For contaminant transport modelling, MT3D model was calibrated to the extent possible by adjusting the diffusivity parameter and validated.

(x) Pre- and post-monsoon data of physico-chemical parameters of groundwater of different locations in Maniyari Shell Formation Region may be used to identify the probable locations for artificial recharge to improve the quality of the degraded zones. Some scenarios have been investigated at three different locations by diluting groundwater quality through artificial groundwater recharge measures to make it potable. It was observed that the concentration of sulphate decreases with increase in the rate of ground water recharge through injection well. If the rate of recharge is low, then it will take more time to decrease the sulphate concentration to bring within the permissible limit. The groundwater recharging may also be practiced by a single well or multiple wells depending on the local site conditions and availability of source water for recharging to groundwater. This technique may be used to restore the quality and sustainable use of groundwater for drinking purpose in the degraded zones.

Use of Outcomes:

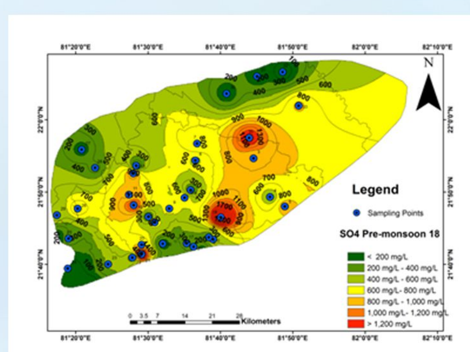
The identification of degraded water quality zones and estimated artificial recharge for high sulphate zone to restore the groundwater quality for sustainable use by various users investigating site-specific measures considering contaminant transport modeling will enable the policy makers and planners for better planning and management of groundwater resources.



Map of Study area

Groundwater Sample sampling

Groundwater level Observation



Sulphate distribution in groundwater of the study area

5. The regional hydrological impact of agricultural water saving measures in the Gangetic plain

Increased population and increasing demands for food in the Indo-Gangetic plains are likely to increase intensification of agriculture and more use of irrigation. The Indo Gangetic Plain has perhaps one of the most important water systems on the planet that accounts for 25 % of global groundwater abstraction (Fendorf and Benner, 2016).The middle Gangetic plain (GP) plays an important role in providing livelihood to millions from its dominant rice–wheat cropping system (Subash et al., 2015). Groundwater together with surface water is utilized in middle Gangetic plain for agricultural practices. One potential remedy for combatting the unsustainable use of groundwater is to use conservation agriculture techniques and other farm-scale water saving measures. Water-saving strategies viz. improved irrigation technology such as drip and sprinkler irrigation, reduction in conveyance system, mulching, conservation tillage, improved crop varieties have been proved to be effective to achieve substantial water-saving (Hu et al., 2016). The aim of this scoping study is to review the state of knowledge of agricultural water saving measures and their relation to the regional hydrology, particularly groundwater. The Bhojpur district, Bihar located in middle Gangetic plain has been selected for the study. The objectives of this study are: (i) a review of agriculture practices and agricultural water saving measures and their impact on groundwater resources; (ii) trend analysis of groundwater level data to understand recharge and discharge processes; (ii) to study surface water and groundwater interaction based on the available and monitored data.

The scoping study was mainly based on a desktop analysis using existing hydrological, meteorological and agricultural data etc. A review of literature was done to study the existing agricultural practices including irrigation in the study area. Various thematic map such as drainage, geological, depth to water level, LULC map for the study area was prepared. Trend analysis of groundwater level was carried out using Mann- Kendall test. Based on the available and generated data, a coarse GW modelling using 'Visual MODFLOW Flex' has been attempted to study the SW-GW interaction.

The Bhojpur district is covered by two major rivers viz., Ganga and Son in the north and eastern side. The population of the district is 27.20 lakh with population density of 1136 inhabitants per square kilometre. The land use and land cover (LULC) classification showed that vegetation (46.13 %) followed by built-up area (21.64 %), fallow (16.52 %), barren land (7.37 %), sand bank (6.08 %), water (2.26 %) are the major types of land uses. The groundwater level data collected from Central Ground Water Board (CGWB) and analyses revealed that depth to water level varies from 3.0 to 9.0 (m bgl) in the study area. A temporal variation of groundwater level (GWL) is shown in Fig. 1. There is no significant declining trend for the CGWB monitoring wells was observed as analysed by M-K test. A coarser transient groundwater modelling was attempted with data collected/generated and certain assumptions were made in case of non-availability of data. The results revealed that groundwater head is higher in southern part in comparison to northern part of the study area and thus, GW is contributing to the river Ganga (Fig. 2).

