

Satellite-Based Geospatial Products and Services under the National Hydrology Project: Close-Out Summary Report



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16	Abstract: This report highlights the National Remote Sensing Centre's (NRSC) extensive contributions to the National Hydrology Project (NHP) through the development and operationalization of Earth Observation (EO)-based tools and platforms for enhanced water resource management in India. It presents nine major initiatives encompassing glacial lake outburst flood (GLOF) risk assessment, snowmelt runoff forecasting, evapotranspiration monitoring, irrigation scheduling, national hydrological modelling, flood early warning, and drought assessment. These efforts leverage satellite data, hydrological models, and field validations to deliver real-time, scalable, and actionable insights. A web-enabled platform, HydroSight, serves as the central repository for disseminating the resulting products and services. Capacity building through targeted training programs has also been a key component, fostering widespread adoption and skill development. Collectively, these initiatives represent a transformative, technology-driven approach to sustainable and resilient water governance in India. Keywords: National Hydrology Project, Glacial Lake Outburst Flood, Snowmelt Runoff, Evapotranspiration, Irrigation Scheduling, Hydrological Modelling, Flood Early Warning, Hydrological Drought				

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Project Team

Executive Summary

The **National Remote Sensing Centre (NRSC)**, as a key central implementing agency under the **National Hydrology Project (NHP)**, has spearheaded the development and operationalization of Earth Observation (EO)-based systems aimed at transforming the landscape of water resource management in India. The overarching goal has been to enhance the quality, accessibility, and utility of hydrological information through advanced remote sensing technologies, modelling frameworks, and user-centric platforms. This report presents a comprehensive account of nine major activities and the creation of an integrated geoportal that collectively address various dimensions of India's hydrological challenges.

Among the prominent initiatives, NRSC undertook a detailed **Glacial Lake Outburst Flood (GLOF) risk assessment** across the Indian Himalayan region. A vast inventory of 28,043 glacial lakes was generated using high-resolution satellite data, followed by prioritization based on a multi-criteria framework. Fifteen lakes were selected for in-depth hydrodynamic modelling to simulate potential GLOF scenarios, resulting in the generation of flood hazard and risk maps which also incorporated downstream infrastructure vulnerability. These efforts culminated in the publication of comprehensive Glacial Lake Atlases for the Indus, Ganga, and Brahmaputra basins. In parallel, a **Spatial Snowmelt Runoff Product** was developed for the Indian Himalayas, employing an energy balance approach that integrates satellite-derived snow cover, albedo, and temperature data to forecast snowmelt runoff over a three-day horizon. This initiative significantly contributes to water availability estimation, hydropower planning, and reservoir management during the crucial snowmelt season.

The **Evaporative Flux Monitoring System** was operationalized to estimate Actual Evapotranspiration (AET) across India using a combination of satellite observations and meteorological data. A network of ten Open-path Eddy Covariance towers ensures validation, while long-term AET datasets and derived indices such as Potential Evapotranspiration (PET), Moisture Adequacy Index (MAI), and Evaporation Stress Index (ESI) products generated support agricultural planning and drought monitoring. To improve irrigation efficiency, NRSC implemented a satellite-based decision support system in the **Narayanpur Command Area, Karnataka**. The system, named IRrigation Information System (IRIS), leverages EO data and weather forecasts to map crops, estimate irrigation requirements, and evaluate irrigation performance, thereby enabling equitable and optimal water distribution across the command.

At the national scale, NRSC established a **Hydrological Modelling System** using the Variable Infiltration Capacity (VIC) model to simulate water balance components such as soil moisture, runoff, and evapotranspiration. This model integrates data from 150 major reservoirs and supports inflow forecasting, soil moisture anomaly assessment, and operational water resource decision-making. To democratize hydrological modelling, NRSC in collaboration with IIT Madras, developed a **web-enabled SWAT-based platform** known as HUMID (Hydrologic Unit Model for InDia). This system allows stakeholders to simulate hydrological scenarios at the watershed scale using preloaded national datasets. Customized analytical tools facilitate

irrigation planning, water harvesting assessment, and capacity building through hands-on training programs.

For flood risk mitigation, NRSC has built a **Real-time Spatial Flood Early Warning System** for the Godavari and Tapi basins, integrating space-based rainfall data, high-resolution terrain models, and reservoir operations. These models offer flood forecasts with over 85% accuracy and up to 50 hours lead time, enhancing the preparedness of disaster management agencies. In the realm of drought monitoring, NRSC developed a suite of hydrological drought indices, including the **Standardized Runoff Index (SRI)**, **Reservoir Storage Index (RSI)**, **Groundwater Index (SGWI)** and **Water Spread Index (SWSI)**. These indices are synthesized into a **Composite Hydrological Drought Index (CHDI)**, providing a multi-faceted view of drought severity across surface, subsurface, and groundwater resources. The products are delivered in GIS-compatible formats with low latency, enabling near real-time drought monitoring and mitigation planning.

To complement these technical advancements, NRSC placed strong emphasis on **capacity building** by conducting 32 training programs from 2017 to 2025, training 739 officers from 47 implementing agencies across India. These programs, covering remote sensing and GIS fundamentals and water resource applications, achieved a high satisfaction rating of over 90%. Finally, all geospatial outputs from these projects are seamlessly integrated and made accessible via **HydroSight**, a web-based portal hosted on Bhuvan. This portal serves as a one-stop platform featuring eight dedicated modules addressing flood early warning, drought monitoring, glacial lakes, snow cover, evapotranspiration, irrigation scheduling, hydrological modelling, and HUMID.

Through this multi-dimensional approach combining advanced geospatial technology, operational modelling, and stakeholder engagement, NRSC has significantly advanced the mission of the NHP. The initiatives outlined in this report exemplify how Earth Observation data can be harnessed to deliver actionable intelligence for **resilient, data-driven, and sustainable water resource management** across India.

1. Introduction

The National Hydrology Project (NHP), initiated by the Ministry of Jal Shakti with World Bank assistance, aims to improve the extent, quality, and accessibility of water resources information. NRSC's involvement focuses on developing Earth Observation (EO)-based applications and tools to monitor, analyse, and visualize key hydrological parameters. NRSC's role also centres on the development and deployment of space-based hydrological tools and services to support basin-level planning and real-time water management. This report presents a summary of the nine major activities executed by NRSC under NHP and also on the geoportal platform developed for dissemination of these information products.

1.1 About the National Hydrology Project

The objective of NHP is to improve the extent, quality, and accessibility of water resources information, decision support system for floods and basin level resource assessment/planning and to strengthen the capacity of targeted water resources professionals and management institutions in India. All the activities under NHP were carried out under four major components to achieve these objectives.

A. Water Resources Monitoring System

This component will focus on improving the extent, timeliness and reliability of water resources data. It will finance the establishment or upgrading of new and existing hydromet data systems including meteorology, streamflow, groundwater and water storage measurements, together with construction of data centres that capture both water resources and uses. The component will be implemented by all state/UTs with the support of central implementing agencies.

B. Water Resource Information System

Component B will support strengthening of National and sub-national water information centres with web-enabled water resources information systems through standardization of databases and products from various data sources/departments; and make comprehensive, timely and integrated water resources information available to decision makers for effective planning, decision taking and operations. The sources of data/information will include the real time data acquisition networks and centres under Component A, remote sensing data, topographical maps and knowledge products developed under Component C.

C. Water Resources Operation and Planning System

This component will support the development of interactive analytical tools and decision support platform that would integrate database, models and scenario manager for hydrological flood forecasting, integrated reservoir operations and water resources accounting for improved operation, planning and management of both surface and groundwater. The component will provide interactive systems to analyse the impacts of alternative management scenarios and generate knowledge product using real time data under component B.

D. Water Resources Institutions Capacity Enhancement

Component D aims to build capacity for knowledge-based water resources management. It would support establishment of water resources knowledge centres, professional development, project management and operations.

1.2 NHP Implementing Agencies

Under the National Hydrology Project, implementation is carried out by multiple agencies across different administrative levels. These include 34 state implementing agencies, comprising surface and groundwater departments or organizations of various states, 2 union territories, 9 central government organizations, and 3 river basin organizations. The National Remote Sensing Centre (NRSC) is one of the central implementing agencies contributing to the project.

2. Overview of Activities

As part of the National Hydrology Project (NHP), the National Remote Sensing Centre (NRSC) has undertaken a series of advanced Earth Observation (EO)-based studies aimed at enhancing water resource monitoring, assessment, and decision-making across India. These studies (Table 1) span the entire hydrological cycle—from the icy expanses of the Himalayas to drought-prone plains—addressing critical challenges such as glacial lake outburst floods, snowmelt runoff forecasting, evaporative loss estimation, irrigation management, reservoir inflow simulation, flood early warning, and hydrological drought monitoring. Each initiative is anchored in scientific rigor and operational relevance, integrating satellite data, field observations, and hydrological modelling frameworks. The studies have not only generated rich datasets and decision support tools but have also been deployed in real-time through user-friendly geoportal, HydroSight on Bhuvan Geoplatfrom, empowering water managers, planners, and policymakers. By combining geospatial innovation with stakeholder capacity building, NRSC's contributions under NHP offer a transformative model for data-driven, technology-enabled, and climate-resilient water governance in India. The following sections provide brief overview of each activity.

