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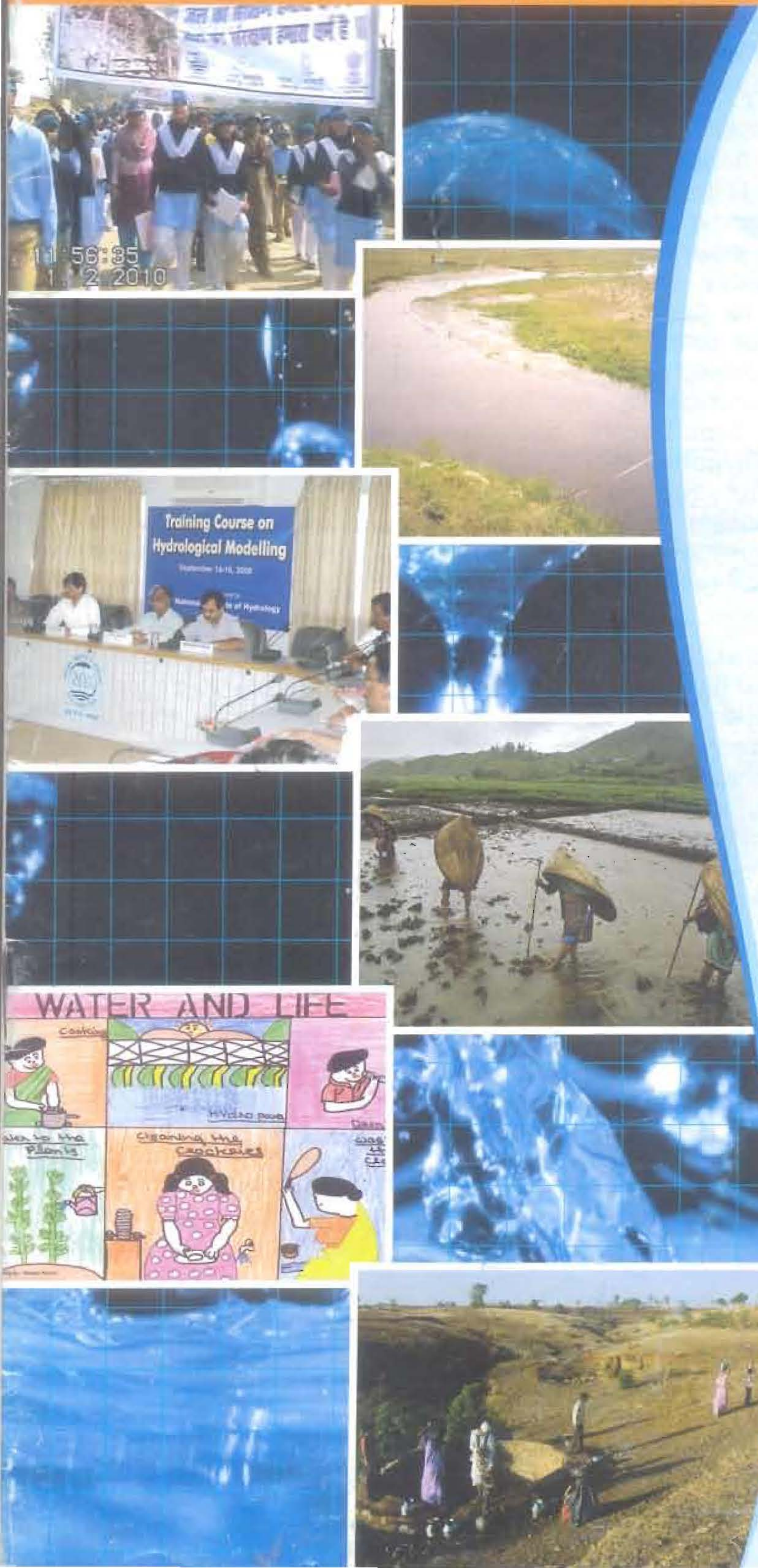
Hydrology for People™

Newsletter of National Institute of Hydrology, Roorkee (India)



From Director's Desk

Society's growing water resource needs include hazard mitigation (floods, droughts, and landslides), agriculture and food production, human health, municipal and industrial supply, environmental quality, and sustainable development in a changing global environment. Desertification and drought are problems of global dimension that affect more than 900 million people in about 100 countries. Irrigation already accounts for more than 70% of freshwater withdrawn from lakes, rivers, and groundwater aquifers, and according to the UN's recent estimates, perhaps 80% of the additional food supplies required to feed the world's population in the next 30 years will depend on irrigation. Today, about one-third of world's population live in countries that are experiencing moderate to high water stress, that is, renewable freshwater availability is below 1700 cubic meters per person. With increased prospects of feeding increased population in 2050, the industrial, individual and agricultural demand is expected to escalate dramatically. Also, the climate change is becoming a more and more important issue for growing water scarcity. This calls for awareness that water is very scarce and valuable natural resource and that we need to initiate innovative technological and management changes.

National Institute of Hydrology has been conducting the research in the field of hydrology and water resources, over the last three decades. Many purpose driven studies and strategic projects were carried out to solve the various need based problems touching almost every sphere of water resources development. With growing interest of managing water resources under the constant threat of climate change, the Institute is gearing-up to conquer the challenges and fulfill the needs of the country via demand driven strategic studies. The Institute is also pro-actively contributing to the knowledge dissemination, mass awareness and capacity building programmes.

R D Singh

Editorial

The country is going through a phase of rapid transformation encompassing various sectors of development. Enhancing crop production and farmers' income, increasing water use efficiency, cleaning and revival of polluted rivers, rejuvenation of water bodies such as lakes and ponds, developing basic amenities and facilities in rural areas, developing skill sets for indigenous manufacturing and service sectors workers, bringing more and more ICT applications for the benefit of farmers, labourers, micro-entrepreneurs, etc. are some of the priorities of the present government.

As ensuring water security is a priority for India's water sector, a scientific understanding of the wide range of water conservation and management measures at various scales (e.g. basin, watershed and sub-watershed) is vital for economic development of the country and for welfare of the society at large. The concept of Integrated Water Resources Management (IWRM) becomes further more important in the present context, and the country is experimenting with the various operational and institutional issues that have hindered the desired progress of this concept. NIH has also recently taken initiatives on developing the IWRM Plan at watershed and sub-watershed (Gram-Panchayat) scales in some of its "Action Projects". Response of the local stakeholders to these IWRM Plans in the Bundelkhand region has been encouraging so far and the actual effectiveness of these plans will be known once these are implemented by the district authorities and the line departments.