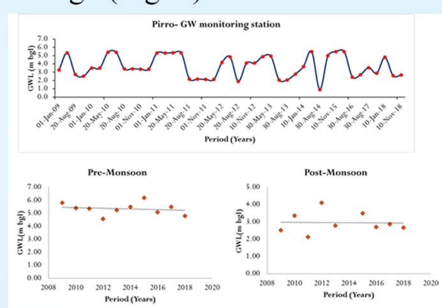


Fig. 1 Temporal variation of groundwater level in a selected monitoring station (Pirro) in the study area

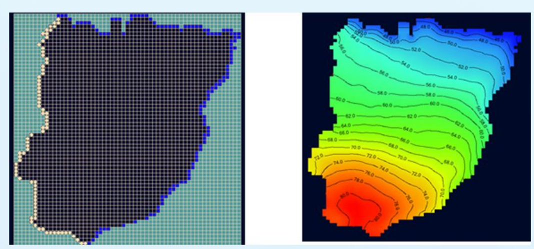
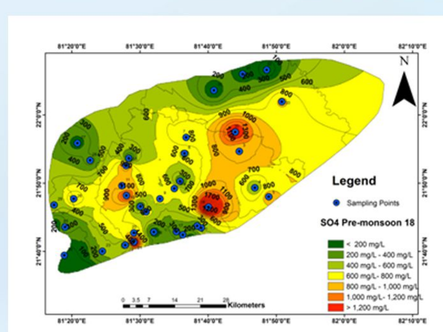


Fig. 2 (a) Model grids with outer boundary showing boundary conditions (b) Groundwater head distribution in the study area.



Sulphate distribution in groundwater of the study area

6. Assessment of Hydrological Characteristics of a Western Himalayan River – A Case Study on River Ujh

The present study was envisaged to cover three hydrological aspects of River Ujh, a Western Himalayan River: (i) Morphometric Analysis and prioritization of catchment; (ii) Assessment of the Land Use and Land Cover change (LULC) in the Ujh catchment; (iii) To set up a hydrological model using HEC-HMS for Ujh catchment. The summary of the study and conclusions drawn with respect to these three objectives are as follows:

Morphometric Analysis and prioritization of catchment

Prioritization is generally the foremost activity in designing any watershed management and planning project and the success of the project depends upon the accuracy in prioritization to a large extent. In a developing country like India where availability of data is a major constraint, to prepare a fruitful project plan, a morphological parameter based methodology as discussed in this study has high practical utility. The proposed methodology for prioritization of a catchment is easy to use and very useful for an un-gauged catchment. Since, most of the data employed is freely available, it makes the methodology frugal and time-saving. The identification of vulnerable watersheds helps in facilitating investment decisions and making the best use of the available resources. The proposed approach also quantifies the erosivity of the sub-watersheds in terms of their Sediment Production Rate (SPR) values, which is helpful in apportioning of the treatment activities.

Morphological parameters (linear, aerial and relief) for all sub-watersheds are calculated separately. For prioritization, all eight sub-watersheds are ranked based upon their corresponding morphological parameter values. Morphological parameters like drainage density, stream frequency, bifurcation ratio, infiltration number and texture ratio have direct relationship with erosivity. Whereas, aerial parameters like elongation ratio, circulatory ratio, form factor and compactness coefficient have inverse relationship with erosivity, relief aspect have a direct relationship with erosivity. The highest priority indicates the greater degree of erosivity. The highest priority indicates the greater degree of erosion in the particular sub-watershed making it a potential candidate for applying soil conservation measures.

Assessment of Land Use - Land Cover (LULC) Change

LULC maps have been obtained for the years 1985, 1995 and 2005 from data prepared by Oak Ridge National Laboratory, National Aeronautical Space Administration (NASA) under NASA's Land Use/Land Cover change programme. Thematic maps have been prepared considering the six major LULC classes prevailing in the study area i.e. Crop land, Evergreen Broad Leaf Forest, Grass Land, Shrub Land, Waste Land and Water Bodies. It was observed that no major change has taken place in the land use pattern over the time period for which change was assessed. The catchment is a virgin catchment with population confined to small urban and semi-rural pockets, which is a miniscule area in comparison to that of the catchment. Evergreen broadleaf forest has been found to be reduced by around 4.6%; this change can be attributed to the increase in area of grasslands which are shown to have grown by 95%. Not much change is identified in other.