Table 1: List of major activities carried out by NRSC under NHP

Sl. No	Activity Name
1	Glacial Lake Outburst Flood (GLOF) Risk Assessment of Glacial Lakes in the Himalayan Region of Indian River Basins
2	Development of Spatial Snowmelt Runoff Product in the Indian Himalayas
3	Development of Satellite-based Regional Evaporative Flux Monitoring System for India
4	Satellite Inputs Based Irrigation Scheduling for Narayanpur Command Area, Karnataka State
5	Operational National Hydrological Modelling System
6	Web Enabled Hydrologic Modelling In SWAT
7	Real time Operational Spatial Flood Early Warning Systems for Godavari and Tapi basin
8	Operational Hydrological Drought Assessment
9	Customised RS&GIS Training and Capacity Building

3. Detailed Activity Summaries

3.1 Glacial Lake Outburst Flood (GLOF) Risk Assessment

The primary objective of this study is to conduct a risk assessment of critical glacial lakes in the Indian Himalayas concerning Glacial Lake Outburst Floods (GLOFs). The specific objectives are

- Generation of Glacial Lakes Inventory using high-resolution data.
- Ranking and Prioritization of Glacial Lakes based on various parameters.
- GLOF modelling and inundation mapping utilizing high-resolution Digital Elevation Model (DEM).

- Infrastructure mapping of selected glacial lakes and their surroundings using on high-resolution satellite data.
- GLOF risk assessment for 15 selected glacial lakes

Under this study a comprehensive assessment of Glacial Lake Outburst Flood (GLOF) risks across the Indian Himalayan region (Figure 1), covering a catchment area of 989,784 km² was conducted. This includes a detailed inventory of glacial lakes, ranking & prioritization of lakes, and hydrodynamic modelling to simulate potential GLOF scenarios for selected glacial lakes within the Indus, Ganga, and Brahmaputra River basins.

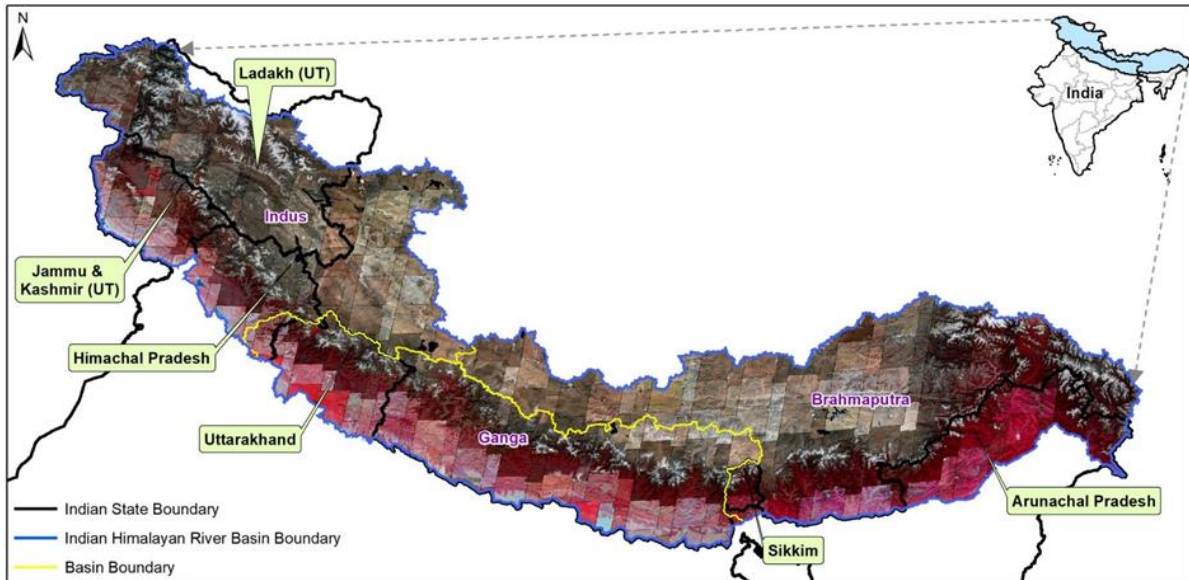


Figure 1: Location of Indian Himalayan River basins showing RS-2 LISS-IV images

A total of 28,043 glacial lakes (Table 2) were mapped along with 22 associated attributes across the Indian Himalayan River basins using high-resolution Resourcesat-2 (RS-2) LISS-IV satellite images. The inventory categorized lakes into four major types: Moraine-dammed, Ice-dammed, Glacier Erosion, and Other Glacial Lakes (Table 3). The study identified that over 93% of the lakes are located above 4,000 meters amsl (Figure 2), with 57.43% classified as Other Glacial Erosion Lakes. The Brahmaputra basin holds the highest number of lakes (64.19%), followed by the Indus (19.02%) and Ganga (16.78%) basins. Large lakes (≥ 50 ha) are concentrated in the Brahmaputra basin (207 out of 299), while the Indus basin contains the highest number of Supra-glacial Lakes. Approximately 27% of the lakes lie within the Indian region, with the remainder located in transboundary areas.

Table 2: Area range-wise distribution of Glacial Lakes (GL) in IHR Basins

S. No.	Lake Area Range (ha)	No. of Lakes	Total Lake Area	
			(ha)	(%)
1	0.25 - 0.5	6,284	2,244.06	1.71
2	0.5 - 1	6,252	4,473.30	3.41
3	1 - 5	10,631	24,370.94	18.59
4	5 - 10	2,445	17,180.97	13.11
5	10 - 50	2,132	41,281.30	31.50
6	> 50	299	41,520.33	31.68
Total		28,043	1,31,070.90	100.00

Table 3: Type-wise distribution of GL in IHR Basins

S. No.	Code	Types of Glacial Lake	No. of Lakes	Total Lake Area	
				(ha)	(%)
1	M(e)	End-moraine Dammed Lake	1,058	21,479.58	16.39
2	M(l)	Lateral Moraine Dammed Lake	363	1,145.38	0.87
3	M(lg)	Lateral Moraine Dammed Lake with Ice	56	118.33	0.09
4	M(o)	Other Moraine Dammed Lake	5,664	15,159.27	11.57
5	I(s)	Supra-glacial Lake	1,698	1,438.32	1.10
6	I(d)	Glacier Ice-dammed Lake	5	239.48	0.18
7	E(c)	Cirque Erosion Lake	1,286	11,467.10	8.75
8	E(v)	Glacier Trough Valley Erosion Lake	9	3,463.16	2.64
9	E(o)	Other Glacial Erosion Lake	16,106	61,228.37	46.71
10	O	Other Glacial Lake	1,798	15,331.89	11.70
Total			28,043	1,31,070.90	100.00

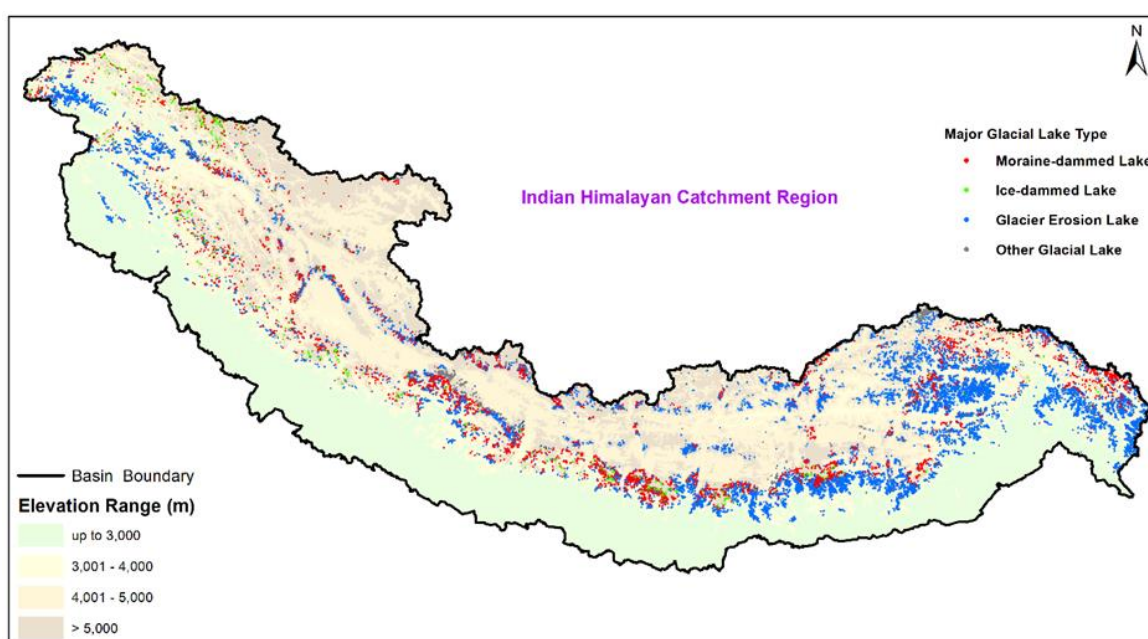


Figure 2: Elevation Range-Type-wise spatial distribution of GL in IHR Basins

The comprehensive inventory of glacial lakes prepared under this study was published in the form of basin-wise Glacial Lake Atlases for the Indus, Ganga, and Brahmaputra River basins, along with a combined atlas for the entire Indian Himalayan Region (IHR). These atlases provide detailed insights into the mapped glacial lakes, including their attributes, areal extent, elevation variations, and distribution across various administrative units at the basin, sub-basin levels.