Publication of this newsletter is an attempt to rejuvenate the knowledge dissemination efforts of the Institute, with a flavour of 'connecting to the people'. The intent is to take the research findings to the community so that they are incited to develop interest in the scientific developments taking place in the country. This is the time to make information related with water reach all nooks of the country. And, NIH fraternity is zestful enough to do its bit in this endeavour.

Response to the previous issues has been encouraging. Your suggestions and feedback are welcome, and will help us in improving future issues!

V C Goyal

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 Centers located at Belgaum, Jammu, Kakinada and Bhopal, and two Centres for Flood Management Studies at Guwahati and Patna in Hydrology, Water Quality, Soil Water, Remote Sensing & GIS Applications, Groundwater Modelling and Hydrological Instrumentation.

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. NIH has so far completed more than 150 sponsored research and consultancy projects- the sponsors included Indian Army, PSUs, Planning Commission, National Productivity Council, State Government Departments, and central ministries of Science & Technology, Environment & Forests, Agriculture, Rural Development, etc. 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 Hydrology Project Phase-II.

Some of the significant contributions of NIH include studies for solution of real-life problems related to augmentation of water supply and water management in cities, glacier contribution in streamflow of Himalayan rivers for hydro-electric power projects, watershed development, water quality management plan for lakes, watershed development, storm water drainage network in cities, flood inundation mapping and flood risk zoning, and water quality assessment in major cities. The Institute is actively pursuing the IEC activities and mass awareness programmes of the Ministry of Water Resources. NIH works as a nodal centre of the Ministry for effective implementation of the National Water Mission.

Vision

Providing innovative and effective S&T for hazard-free sustainable development and management of water and water-related disasters

Mission

- Develop methodologies for optimum utilization of water resources and environment
- Propagate applications of emerging technologies for water resources development and management
- Find ways to save the society from water-related hazards
- Develop mass awareness for water conservation and optimum utilization

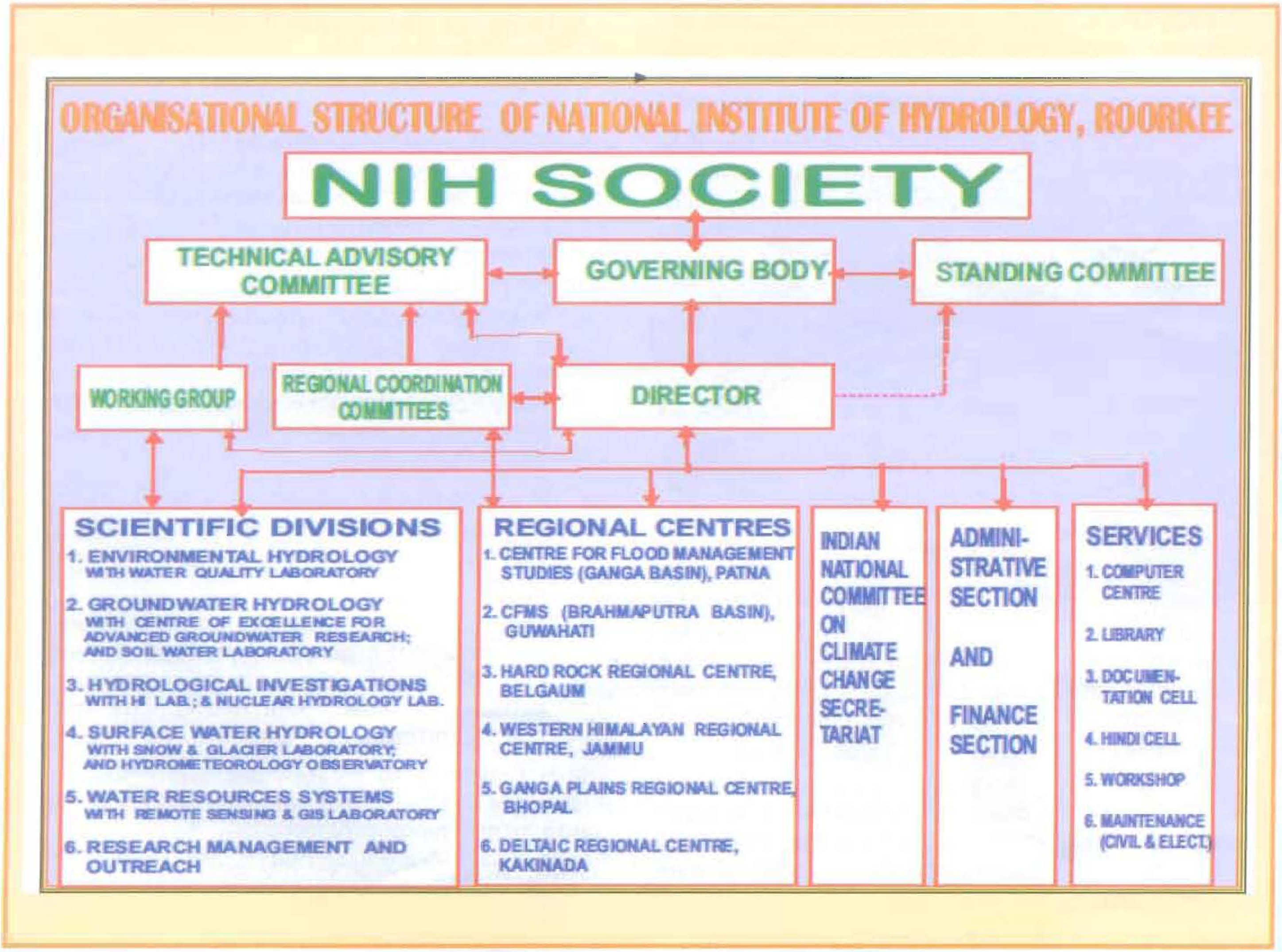
Thrust Areas

- 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 provide the solution to hydrological problems

Hydrology Primer

Hydrology is the science that treats the waters of the earth, their occurrence, circulation, movement and distribution, their chemical and biological properties and their reaction with the environment, including their relation to living things. The domain of hydrology embraces the full life history of water on the earth.