Runoff simulation through HEC-HMS and Trend Analysis

HEC-HMS model has been employed for simulation of flows in this study. Due to scarcity and paucity of the discharge data obtained from CWC, the model has been manually calibrated for the period 2010-11 using trial and error method to simulate and match the peak discharge. The model was able to simulate the observed peak discharges and under the restrictions posed by data availability, it is assumed that the parameter has been calibrated and the model is set up for the catchment. To analyse the streamflow regime over a period of time, the maximum discharge over the last 60 years was analysed using two non-parametric tests: Mann-Kendal test and Theil-Sen's estimator. Except for the simulated maximum discharge during the Western Disturbance dominated season using APHRODITE data, none of the trends was found to be statistically significant. Due to the limited calibration of model in the absence of good quality data, these results require further investigation, which can be achieved in subsequent studies wherein adequate data availability for model calibration and validation is ensured.

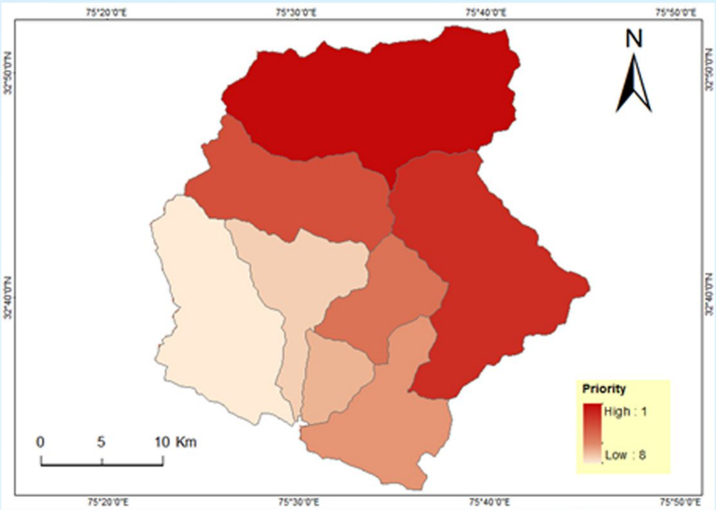


Fig. 1: Sub-Watershed priority map based on Morphometric Analysis

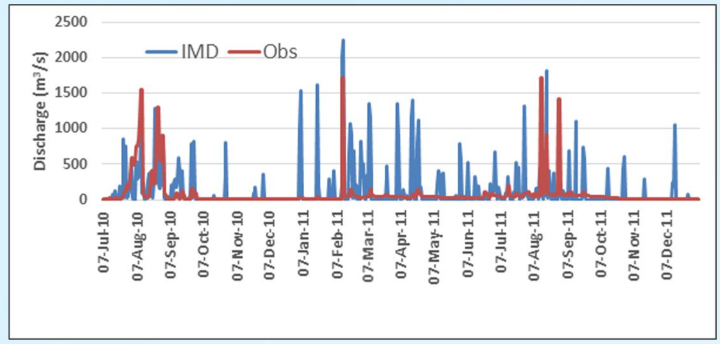


Fig. 2: Simulated Vs Observed discharge data from July 2010-Dec 2011 Employing IMD gridded dataset

Training courses/Workshop/Conference attended by Scientist/ Scientific Staff during January – June, 2021