The inventoried glacial lakes are prioritised based on a two-step process of preliminary screening and prioritization. In the preliminary screening phase, lakes were filtered sequentially based on key parameters such as lake type, size, association with a glacier, and whether contributing to the downstream water body. The prioritization phase involved a comparative assessment using multiple quantitative and qualitative methodologies, including equal and unequal weight methods, Analytical Hierarchy Process (AHP), and qualitative ranking approaches. The unequal weight method was ultimately chosen for finalizing the prioritisation process. This process led to the selection of prioritised lakes in each basin, which were then subjected to detailed GLOF modelling and risk assessment to evaluate potential flood scenarios (Figure 3) and generation of GLOF risk maps.

Fifteen prioritized glacial lakes (five in each basin) were selected for detailed hydrodynamic modelling using high-resolution Tandem-X 5m resolution Digital Terrain Model (DTM). Various simulations were carried out considering 100%, 75%, and 50% volume discharge, as well as 100% volume discharge under Probable Maximum Precipitation (PMP) conditions. Further, to analyse the potential impact of GLOF events, hazard and risk maps were generated for each modelled lake, integrating key flood wave characteristics such as depth, velocity, and flood wave arrival time. The risk classification categorized affected downstream areas into high, medium, and low-risk zones based on flood severity and flood wave arrival time. The mapped infrastructure in the downstream area such as bridges, roads, settlements, hydroelectric power plants, and agriculture fields were superimposed on the risk maps to assess risk associated with each of these elements. The detailed technical reports for all 15 prioritized lakes were prepared providing comprehensive insights into GLOF inundation modelling, and GLOF risk assessment for different scenarios.

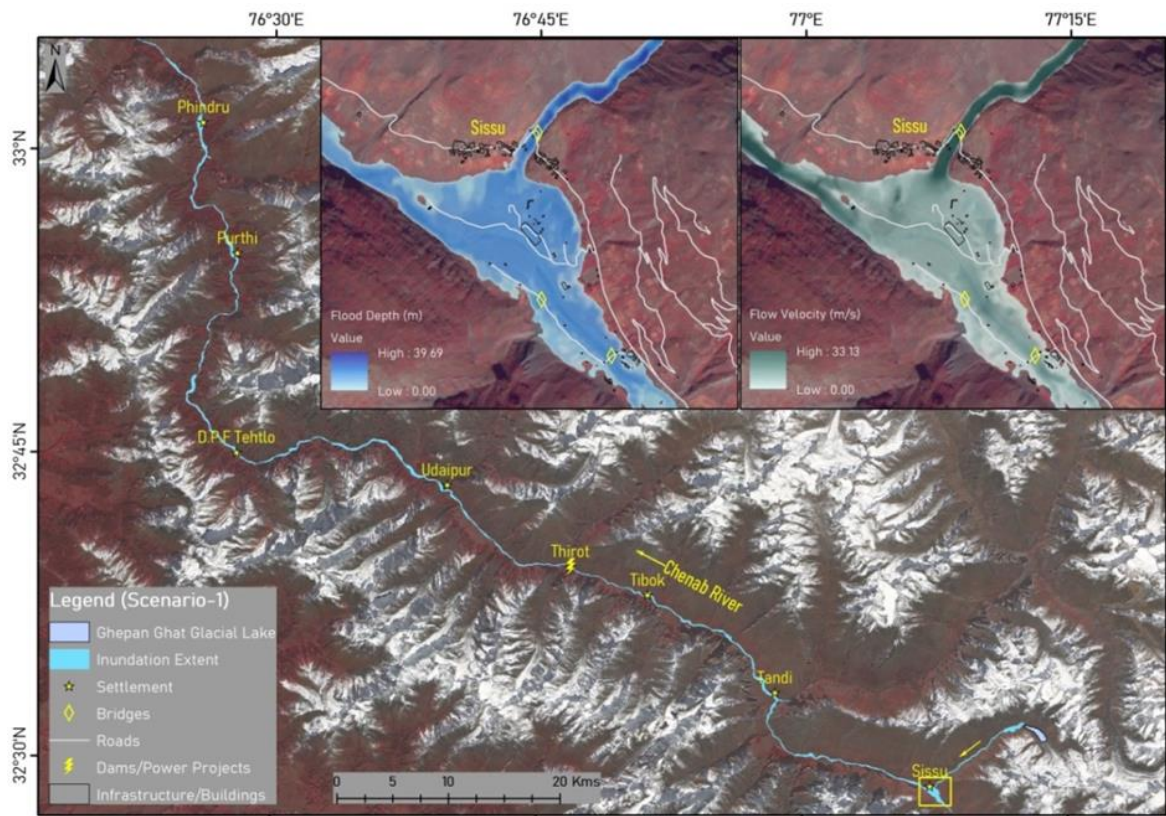


Figure 3: Map of Flood Inundation Extent for GLOF Scenario-1 for Ghepan Ghat Glacial Lake

3.2 Spatial Snowmelt Runoff Product for Indian Himalayas

The primary objective of the study is to develop a spatial snowmelt runoff product for the Indian Himalayan region (IHR) by utilizing satellite-derived inputs. The specific objectives are

- To develop a short-term snowmelt runoff forecasting model using satellite-derived inputs and field data
- To generate a spatial daily gridded snowmelt product
- To generate a spatial 3-day gridded snowmelt forecast products
- To provide short-term (3-day) snowmelt runoff forecast at selected basin outlets during the snowmelt season

This study was undertaken by leveraging remote sensing derived datasets for providing daily 3-day forecasts for snowmelt runoff during snowmelt season (April to June). This involves

development of energy budget-based snowmelt runoff forecast model for selected basins in Indian Himalayas.

A major achievement is the quantification of snowmelt runoff for selected river basin outlets (Figure 4) and the incorporation of meteorological forecast data to enable a 3-day forecast snowmelt rate and runoff. By adopting an energy balance approach, daily snowmelt rates are computed during the snowmelt season (April to June) using satellite-derived products such as snow cover, albedo, surface temperature, and amount of various atmospheric constituents. Satellite data from Suomi-NPP and INSAT-3D/3DR were used.