- The hydrologic cycle is a continuous process that exists on the earth by which the water from over and beneath the earth's surface (including the ocean) is transported to the atmosphere through the process of evaporation and evapo-transpiration from the vegetative cover and to the land surface through the process of rainfall and snowfall, and reaches to the surface and groundwater storages, and the ocean by means of the various paths.
- The various phases of the hydrologic cycle may be short, or it may take millions of years. Water may be captured for millions of years in polar ice caps, groundwater reservoirs (aquifers) and in the sea.
- The hydrological cycle moves enormous quantities of water about the globe. However, much of the world's water has little potential for human use



because 97.5% of all water on earth is saline water. Out of remaining 2.5% fresh water, most of which lies deep and frozen in Antarctica and Greenland, only about 0.26% flows in rivers, lakes and in the soils and shallow aquifers which can be readily used.

- Certain hydrological problems and weaknesses have affected a large number of water resources all over the world due to the effect of Climate Change due to Global Warming.
- In case of India, floods and droughts affect vast areas of the country, transcending state boundaries. One-sixth area of the country is drought-prone. Out of 40 million hectares of the flood prone area in the country, on an average, floods affect an area of around 7.5 million hectares per year.

Role of Hydrologist

- The hydrologist plays very important role in solving water-related problems in society such as quantity, quality and water availability or basin water budgeting through application of the proper scientific knowledge and mathematical principles.
- The hydrologist studies the fundamental transport processes to be able to describe the quantity and quality of water as it moves through the hydrologic cycle (evaporation, precipitation, streamflow, infiltration, groundwater flow, and other components).
- Hydrologists estimate the volume of water stored underground by measuring water levels in local wells and by examining geologic records from well-drilling to determine the extent, depth and thickness of water-bearing sediments and rocks. Before an investment is made in full-sized wells, hydrologists may supervise the drilling of test wells. They note the depths at which water is encountered and collect samples of soils, rock and water for laboratory analyses. They may run a variety of geophysical tests on the completed hole, keeping and accurate log of their observations and test results. Hydrologists determine the most efficient pumping rate by monitoring the extent that water levels drop in the pumped well and in its nearest neighbors.
- The engineering hydrologist, or water resources engineer, is involved in the planning, analysis, design, construction and operation of projects for the control, utilization, and management of water resources.
- He may also deal with the study concerning the municipal water supply, irrigation water supply and management, mitigation of floods and droughts, integrated watershed management, ground water recharge and solving reservoir sedimentation problems.
- Scientists and engineers in the field of hydrology may be involved both in the field investigation and office work.
- In the field investigation, they may collect basic hydrological, geological, meteorological and water quality data, sometimes from remote and rugged terrains with use of measuring instruments and equipments. While, in the office, they may do many jobs that includes the assessment of water quality in the laboratory, remote sensing data processing and analysis using GIS, interpretation and analysis of field data, modelling studies for flood hazards mitigation, groundwater replenishment, water-logging problems, sea water intrusion, reservoir operations in the command area and assessment of their impacts on environment.

Jal Kranti Abhiyan

"Jal Kranti Abhiyan"shall be celebrated during year 2015 -16 to consolidate water conservation and management in the country through a holistic and integrated approach involving all stakeholders, making it a mass movement.

जल क्रान्ति अभियान

जल बचत - जल संचय

- With a rapidly growing population and increasing needs of a fast developing nation, coupled with likely adverse impact of climate change, per capita availability of water would be declining year after year.
- If not addressed properly in a timely manner, the fast growing water demand is likely to lead to water conflicts among different user groups as well basin states.
- There is an urgent need to promote as well as to consolidate the activities of water conservation, optimization of water use efficiency and water demand management in the country through a holistic and integrated approach.

It is important to create mass awareness on these issues or in other words, we need "Jal Kranti Abhiyan" throughout the country.

Objectives:

Strengthening grass root involvement of all stakeholders including Panchayati Raj Institutions and local bodies in the water security and development schemes (e.g.Participatory Irrigation Management (PIM);

- Encouraging the adoption/utilization of traditional knowledge in water resources conservation and its management;
- To utilize sector level expertise from different levels in government, NGO's, citizens etc; and
- Enhancing livelihood security through water security in rural areas.

Activities Proposed under Jal Kranti Abhiyan

(I) Jal Gram Yojana

(ii) Development of Model Command Area

(iii) Pollution abatement

(iv) Mass Awareness Programme

(v) Other Activities

Projects Solving Real Life Problem

Water Conservation and Management in Ibrahimpur Masahi Village of Haridwar District (Uttarakhand)

Present study was undertaken in Ibrahimpur Masahi Village, District Haridwar (Uttarakhand) under Shipla-Halzora river watershed (Solani river sub-catchment), which lies between 29° 56' to 30° 05' N Latitude and 77° 48' to 77° 55' E Longitude. The area of Shipla-Halzora river watershed is approximately 101.5 km^2 upto Imlikhera bridge. The study area of Ibrahimpur Masahi village is about 14.26 km^2, which mainly consists of five sub-villages, viz. Ibrahimpur Masahi, Masahi Kala, Belki Masahi, Inayatpur and Halzora. The main objectives of the study are: (i) Assessment of water demand for domestic, livestock and agricultural uses in the villages, (ii) Assessment of water availability, (iii) Assessment of water quality/Eutrophication status of ponds, (iv) Preparation of water conservation plan for the village.