S.N.	Topic	Duration	Training organised by
1.	Training Program "Android App Development"	04-22 Jan., 2021	Organised by NWA, Pune
2.	International Workshop on "Teesta Basin Model"	Jan 06, 13, 20, and 27, 2021 Feb. 3, 10, 2021	organized by RTI International
3.	"Smart Water Reclamation & Reuse: Experiences From India & USA	12 Jan. 2021	SWWW MasterClass Webinar Series
4.	"DIAS Community Forum 2021 Online"	18-19, Jan. 2021	organized by DIAS Secretariat (Remote Sensing Technology Center), Tokyo
5.	Online Basic Training on 'Disaster Management for the Town and Country Planning Department'	20 – 22 Jan. 2021	organised by National Institute of Disaster Management
6.	Application of Statistics in Ground Water Studies	08-12 Feb, 2021	Organised under NHP by CGWB
7.	Artificial Recharge to GW System	22-26 Feb, 2021	Organised under NHP by CGWB
8.	Online Training Course on "Application of GWAVA model and Application"	22-26 Feb., 2021	jointly organized by NIH, Bhopal and UKCEH, Wallingford (United Kingdom).
9.	Online Training-cum-Workshop on "Hydrological Modeling of Teesta basin using HydroRAM"	Dec. 16 to Mar. 10, 2021 (Weekly One-day).	Organised by RTI International under National Hydrology Project

10.	Attended the "Landscapes Live" online seminar of 2021 on "Morphodynamics of mixed soil-mantled and bare bedrock hillslopes"	18 March, 2021	Organised by Roman DiBiase (Penn State University)
11.	Workshop on Gross Environmental Product: An Ecological Growth Measure	25 March, 2021	organized by HESCO, UPES, UCOST at University of petroleum & energy studies, Dehradun
12.	USER's Interaction meet	30 March, 2021	organized by NRSC, Hyderabad
13.	Training on "India Patent Act 1970"	30 April 2021	conducted by M/s Turnip Innovations Pvt. Ltd., Mumbai
14.	Purpose-oriented training program on 'Irrigation Planning Aspects for Preparation of Detailed Project Reports'	10-21 May 2021.	conducted by National Water Academy, Pune
15.	Webinar on "Ethical issues in peer review"	11 May, 2021	organized by John Wiley and Sons
16.	Webinar: Coastal Modelling 101- Oceans, coasts and estuaries	19 May 2021.	by Australian Water School,
17.	Purpose Oriented Training through Distance Learning on "Irrigation Planning Aspects for Preparation of DPRs"	10-21 May 2021	organised by NWA, Pune
18.	Training programme on "Introduction to Irrigation Planning Aspects for preparation of Detail Project Report"	10-21 May, 2021.	conducted by National Water Academy (NWA), Pune
19.	Online Training programme on "Automation of canal with modern measurement methods and control techniques"	27-28 May, 2021.	organized by Central Water & Power Research Station, Pune
20.	Online training course on "Introduction to Groundwater, Watersheds, and Groundwater Sustainability Plans"	06 May to June 03, 2021	organized and sponsored by University of California, Davis, USA
21.	Online training programme on "Flood Assets Mapping using GIS" during	31 May - 4 June 2021	organised by NWA, Pune
22.	Online 2-days training programme for Technical Committee Members	02-03 June 2021.	organized by NITS, BIS, NOIDA on
23.	Attended GEOGloWS ECMWF Streamflow Service In-depth Training	8-19 June 2021	organised by the World Bank
24.	भारत सरकार की राजभाषा नीति, नियम-अधिनियम, राजभाषा हिन्दी की संवधानिक स्थिति, पत्र लेखन तथा हिन्दी नोटिंग/ड्राफ्टिंग" विषय पर हिन्दी कार्यशाला	30 June, 2021	NIH, Roorkee

25.	Joint Virtual Workshop on "Connecting global to local hydrological modelling and forecasting: scientific advances and challenges"	29th June 2021 – 1st July 2021	organized by ECMWF