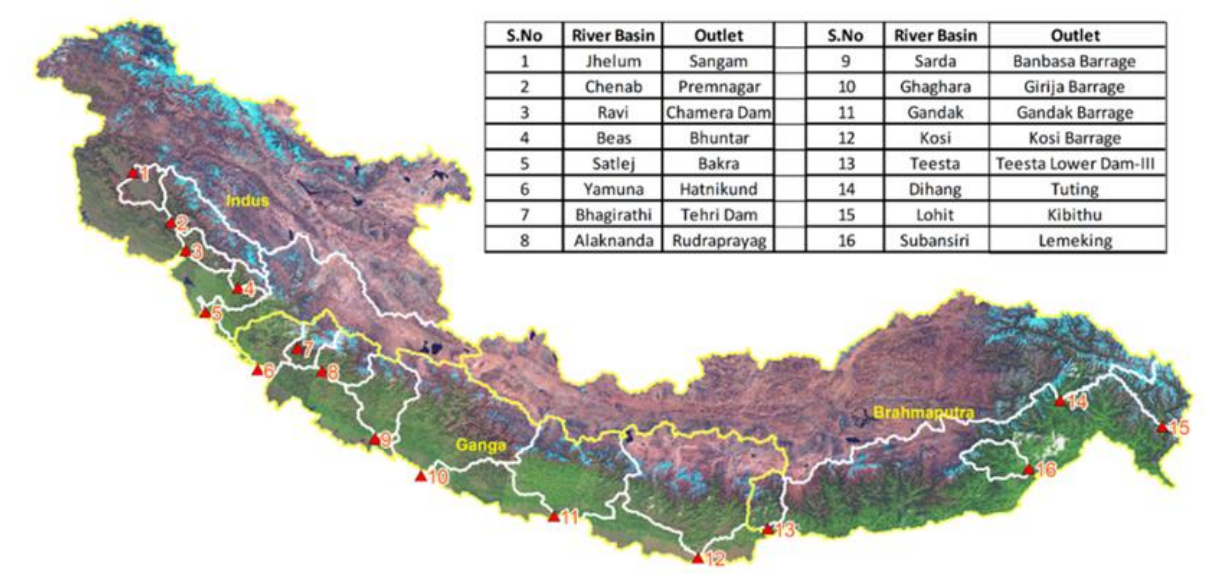


Figure 4 Satellite image of the study area overlaid with basins and outlets

The development of spatial snowmelt runoff model for Indian Himalayas, its automation and web application to host products on near-real time basis through Bhuvan-NHP geoportal provides widespread access and enables the download of products for usage by basin managers, decision makers and researchers. The application has tools for visualization and spatio-temporal analysis of daily snow cover, daily and forecast spatial snowmelt rates. The spatial snow cover (Figure 5 & Figure 6), forecast snowmelt rate and forecast snowmelt runoff (Figure 7) products generated as part of this project provide valuable insights for snow cover monitoring, water resource management, hydropower planning and infrastructure planning in the Indian Himalayan region, which are useful for concerned stakeholders like basin management boards and hydropower corporations for planning reservoir releases and assessment of hydropower potential, thus enabling tangible benefits to water resource management.

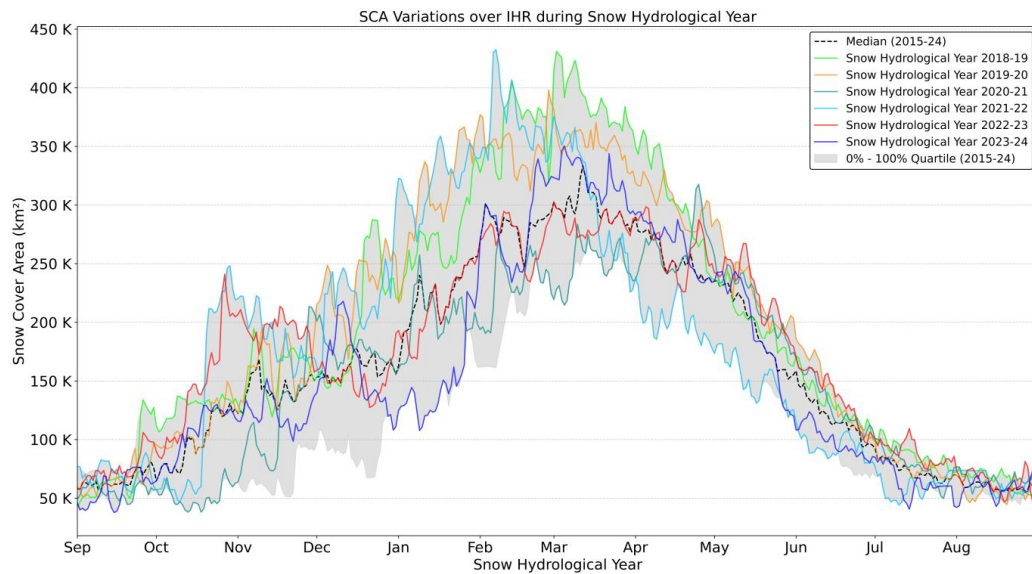


Figure 5 Daily SCA variations over IHR during SHY 2018-19 to SHY 2023-2024

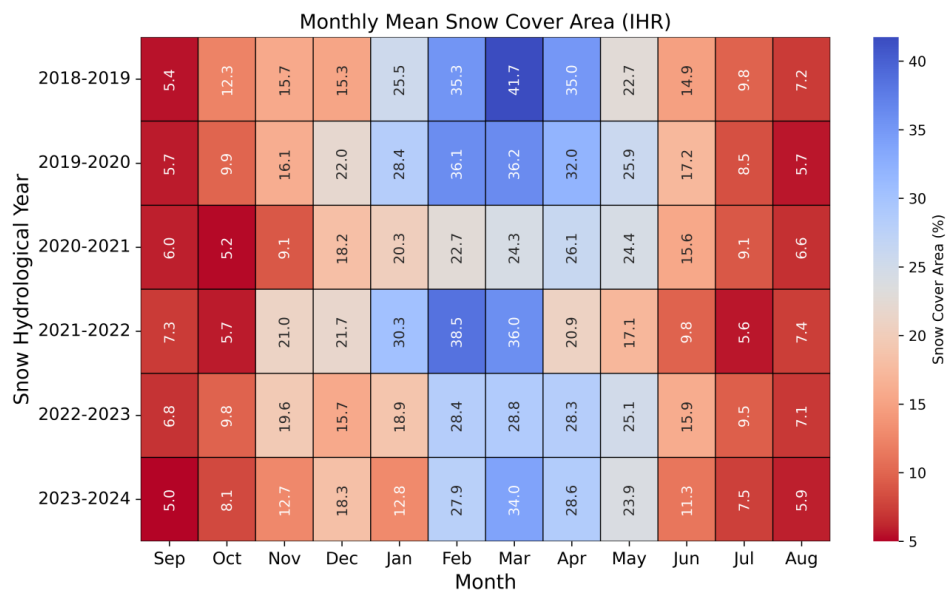


Figure 6 Monthly mean SCA (%) over IHR during SHY 2018-19 to SHY 2023-2024

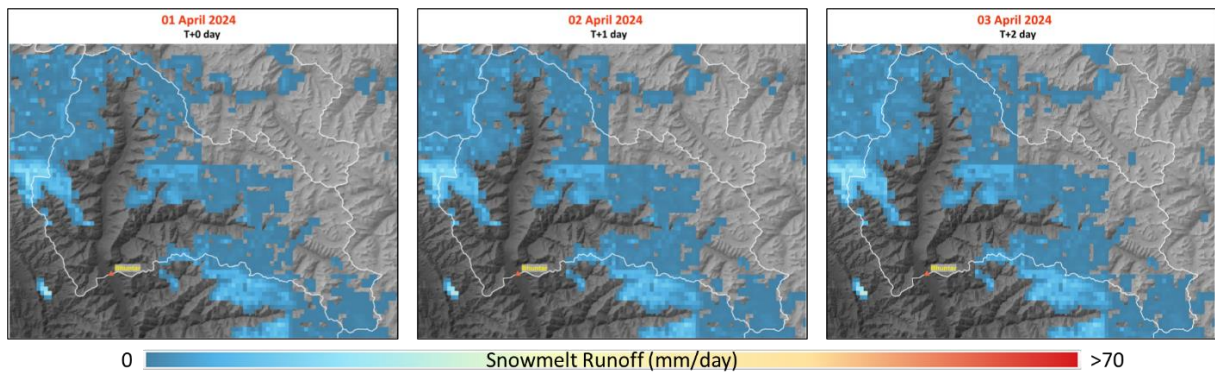


Figure 7 Spatial snowmelt forecast

The study integrated the satellite derived products with snowmelt runoff modelling to address water resource challenges and contributes to informed decision making in managing water resources in the Indian Himalayan region.

3.3 Satellite-based Regional Evaporative Flux Monitoring

The objectives of this study are

- Estimation of daily evaporative fluxes for Indian region at an appropriate spatial framework
- Development of evaporative flux observing and monitoring system at spatial scales of watersheds/river-basins and land use/land cover units and temporal scales.
- Creation of long-term data base of evaporative fluxes and design of structured query and analysis tools.

Evapotranspiration (ET) is a major component of the hydrological cycle. It plays a vital role in the sustainable agriculture practices and water resource management. ET data assist decision-makers with detailed insights into irrigation requirements of crops. Meeting crop water demands and enhancing yields become particularly challenging in the face of water scarcity. To address the need, an operational Satellite-based Evaporative Flux Monitoring System for India was developed. The evaporative flux monitoring system is required to monitor evaporative demand at different spatial (watershed, basin, sub basins, command area, administrative scale) and temporal (daily, fortnightly, and monthly) scales.

Under this project, a methodology was developed for the generation of Actual Evapotranspiration (AET) product using remote sensing (Suomi NPP, INSAT 3D/3DR and Cartosat-1) and meteorological datasets (IMD and NOAA). AET product was generated based on surface energy balance approach and Contextual Model (CM) based Priestly-Taylor (PT) algorithm.

To ensure the reliability of the satellite-derived ET estimates, the NRSC has deployed Open-path Eddy covariance (OPEC) systems across various agro-ecological regions of India. These ground-based instruments play a critical role in validating the satellite data and facilitating the operational generation of ET products. Ground based ET observation is used for evaluation of satellite-based surface energy balance components and validation of ET estimates. Operational AET product is being generated for Indian region at 750 m and 5500 m spatial resolution with daily (Figure 8), fortnightly (Figure 9) and monthly (Figure 10) temporal resolution.