During the year 2015-16, a door to door survey was carried out in 5 sub-villages of Ibrahimpur Masahi to obtain household level information pertaining to number of houses & their average sizes per family, no. of family members, drinking and irrigation facilities, etc. Field investigations were also conducted for bathymetric survey, water quality & eutrophication assessment of existing ponds the study area. A view of bathymetric survey in a pond located at Masahi village is shown in Fig. 1. The eutrophication status of ponds was estimated based on Carlson's Trophic State Indices (Carlson, 1977) using average values of secchi depth, phosphate and chlorophyll content. The overall eutrophication status of the ponds is shown in Fig. 2, which indicates hyper-eutrophic condition (CTSI>70) of the village ponds. Monthly rainwater harvesting potential and balance of harvested rainwater after meeting few designated uses was also estimated for 5 sub-villages using Eqn. given by Ghisi et al., 2006. The analysis include: (a) household monthly harvested rainwater & balance after ablution/toilet flushing, washing of clothes & other uses (combined), (b) assessment of household monthly harvested rainwater & balance after ablution/toilet needs, (c) rainwater harvesting potential of existing village ponds (d) monthly roof top water harvesting potential of schools/govt. buildings, etc. The household level average roof-top area (m^2) in 5 sub-villages, viz., Ibrahimpur Masahi, Masahi Kala, Belki Masahi, Inayatpur and Halzora was obtained in the order of 62, 49, 52, 25, 33 respectively. Based on average roof-top area available in 5 sub-villages, the monthly rainwater harvesting potential (m^3) was estimated for three scenarios of rainfall conditions, viz., (i) at monthly average rainfalls of Roorkee (27 rainfall years data), (ii) at 50% dependable monthly rainfalls, (iii) at 75% dependable monthly rainfalls, respectively. Household monthly harvested rainwater & balance after ablution / toilet flushing, washing clothes & other uses (combined) based on average rainfall is given in Fig. 3. The size of a suitable tank for rain water harvesting in each sub villages was also recommended in the study.

Fig. 1: Bathymetric and Secchi depth survey in a pond at sub-village Masahi Kala

	Pond_Ibrahim P	Pond_Masahi	Pond_InayatP
Series1	87	108	78

Fig. 2: Eutrophication status of ponds in Ibrahimpur Masahi village

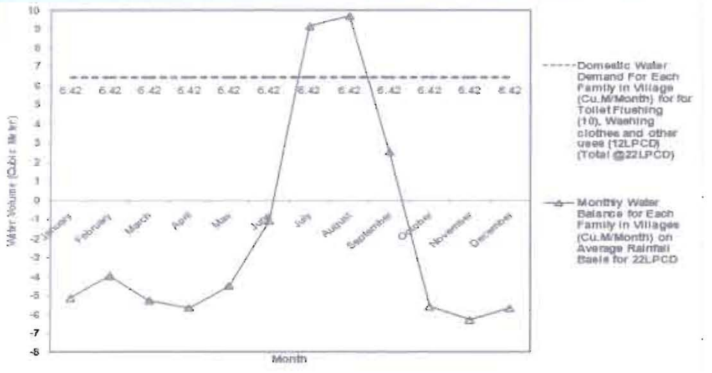
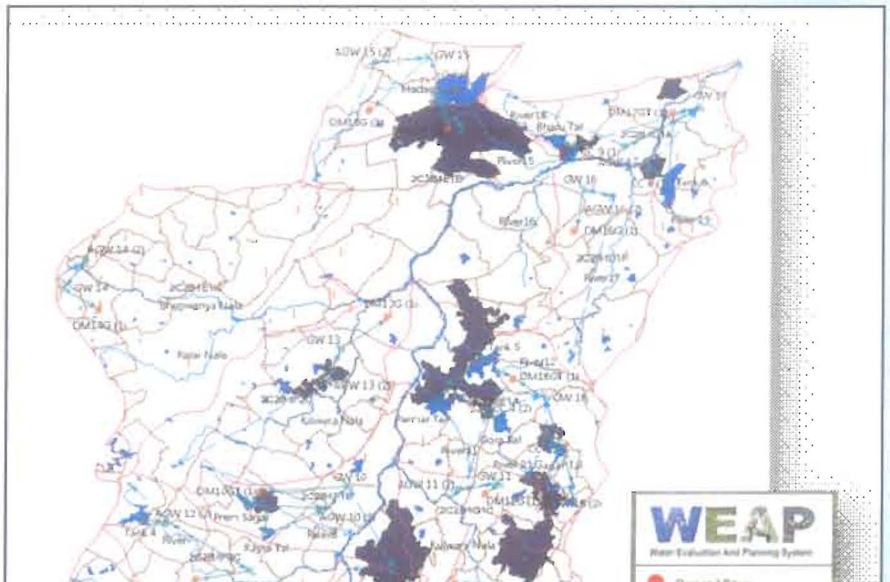


Fig. 3: Monthly water balance for supply of water @ 22 LPCD (toilet flushing + washing clothes and other uses only) for each family in Ibrahimpur Masahi

Integrating hydrology, climate change and IWRM with livelihood issues: Development of methodology and a DSS for water-scarce Bundelkhand region in India

This project is an effort to conduct a rapid assessment of the current status of water in the Ur River catchment (Tikamgarh district, MP) of Bundelkhand region, and to develop methodologies and a DSS for introducing an integrated approach of water management with livelihood issues using WEAP system. A DSS is being developed considering hydrological, technological, economic, and social factors to recommend community-based water management policies for holistic development of the region.

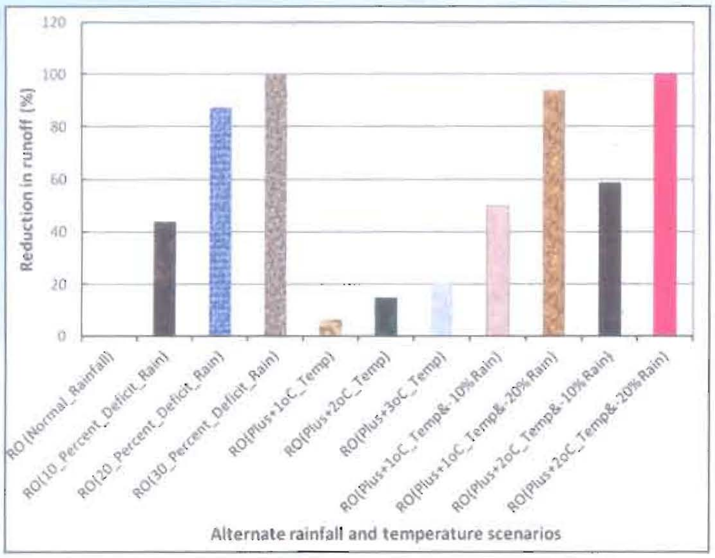
This research study deals with current limitations and hazards, such as water scarcity and soil degradation, and looks across a range of biophysical settings at emerging risks and uncertainties for rural livelihoods due to impending climate changes and powerful demographic and socio-economic trends, with a particular focus on land use change dynamics. Therefore, the main aim of this study to develop conceptual WEAP based Decision Support System with emphasis on hydrological aspects for water budgeting on the priorities of the stakeholders for analysis of most optimistic livelihood options under three scenarios viz. Business As Usual, Adoption of Modern Technology and Improved Managerial Practices with future scenario building under the climate change, and for the comparative assessment of adaptation options.