Training Course/ Workshop organised during January – June, 2021

S.N.	Name of the Course	Date	Venue
PLAN			
1.	One day Webinar on Ecohydrology Engineering harmony for a sustainable World Under INC-IHP	Jan. 27, 2021	NIH, Roorkee
2.	Training course on "Climate Change and Hydrological Impact assessments"	Jan. 25-29, 2021	NIH, Roorkee
3.	5 day online training course 'E-course on Hydro-meteorological data analysis; basics and advanced techniques (HyMCBAT 2021)'	Mar. 1-5, 2021	NIH, Roorkee
4.	भारत सरकार की राजभाषा नीति, नियम-अधिनियम, राजभाषा हिन्दी की संवधानिक स्थिति, पत्र लेखन तथा हिन्दी नोटिंग/ड्राफ्टिंग "विषय पर हिन्दी कार्यशाला	June 30, 2021	NIH, Roorkee
SPONSORED			
1.	Hands-on-Training course on "Estimation of Yield and Flood" for the engineers of Karnataka Power Corporation Limited Bangalore	Feb.8-12 , 2021	Bangalore
2.	Online Workshop on Biodiversity and Ecosystem Health Assessment of Upper Ganga Basin (jointly organized by Department of Zoology and Environmental Science, Gurukul Kangri (Deemed to be University) Haridwar (Uttarakhand) and National Institute of Hydrology Roorkee, (Uttarakhand) under NMSHE Project sponsored by DST, New Delhi)	Feb 22-26, 2021	NIH, Roorkee
3.	2-days Online-training on "Integrated Drought Management" organized by FAO	Mar. 30-31, 2021	NIH, Roorkee
NHP			
1.	An online training course on topic "GW Modelling using Visual MODFLOW"	Jan. 18-22, 2021	NIH, Roorkee
2.	On line training "River Basin Modelling"	Jan.25-27, 2021	RC, Bhopal
3.	Online workshop under PDS "Modelling of Tawa Reservoir Catchment and Development of Tawa Reservoir Operation Policy"	Feb. 12, 2021	RC, Bhopal
4.	Online training course on "Groundwater salinity issues and management solutions"	Feb. 17-19, 2021	NIH, Roorkee
5.	On line training on 'QGIS its application for surface ground water hydrology'	Feb. 22-26, 2021	RC, Bhopal
6.	Online International training course on "GWAVA Model & Application"	Feb.22-26, 2021	NIH, Roorkee & UL CEH, Wallingford

7.	5-days training program on "Advanced Tools & Techniques for Hydrological Investigations"	Feb. 22-26, 2021	NIH, Roorkee
8.	One-day Stakeholders' Workshop on "Snow and Glacier Contribution and Impact of Climate Change in Teesta River Basin, Eastern Himalaya a project sponsored under NMHS"	Feb. 23, 2021	Gangtok
9.	Online training course on "Principles of groundwater hydrology"	Feb. 24-26, 2021	NIH, Roorkee
10	Online training course on "Groundwater management and modeling" during	March 08-12, 2021	NIH, Roorkee
11	Stakeholder workshop under ongoing PDS "Impact Evaluation Rabi Irrigation Ganga River Sub Basin of Madhya Pradesh"	19 March, 2021	RC, Bhopal
12	2 day stakeholder workshop on "Spring water supply and its sustainability in parts of Western Ghats region of Maharashtra" under NHP- PDS "Studies on Occurrence, Distribution and Sustainability of Natural Springs for Rural Water Supply in parts of Western Ghats, India "	March 24-25. 2021	RC, Belgavi
13	Online training course on "GW Modelling using MODFLOW"	June 14-18, 2021	NIH, Roorkee