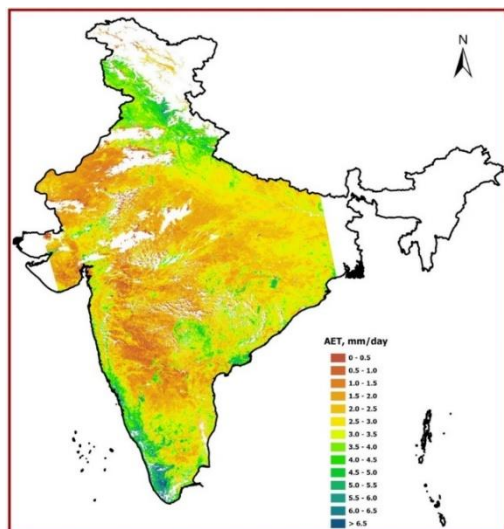


Figure 8: Daily AET for 12 April 2023

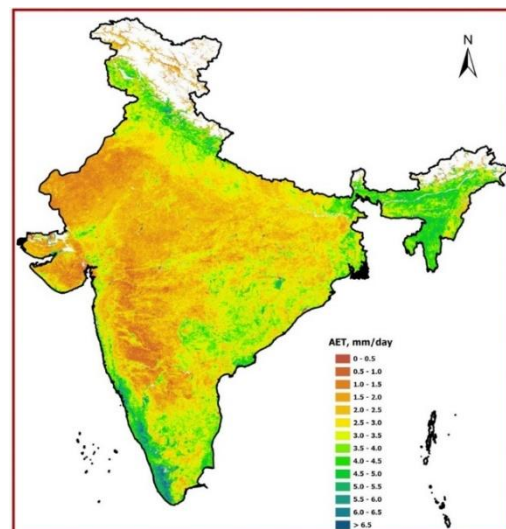


Figure 9: Fortnightly average AET for 2nd fortnight April 2023

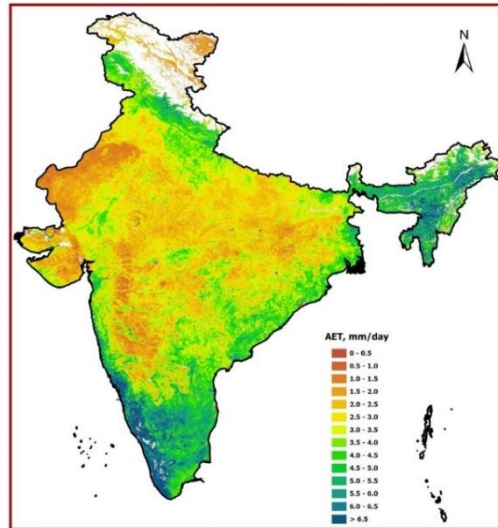


Figure 10: Monthly average AET for June 2023

A data base is generated for the AET products, available from 2015 onwards (Figure 11 & Figure 12). Products are hosted on the Bhuvan NHP HydroSight portal (URL: <https://bhuvan.nrsc.gov.in/nhp/webgis-et/map>). Along with AET three additional derived products: Potential Evapotranspiration (PET), Moisture Adequacy Index (MAI), and Evaporation Stress Index (ESI) were also generated and available on ET geoportal.