Glaciological studies of Phuche Glacier, Ladakh Range

Himalayan glaciology research is focused only on couple of Himalayan basins for the last many decades. This has left a significant void in our understanding of glacier response to changing climate and ensuing runoff variations in other important river systems of the Indian Himalaya. Glacier responses to the climate change vary across the HKH region. Many areas of Karakorum Mountains show glacier mass gains in recent past while glaciers of central and eastern Himalaya show mass loss. However, the genesis of this variability in glacier response has not been understood yet as many regions of the Himalaya are kept out of the preview of glacial research.

SERB sponsored project on "Glaciological studies of Phuche glacier, Ladakh Range" is one of the first comprehensive studies of a glacier in the cold-arid regime of Ladakh in the trans-Himalaya. This work has been carried out at challenging heights of 5400-5700 m a.s.l in one of the toughest Himalayan terrain with following objectives: 1.Winter & Summer Mass Balance studies by glaciological method, 2. Runoff



measurements, 3. Collection and standardisation of meteorological parameters by AWS, 4. Mass Balance & Runoff modeling, and 5. To study the composition of stable isotopes $\delta^{18}O/\delta D$ in the winter snow, summer snow/rainfall and separate snow, rain and glacier melt components in the river flow and its temporal and seasonal variations.

This study was carried on Phuche glacier in the Ladakh range in the trans-Himalayan region. Phuche glacier catchment is the headwater zone of the Leh Nallah which is the only water source for the Leh city. This glacier has NE aspect and lies at 34o 17' 4.5" N and 77o 33' 48.12"E. Guing Topko emerges from Phuche glacier and later become Phuche stream downstream. More than 90% of the glaciers in the Ladakh range are cirque glacier with less than $1km^2$ of area. Phuche glacier is 1.3km long and covers an area of 0.62 km^2. Catchment area above the South pullu is around $15.8km^2$. This glacier extends from 5250 to 5740 m a.s.l.

The methodology adopted in this study includes winter and summer mass balance measurement of the glacier. Winter mass balance was calculated by measuring winter snowpack thickness at various locations on the glacier and snow pack density measurements at selected locations at the end of the winter season following floating date system. Mass balance measurements were carried out by glaciological method by measuring the summer ablation by a network of ablation stakes and summer accumulation by snow pit and measurement of accumulation stakes. Relationship between glacier mass balances with the prevailing weather was studied. Standardization of the mountain climate parameters in cold-arid system such as temperature and precipitation gradients, etc. was carried out by weather monitoring at three elevations. Melt water discharge was measured at a gauging station at the catchment outlet by area-velocity method. Automatic water level recorder was installed for round the clock water level monitoring. Composition of stable isotopes $\delta^{18}O/\delta D$ in the winter snow, summer snow/rainfall and melt water were measured from respective samples and separate snow, rain and glacier melt components in the river flow. Data generated on weather, mass balance and runoff were synthesized into a glacier mass balance and runoff model. Few of the important results are as follows:

- During the five years of glacier mass balance studies, two years experienced slight positive mass balance and three years had significant negative mass balance. It is seen that the negative mass balance years obliterated number of years of mass balance surplus. Hence the cumulative mass loss of Phuche glacier during the five year study period was -925 mm w.e. with mean annual mass balance of -185 mm w.e. Glacier mass balance response is found to be closely associated with the glacier ice exposure dates.
- The tandem mass balance studies conducted over the Khardung glacier shows significant higher glacier melt. Khardung glacier experienced negative mass balance throughout the observation period and had a cumulative mass loss of 2688 mm w.e. during four years of observation with an average annual mass loss of -672 mm w.e. Results suggests that the glaciers in the region are under mass loss regime and the mass gaining trend of Karakorum glaciers did not extend to the Ladakh range.
- The glacier catchment monitoring strategy has brought out the huge precipitation gradient along the steep mountain slopes in the catchment in winter which forces a winter accumulation of 590 mm w.e. on the glacier in comparison to less than 50 mm w.e. of winter precipitation at the valley bottom. This steep precipitation gradient in winter is one of the key forcing factors sustaining the glaciers in the region. Using this data, an altitude-precipitation relationship has been developed for the region.
- Extraordinary steep temperature gradient in summer with monthly mean values ranging around 10K/km persisting through March/April to September every year is brought to light for the first time. This steep temperature gradient is due to the summer aridity experienced by the region which forces cooler environment along the ridges which helps to sustain these glaciers. Hence it is felt that summer aridity is another most important factor sustaining the Ladakh glaciers. Indices for deriving the slope environmental lapse rate (SELR) of two distinct lapse rate altitude.

- Averages water availability for the 15.7 km^2 experimental catchment in summer is 9.87×10^6 m^3 equivalent to 624 mm w.e. of specific runoff. This is a significant discharge considering the very low precipitation of <100 mm in the valley. It is estimated that the glacier contribution to the catchment runoff is as low as 4.2 to 7.3%.
- Study suggests significant ground ice melt contribution to runoff during the dry years. Presence of discontinuous permafrost in this catchment is suspected and detailed studies on these aspects are
- May–June precipitation, which is most crucial for hydrologic and glacier response is found to be sourced mainly from the locally evaporated moisture having enriched isotopic values with weighted average of -7.2‰ ($\delta^{18}O$) and -41.8 (δ^2H). The study confirmed that the July –August precipitation is derived from monsoon moisture with depleted, weighted average of -18.8‰ ($\delta^{18}O$) and -138.2 (δ^2H) and isotopic signatures of western disturbances very much present in the winter snowfall which is also depleted, weighted average of -17.0‰ ($\delta^{18}O$) and -128.7 (δ^2H).
- Hydrograph components were separated by the isotopic method. As glacier melt contribution is less than 10%, separation is attempted between snow/glacier melt and rainfall contributions. Year 2010 experienced highest rainfall contribution amounting 29% and the rest 71% was contributed essentially by snow melt. In subsequent years, rainfall contributed only 7-9% of the annual runoff of the catchment.