Important Meetings

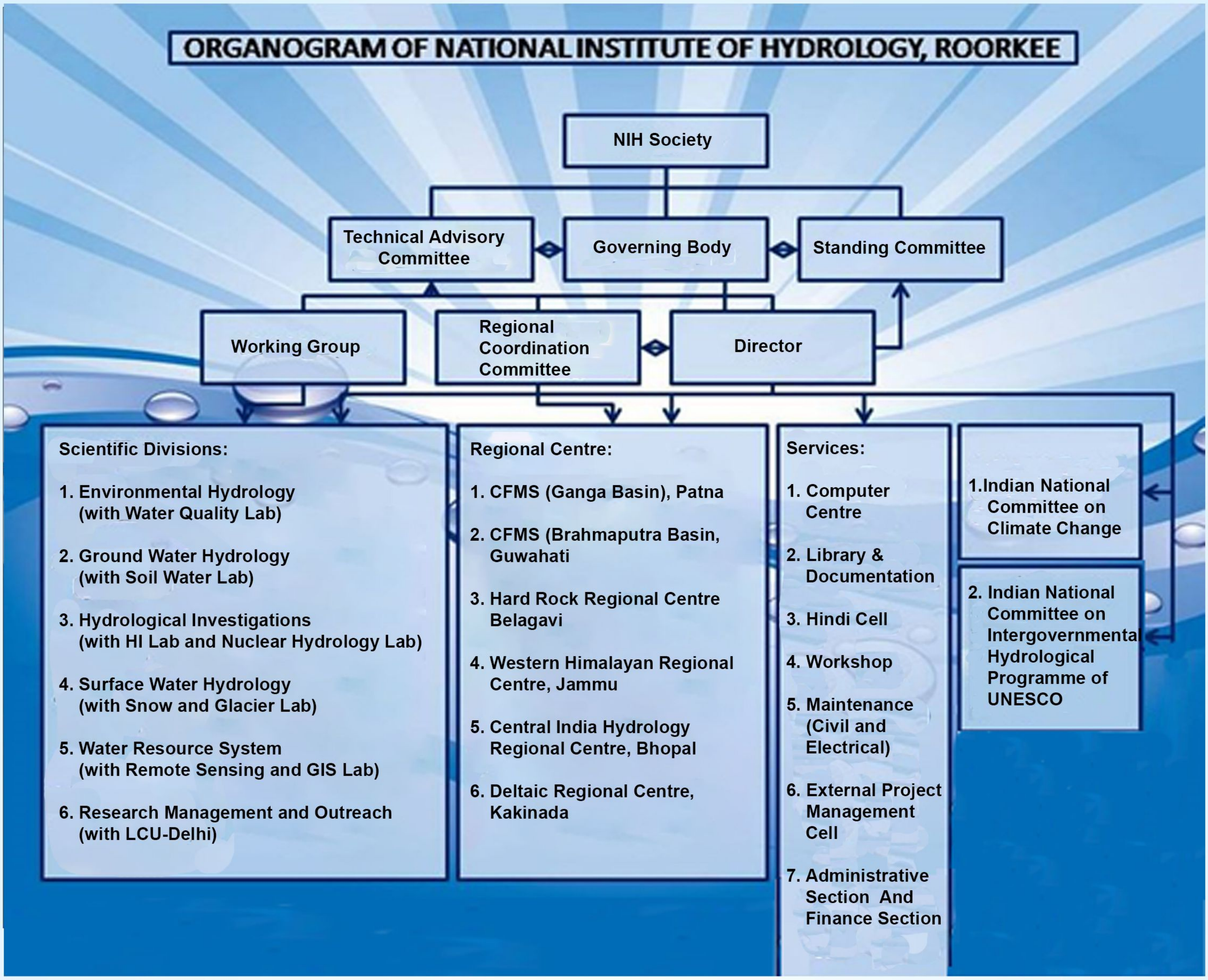
1. 19th Regional Coordination Committee meeting of CIHRC, Bhopal was held on March 18, 2021 in VC mode.
2. 31st Regional Coordination Committee meeting of HRRC, Belgavi was held on March 26, 2021 in VC mode
3. 51st meeting of Working Group was held on June 14-15, 2021 in VC mode.
4. 20th Regional Coordination Committee meeting of CFMS, Patna was held on June 22, 2021 in VC mode.
5. 81st Governing Body meeting was held on June 23, 2021 in VC mode.
6. 39th Annual General Meeting was held on June 28, 2021 in VC mode.

Well said about water

Water and air, the two essential fluids on which all life depends, have become global garbage cans.	Jacques Yves Cousteau
All water has a perfect memory and is forever trying to get back to where it was.	Toni Morrison
Human nature is like water. It takes the shape of its container.	Wallace Stevens
You must not lose faith in humanity. Humanity is an ocean; if a few drops of the ocean are dirty, the ocean does not become dirty.	Mahatma Gandhi

Hindi Glossary for Hydrological terms

Alluvial Stream	जलोढ़ सरिता	Hydrometry	जलमिति	Permeability	पारगम्यता
Auxillary Gauge	सहायक प्रमापी	Inflection Point	नति परिवर्तन बिन्दु	Rainfall Simulator	वर्षा अनुकारित्र
Borometric Efficiency	वायुदाबीय दक्षता	Linear Reservoir	रैखिक जलाशय	Unconfined Aquifer	अपरिबद्ध जलदायीस्तर
Canopy Interception	वितान अंतरोधन	Perennial Stream	बारहमासी धारा	Watershed simulation	जलपरिक्षेत्र अनुकरण



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

Dr V C Goyal, vcg.nihr@gov.in
National Institute of Hydrology
(An ISO 9001:2015 certified organization)
Roorkee (Uttarakhand, India)
Ph: +91-1332-272106; Fax: +91-1332-272123
www.nihroorkee.gov.in