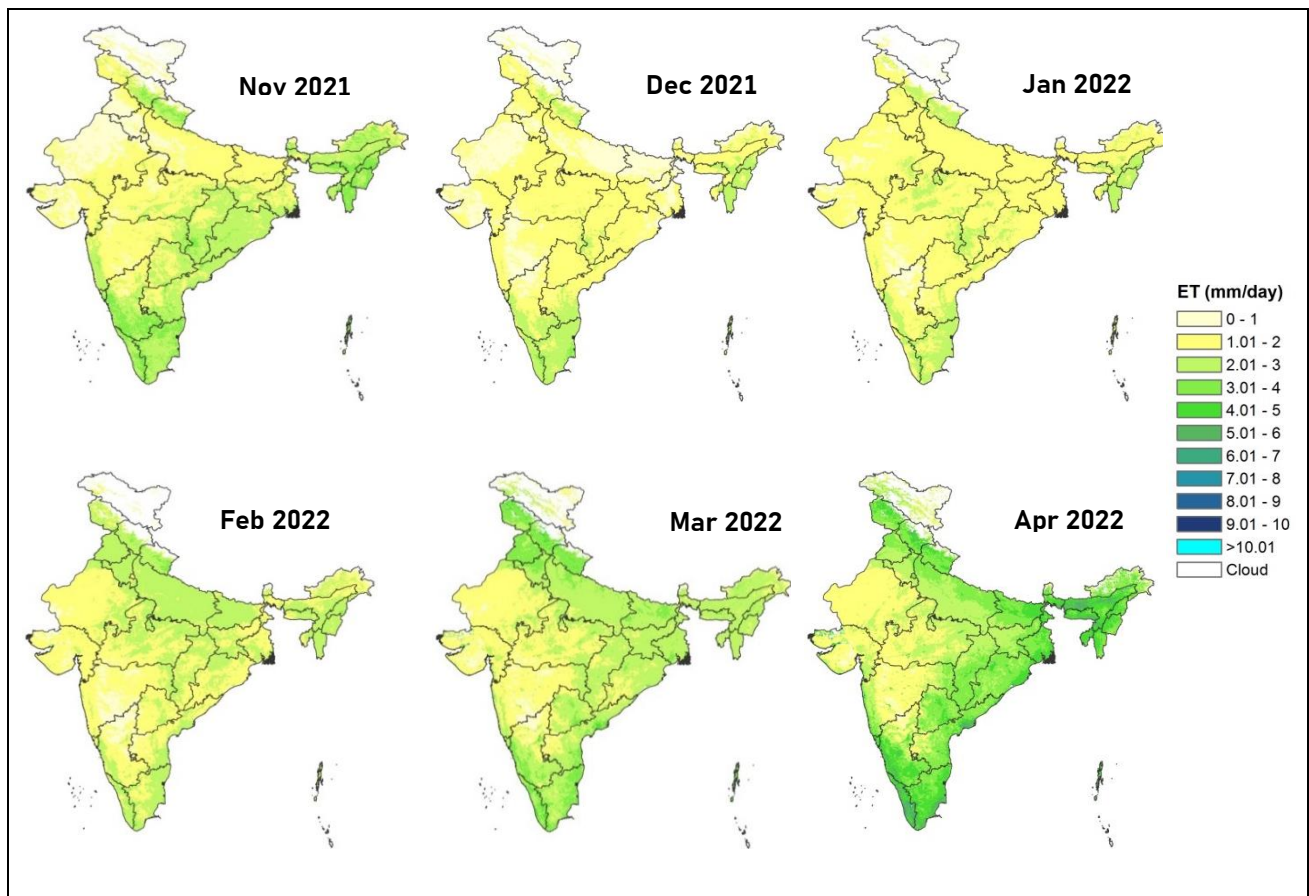


Figure 11: AET variation for Rabi season 2021-22

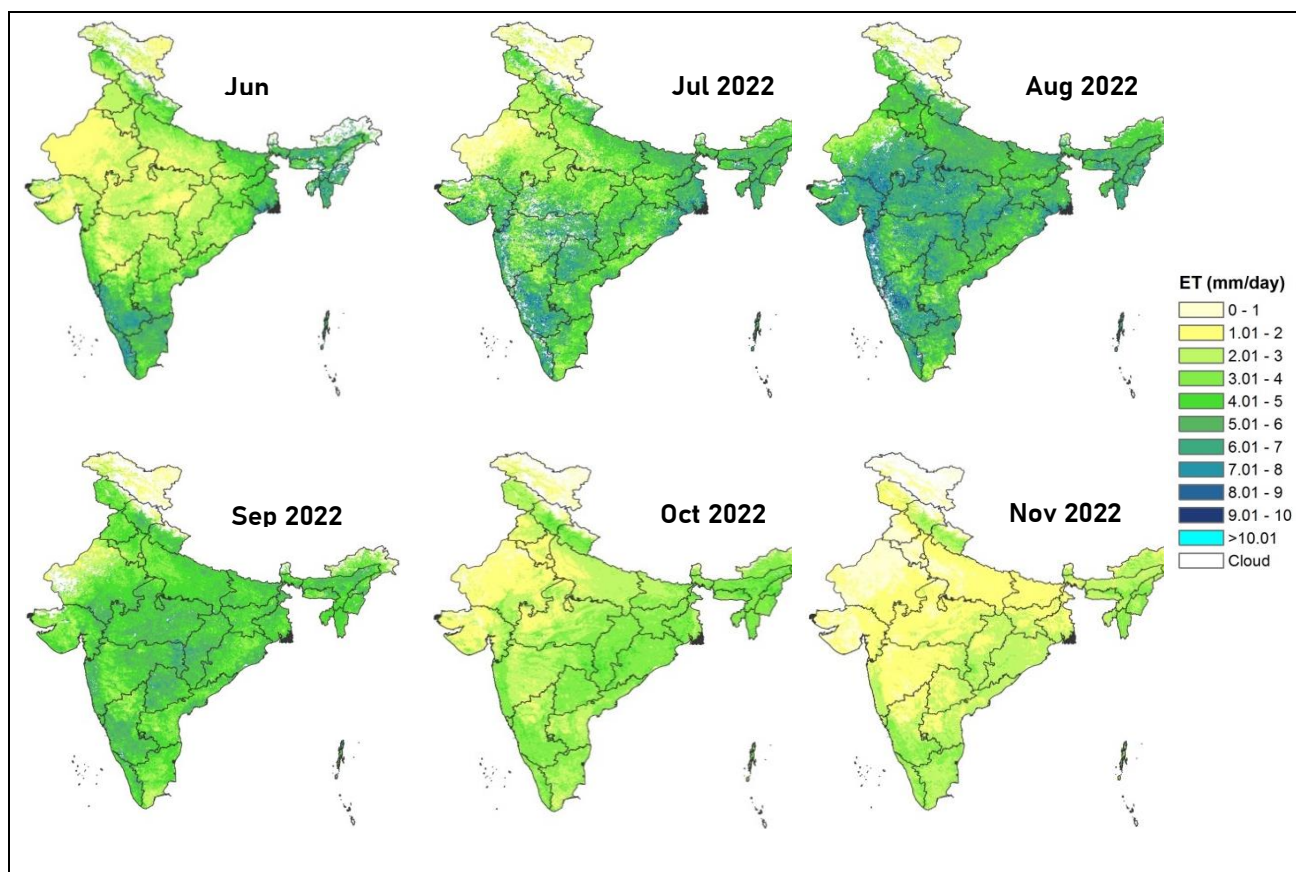


Figure 12: AET variation for Kharif season 2022

Long-term AET database was generated from 2004 onwards using MODIS data. This will allow researchers and policy-makers to assess trends in evaporative flux over time and gain insights into the effects of climate change, land use, and water management practices. These AET products can be utilised for crop water requirement, irrigation scheduling, water resources management, drought assessment, crop phenology monitoring, ecosystem health assessment and climate studies. AET product can also be utilized to address the crop stress condition, sub seasonal drought condition, water availability scenarios and long-term monitoring of evaporative demand in real world applications of water resources and agriculture sectors.

NRSC established a comprehensive ET monitoring network across ten (10) different agro ecological zones in the country. This network consists of 10 Open-path Eddy Covariance flux tower (OPEC) and one Large Aperture Scintillometer. OPEC flux tower setup includes two sensors like rapid and slow responses whose arrangement includes a CO₂ / H₂O open-path gas analyzer (IRGASON-EB-IC) and 3D Sonic Anemometer (Wind Sonic 60, Gill Ultra Sonic Wind Sensor) to simultaneously monitor wind speed, temperature, humidity, CO₂ and H₂O levels. According to the height of the crop these sensors are mounted. Four-component net radiometer (CNR 4) which is positioned at 2.5 to 3 m above the ground level is used to measure the net radiation. HygroVUE10-L17 probe (CSL Temperature/RH Probe) records the air temperature and RH which is located at a height of 2 m. every five minutes data is recorded and averaged to 30 minutes and logged in to the CR1000X data logger. Soil moisture is measured at 15, 30, and either 45 or 60 cm below the ground surface using CS655-L33ft-PT-DS reflectometers (12 cm Water Content Reflectometer). While Hukseflux Soil Heat Flux Plates (HFP01-L33ft-PT) sensor is adjusted at 10 and 30 cm, which measures soil heat flux. TE525-L12ft-PT tipping bucket rain gauge is used to measure the precipitation. Flux tower network (10 OPEC systems) is integrated with Bhuvan NHP flux tower

dashboard as shown in Figure 13. Data logger consists of on-board processor which transmits data to Bhuvan server in near real time. Near real time sensor observation can be visualized for all flux tower sites as shown in Figure 14.

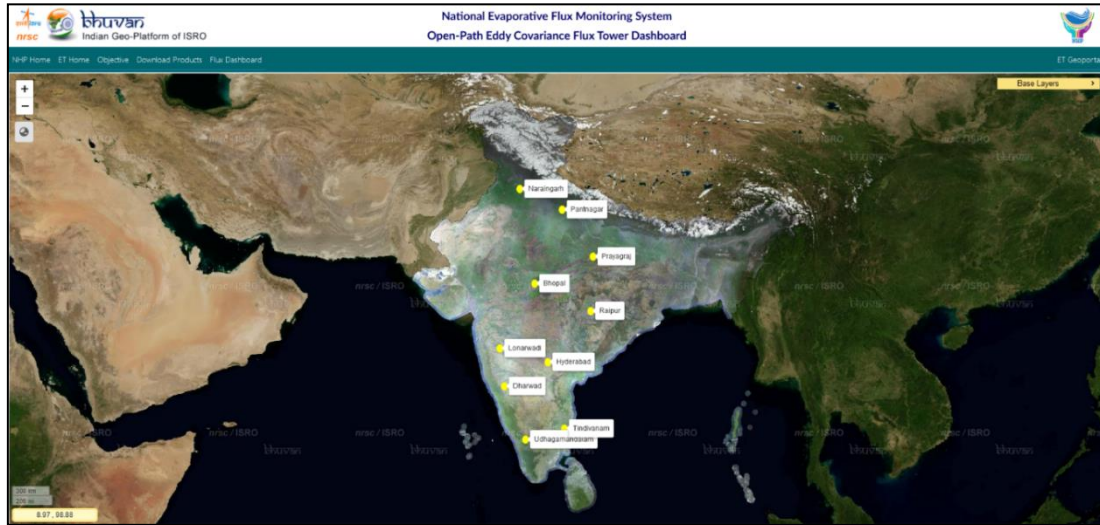


Figure 13: Flux dashboard

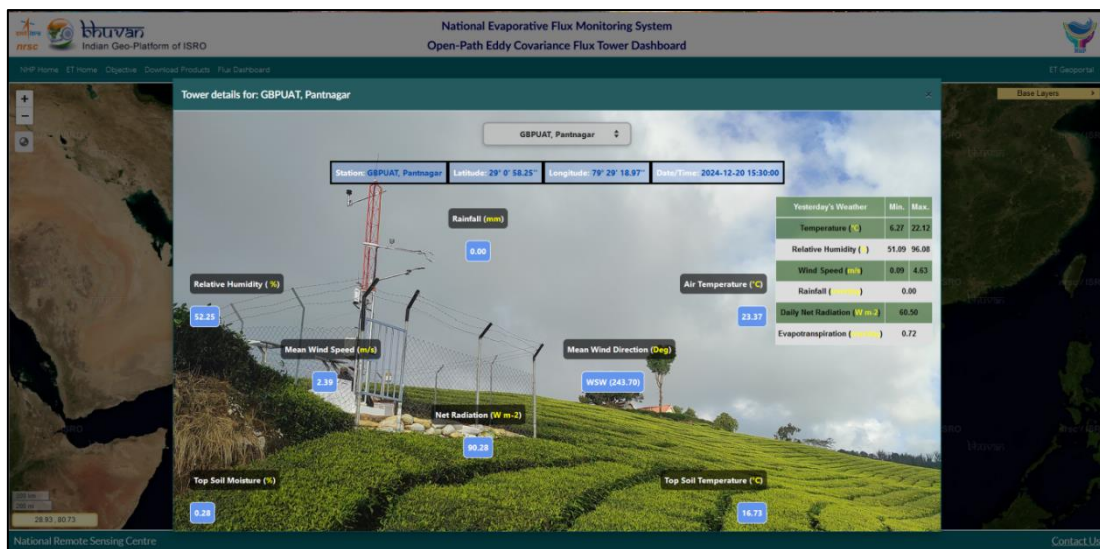


Figure 14: Visualization of flux tower sensor observation in near real time

3.4 Satellite-based Irrigation Scheduling for Narayanpur Command, Karnataka

The objectives of the study are

- Generate in-season cropping pattern and crop condition information using near-real-time satellite data for Rabi season in a command area.
- Estimate field and canal level irrigation requirement at weekly/fortnightly time-step for Rabi season in a command area.
- Assess the performance variations across the command area and evaluate the performance of irrigation system for Rabi season in a command area.
- Development of Decision Support System for Irrigation Scheduling in a Command Area

Efficient irrigation management is crucial for sustainable agriculture, particularly in water-scarce regions. Under NHP a comprehensive study was conducted on satellite inputs-based irrigation

scheduling for the Narayanpur command area in Karnataka state (Figure 15). This project has led to the development of the IRrigation Information System (IRIS). IRIS serves as a Decision Support System (DSS) that integrates Earth observation data and meteorological forecasts to enhance irrigation planning and improve water use efficiency.