Present study demonstrated the need to adopt a new benchmark catchment strategy for Himalayan glacier research for better understanding of orographic forcing driving the glacier/hydrology response in high elevation nival-glacier regime. Study also showed that the snowmelt is the dominant runoff component in the stream in the cold-arid system. Glaciers mass balance studies showed that the glaciers are under the melting regime and demonstrated the importance of measuring winter mass balance to link glacier MB with streamflow. Water availability (624 mm w.e.) calculated for the high elevation zone of the catchment suggests that the water availability at the dry valley bottoms are regulated by the nival-glacier zone of the catchment. Large inter-annual variability in the seasonal distribution of streamflow suggests that the runoff prediction would help managing this sparse resource better. Daily runoff variability studies have shown that efficient water use practices in these areas should incorporate mid-noon to mid-night water use/storage during July and August months and mid-night to morning water use/storage in May – June months to make use of the daily peak flows. Long-term monitoring of glacier mass balance and climate is required to establish the relationship between the two and it recommended to continue study of these glaciers. Permafrost thaw or ground ice contribution is also probably influencing the runoff pattern and more studies on cold-arid permafrost characteristics are recommended.

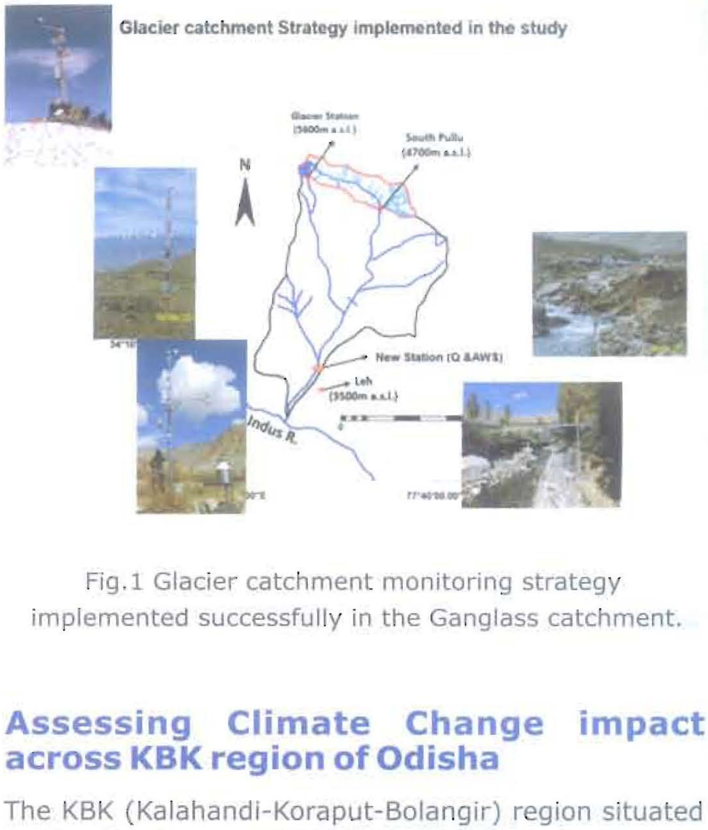


Fig.1 Glacier catchment monitoring strategy implemented successfully in the Ganglass catchment.

Assessing Climate Change impact across KBK region of Odisha

The KBK (Kalahandi-Koraput-Bolangir) region situated in the Southern-Western part of Odisha is prone to drought and poverty in spite of good rainfall and lot of agriculture activities. This can be attributed to several reasons including physiography, climate, soil, landuse-landcover, poor land and water management, human interventions, etc. To investigate the effect of climate change in the region, the study was conceptualized with three major objectives: (i) To analyze long-term historical climatic data to determine trend; (ii) To analyze the future climate in the region based on downscaled GCM data; and (iii) To assess the current potential and utilization gap of water resources in the region to develop management plan.

In this study, Mann-Kendall test and Sen's slope estimator test are utilized to investigate the trend for rainfall (110 years), temperature (102 years), and potential evapotranspiration (102 years). The year having considerable shift in rainfall and temperature pattern in the region has been detected using Pettitt's test and Standard Normal Homogeneity Test (SNHT). The results indicate significant decreasing annual rainfall trend at 5% significant level in the district of Nuapada and increasing trend in Malkangiri district (Fig.1). The southern districts with dominant forest coverage viz. Koraput and Rayagada are showing increasing rainfall trend though non-significant, whereas Bolangir, Kalahandi, Nabarangpur and Sonepur districts are showing decreasing trend. Monsoon rainfall shows decreasing trend in the districts of Nuapada, Kalahandi, Sonepur, Bolangir and Rayagada. The entire region is witnessing decrease in winter rainfall which plays a significant role for the rabi crops.

The future rainfall and temperature was downscaled for the region using HadCM3 Global Climate Model (GCM) for A2 and B2 scenarios. The KBK region is falling mainly in two sub-basins viz. Tel and Sabari sub-basins. Indravati project, Patora dam are few projects meeting the irrigation and drinking water demand in the region. Apart from this, few multipurpose projects (major and minor) are in pipe-line in the KBK region such as Ong irrigation project, Lower Suktel project, Tel project, etc. The water availability and utilization for Tel basin (sub-basin to Mahanadi basin) has been investigated. Daily discharge data for the Tel River for the duration 1972-2012 has been analyzed to compute annual dependable flow. The average annual yield for the basin is found to be about 9934 Mm^3 at 75% dependability. SWAT model has been applied to validate the results for the Kantamal G&D site (Fig. 2 (a & b); Fig. 3 (a & b)). There are no major irrigation projects in the Tel basin at present. However, the combined annual utilization for drinking water, irrigation, and industry is about 4210 Mm^3.