IRIS maps crop type and extent at fortnightly intervals throughout the Rabi season using medium-resolution satellite imagery and machine learning classification techniques (Figure 16). It estimates volumetric irrigation requirements based on real-time and forecasted meteorological data, considering evapotranspiration and water balance modelling. The system enables precise regulation of water distribution at various canal levels, optimizing irrigation scheduling and minimizing inefficiencies. Additionally, periodic assessments of irrigation system performance (Figure 17) using satellite-derived evapotranspiration data help identify underperforming distributaries, allowing timely corrective measures to enhance agricultural productivity.

Successful implementation of IRIS (Figure 18) in the Narayanpur Command Area, Karnataka, has demonstrated its potential for improving irrigation efficiency. The system ensures equitable water distribution, prevents excessive water release, and enhances canal operation management. It has facilitated better water governance by providing a structured approach to irrigation scheduling, ensuring that water reaches the intended fields without undue losses. Furthermore, the system's ability to assess variations in crop water demand enables targeted interventions, reducing over-irrigation and conserving water for critical periods.

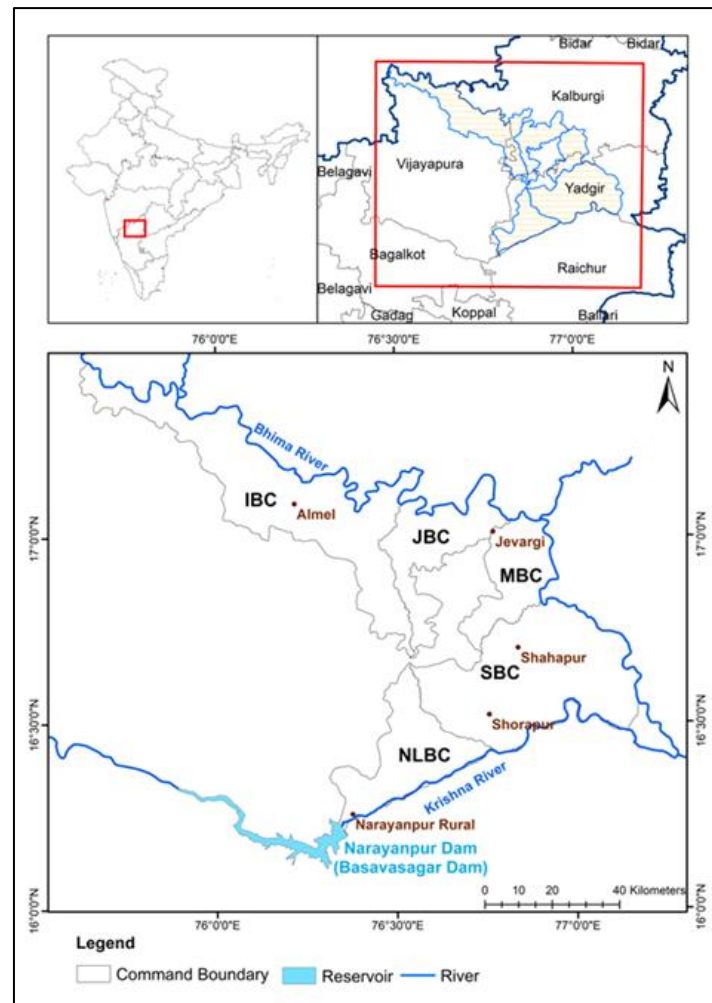


Figure 15: Command Area of Narayanpur Irrigation Project

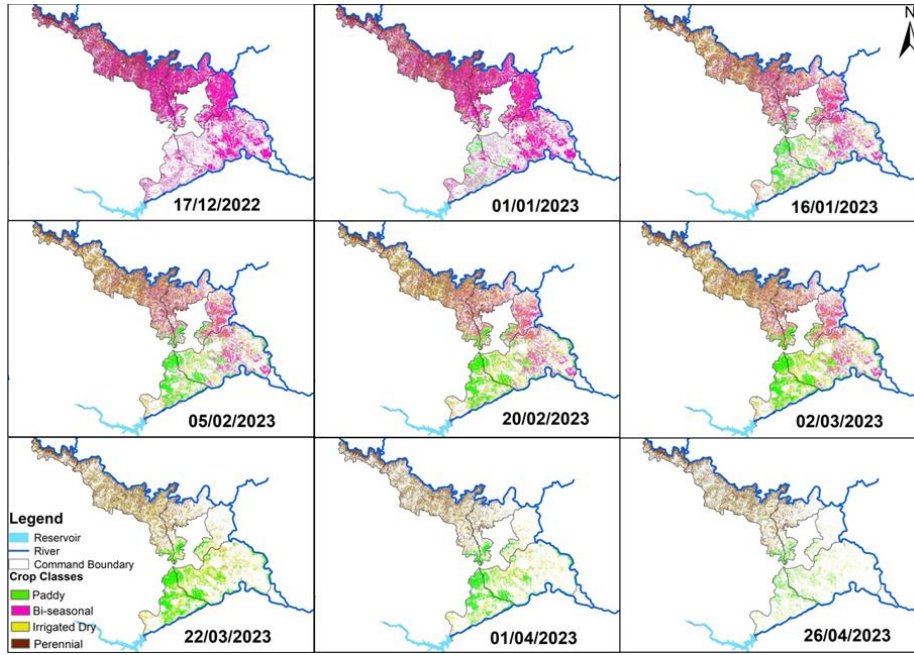


Figure 16: In-season crop maps for the study year 2022-23

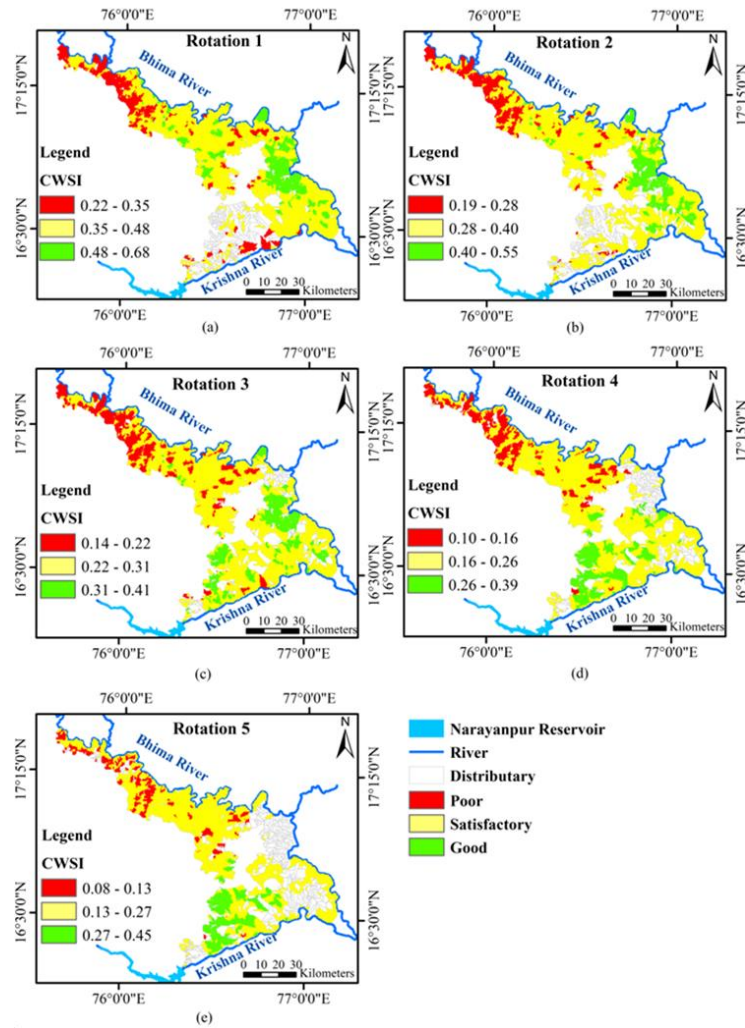


Figure 17: CWSI computed for Rabi 2021-2022 (a) Rotation 1 (b) Rotation 2 (c) Rotation 3 (d) Rotation 4 (e) Rotation 5