The distinct climate variability of the Northern-Southern parts can be attributed to the distinct

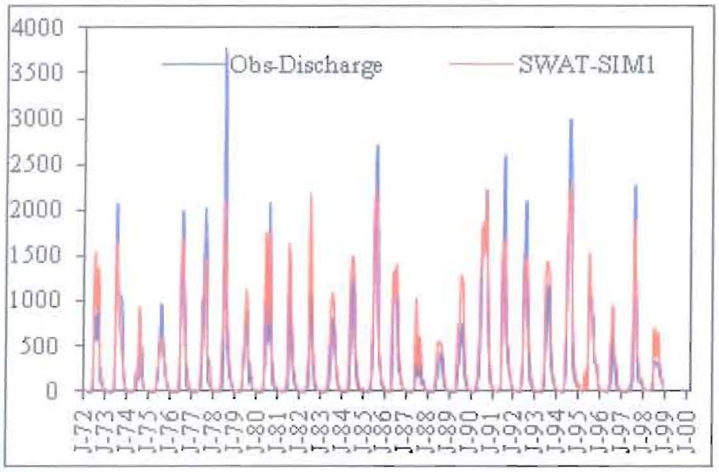


Fig. 2(a): Pre-calibrated observed and simulated discharge of the Tel basin;

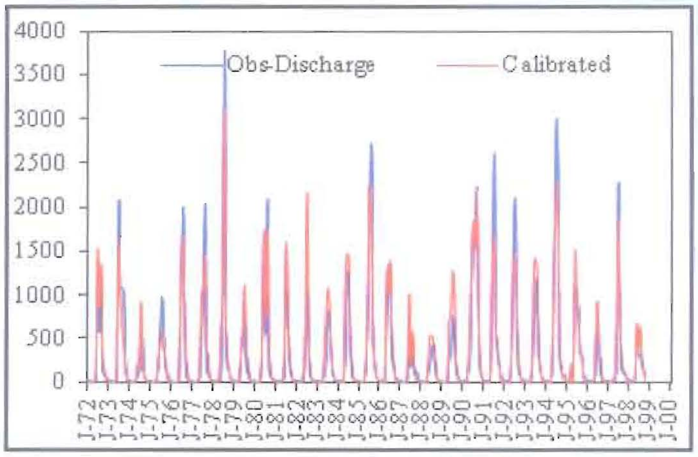


Fig. 2(b). Calibrated observed and simulated discharge of the Tel basin

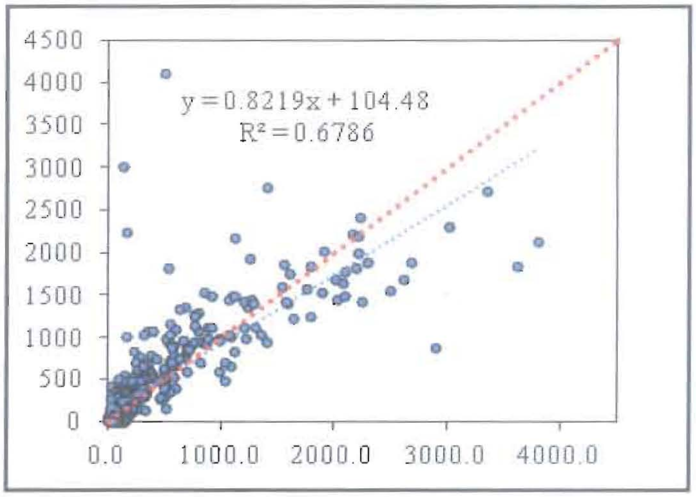


Fig. 3(a): Scatter plot showing pre-calibrated observed and simulated discharge;

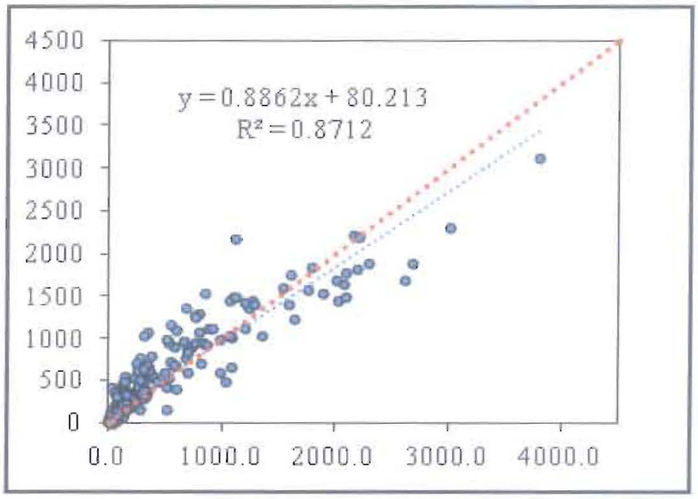
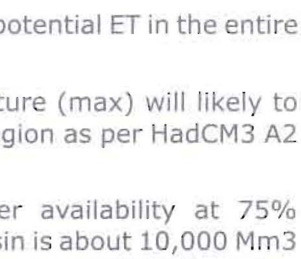


Fig. 3(b). Scatter plot showing calibrated observed and simulated discharge of the Tel basin physiography of the region with a clear ridge line dividing the Northern and Southern districts (Fig.3). Northern districts are 'land-locked' with less coastal influence (about 300-350 km away) in comparison to South parts (100-150 km from the sea). Also the northern region is exposed to intense irrigated agriculture due to Hirakud reservoir and presence of lot of industries since 2003-04, whereas the southern districts viz. Malkangiri and Koraput have dense forest coverage influencing the climate in the region. Soils in district of Nuapada and Kalahandi are mostly 'Black Cotton' with high clay content resulting in poor retention of rainfall.

The important findings from the study are:

1. Northern KBK region is getting drier (decreasing rainfall trend) whereas Southern KBK region is getting wetter.
2. Entire KBK region is 'warming', the Northern part is showing increasing rate of trend in last one decade, whereas Southern KBK region is showing a nearly constant rate of change in the temperature.
3. An increasing trend in the potential ET in the entire KBK region was noticed.
4. Precipitation and temperature (max) will likely to increase in future in the region as per HadCM3 A2 and B2 scenarios.
5. The average annual water availability at 75% dependability in the Tel basin is about 10,000 Mm3 sufficient to meet the water demand in the region with proper storage and water management practices.

Runoff modelling of Shyok River, Karakorum Range



Within the upper Indus region, the Shyok basin has the largest number of glaciers enumerated at 2454 covering a 10810 km^2. A discharge station equipped with radar water level recorder is established to monitor the discharge of Shyok River and to evaluate the hydrological characteristics and resource potential under climate change regime.

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4. Behera S., Khare, D., Mishra, P. K., and Sahoo, S (2016) "Impact of climate change on crop water requirement for Sunei Medium Irrigation project, Odisha, India", International Journal of Engineering Trends and Technology (IJETT) ISSN: 2231-5381, Volume 34, Number 8, *pp 358-367.*
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23. Thomas, T., Jaiswal, , R K., Galkate Ravi, Nayak, P.C and Ghosh, N. C. (2016), 'Drought indicators-based integrated assessment of drought vulnerability: a case study of Bundelkhand droughts in central India', Natural Hazards, 81(3), 1627-1652, DOI 10.1007/s11069-016-2149-8.

Workshop/ Conference/ Symposium/ Training attended by the Scientists/Staff

S.No.	Name of the Training Course	Date & Month	Place
1	Workshop on 'Introduction to Soil and Water Assessment Tool (SWAT) using open source tools'	Jan.4-9, 2016	IIT, Madras
2	Training on 'Hands on Advanced Instruments of Water Quality Testing'	Jan.11-15, 2016	NIH, Roorkee
3	Training on 'Climate Change Vulnerabilities and Adaptation Strategies'	Feb.8-12, 2016	ICFRE, Dehradun
4	Training on 'Design and Development of Digital Libraries using Dspace-Advance'	Feb.8-12, 2016	NISCAIR, Delhi
5	National Seminar on 'Conjunctive use of surface water and groundwater in major and medium irrigation project command area	Feb.11-12, 2016	Vijayawada
6	Workshop on 'Enhancing Organizational Performance	Feb.15-19, 2016	New Delhi
7	National Workshop on 'Technology Development and Application for climate change" The module on 'Application of Mathematical Modeling in Climate Change'	Feb.16, 2016	CSIR-NISCAIR, New Delhi
8	Training on 'Web Based Hydrological Tools'	Feb. 16-20, 2016	NIH, Roorkee
9	International Conference on 'Natural Resource Management Ecological Perspectives'	Feb.18-20, 2016	Sher-e-Kashmir Univ. Jammu
10	Training on 'A participatory assessment of vulnerability of watersheds and project areas to climate change (using software based tool)'	Feb.20-24, 2016	Watershed Org. Trust, Ahmednagar
11	International Conference on 'Disaster Mitigation and Management for Sustainable Development and Risk Reduction	Feb.22-24, 2016	NIT, Trichy
12	Training on 'Application of Isotopes in Hydrology and WR'	Feb.29-March 4, 2016	NIH, Roorkee
13	International Conference on 'Biodiversity Conservation and Pollution Control-Challenges and Strategies (BCPC-2016)	March 9-10, 2016	Univ. Of Jammu, Jammu
14	International Conference on 'Water Environment, Energy and Society (ICWEES-2016)	March 15-18, 2016	Bhopal
15	9th International Geographical Union (IGU) Conference on 'Land Use Change, Climate Extremes and Disaster Risk Reduction;	March 18-20, 2016	Univ. of Delhi, Delhi
16	National Seminar on 'Technology and Management of Micro Irrigation in Floriculture'	March 19-20, 2016	Jammu
17	Workshop on 'Climate Changes in Indian Sub-Continent with Special Reference to Himalayas	April 2, 2016	Faridabad
18	India Water Week-2016	April 4-8, 2016	New Delhi
19	Modern river management and history reconstruction with advanced fluvial remote sensing	April 9-10, 2016	IIT, Kanpur
20	National Symposium 'On Excellence in Training'	April 10-11, 2016	New Delhi
21	Training on 'Microwave Remote Sensing and Applications'	April 11-22, 2016	NRSC-ISRO Hyderabad
22	Workshop on 'Totality of project management leading to certificate in Project Management (CIPM)	April 11-13, 2016	Delhi

Organization of Workshops/ Training Courses/ Seminar/ Symposium

S.No.	Name of Seminar/Workshop/Training Course	Date	Place
1.	Hands on training on "Advanced Instruments of Water Quality Testing"	Jan. 11-15, 2016	Roorkee
2.	Disaster Risk Reduction and Resilient Livelihoods as a part of the Kosi Basin Program	Feb.4-5, 2016	Patna
3.	Training on 'Investigations, Assessment, and Management for sustainable groundwater development of coastal aquifers'	Feb. 9-13, 2016	Kakinada
4.	'Training Needs Assessment (TNA) & PDS' under NHP	Feb. 15, 2016	Roorkee
5.	'Training Needs Assessment (TNA) & PDS' under NHP.	Feb. 19, 2016	Chandigarh
6.	'Training Needs Assessment (TNA) & PDS' under NHP	Feb. 25, 2016	CWPRS, Pune
7.	'Training Needs Assessment (TNA) & PDS' under NHP	Feb. 26, 2016	Kolkata
8.	'Training Needs Assessment (TNA) & PDS' under NHP	March 3, 2016	Bangaluru
9.	Training course on 'Application of Isotopes in Hydrology & Water Resources'	Feb.29- March 4, 2016	Roorkee
10.	Training Needs Assessment and Purpose Driven Studies	March 2, 2016	WRDO, Anand Rao Circle
11.	Training course on "Application of CROPWAT Software".	March 8-11, 2016	HIRMI, Kurukshetra
12.	Training course on 'Hydrologic Modeling using RS/GIS with special Reference to Climate Change' funded by National Water Mission	March 28-31, 2016	Roorkee
13.	Workshop on 'Water Quality Assessment and Management of Lentic Water Bodies'	March 9-11, 2016	Belgaum
14.	Instrumentation and Techniques for Operation of Silt Observation Post (SOP)	25-29 April, 2016	Jammu
15.	Training course on "Use of modeling techniques, GIS and remote sensing" for state irrigation engineers of Rajasthan state.	May 02-06, 2016	Roorkee

Mass Awareness

S.No.	Activities	Organised by & Date
1	World Water Day Workshop	22nd March, 2016 at WHRC, Jammu
2	Earth Day 2016: Trees for the Earth	22nd April, 2016 at CFMS, Patna
3	Flood Safety Week	1-7 June, 2016 at CFMS, Patna
4	World Environmental Day	5th June, 2016 at CFMS, Patna

Other News

Institute Important Meetings

1. 35th Annual General Meeting held at New Delhi during 10 March, 2016
2. 44th Working Group Meeting, held at Roorkee during 18-19 April, 2016.

Retirement

1. Dr. Avinash Agarwal, Scientist G
2. Sh. Dayanand, Technician Grade-II

Training course on 'Hands on Advanced Instruments of WQ Testing

Training course on 'Application of Isotopes in Hydrology and Water Resources

Hindi Workshop

35th Annual General Meeting

44th Working Group Meeting

Training Course on 'Web Based Hydrological Tools'

Training course on 'Use of Modeling Techniques, GIS and RS

44th Working Group Meeting

RS/GIS with special reference to Climate Change

India Water Week

India Water Week

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