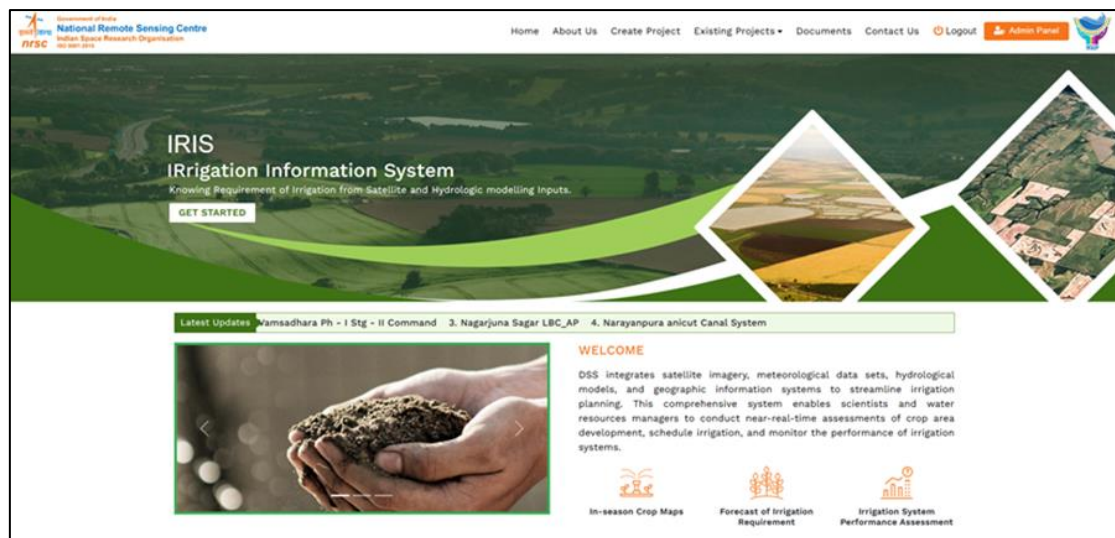


Figure 18: Home Page of IRIS (Irrigation Information System)

The integration of remote sensing, hydrological modelling, and real-time analytics within IRIS (Figure 19) establishes a comprehensive framework for modernizing irrigation management. Systematic adoption across command areas will significantly enhance water resource sustainability, ensuring optimal utilization and long-term agricultural resilience. By fostering data-driven irrigation practices, IRIS contributes to water conservation efforts while improving farm-level productivity, ultimately supporting national food security and sustainable agricultural development.

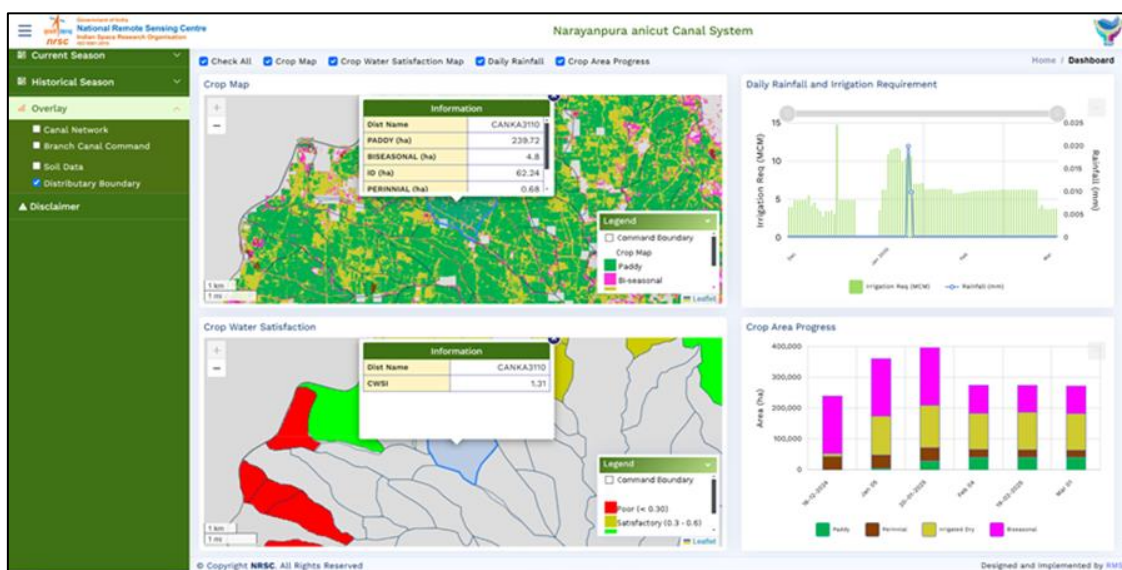


Figure 19: Information visualization in IRIS

3.5 Operational National Hydrological Modelling System

The primary objective of this study is to develop a national-level hydrological modelling framework that integrates geospatial and hydro-meteorological datasets to simulate key hydrological processes and generate value-added products for informed water resource management. The specific objectives take up under this project are:

- To establish national-level hydrological modelling framework for in season hydrological fluxes estimation at a daily time step.

- To setup a comprehensive field experimentation network for the calibration and validation of model computed soil moisture.
- To provide forecasting of inflows into important reservoirs of India.
- To develop a web-enabled hydrological flux information system for the entire country on Bhuvan.

As part of this study, a national-level hydrological modelling framework using the Variable Infiltration Capacity (VIC) model was developed at a 5.5 km grid resolution to estimate daily hydrological fluxes. Model input parameterization was carried out using various geospatial datasets, including Digital Elevation Model (DEM), NBSSLUP soil map of India, and NRC-250k land use land cover information, along with meteorological data obtained from the India Meteorological Department (IMD). The model simulates grid-wise water balance components such as surface runoff, soil moisture, and evapotranspiration (Figure 20) at a daily time scale for the entire country, providing a comprehensive overview of hydrological fluxes. The model computed discharge was calibrated using observed streamflow data from Central Water Commission (CWC) gauging stations at various locations, ensuring accurate simulation of streamflow dynamics.

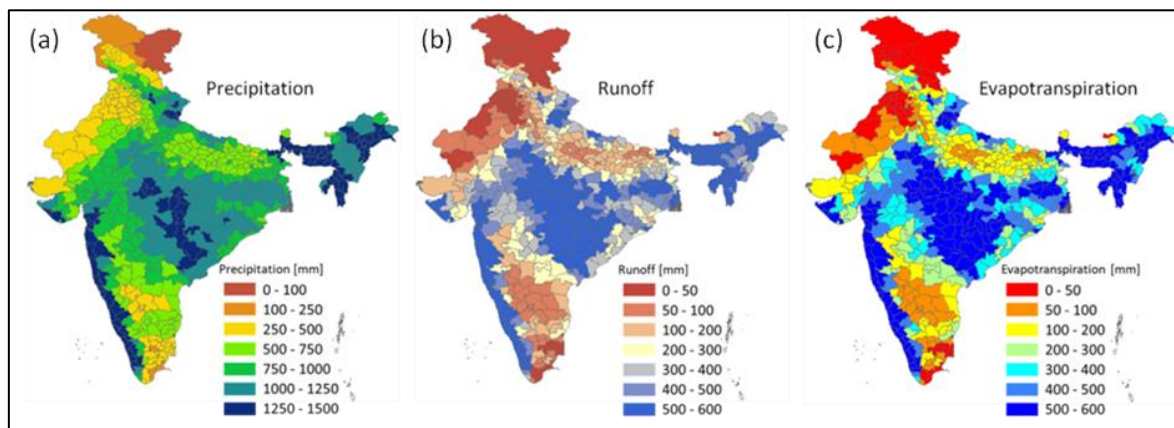


Figure 20: Seasonal (June to September) water balance components for the year 2024

To enhance the model's reliability, a field-based soil moisture validation network (Figure 21) was established by deploying 10 Permanent Soil Moisture (PSM) probes and 2 Cosmic Ray Soil Moisture Observation Stations (COSMOS) across diverse agro-climatic regions. The VIC model was validated against in-situ soil moisture data obtained from PSM probes and satellite-derived soil moisture products (Figure 22), demonstrating good agreement with the model-simulated soil moisture. The validation results showed Nash-Sutcliffe Efficiency (NSE), Kling-Gupta Efficiency (KGE), and Coefficient of Determination (R^2) ranging between 0.55 and 0.85, indicating the model's reliability and accuracy in capturing soil moisture dynamics.

A key highlight of the project was the incorporation of 150 important reservoirs into the modelling framework to simulate reservoir inflows and water storage dynamics. The model simulates daily reservoir water balancing and releases are based on the operating rule curves for each reservoir. The inflow simulations were performed considering upstream reservoirs and their respective release rule curves. The reservoir inflow estimates were validated against observed inflows for the Krishna, Cauvery, Godavari, Mahanadi, and Narmada basins, demonstrating a significant improvement in model efficiency with the inclusion of upstream reservoirs. The results showed enhanced statistical metrics, including R^2 , NSE, and KGE. Furthermore, 3-day inflow forecasts are also provided for 150 important reservoirs and river discharge estimates at 59 unrestricted river gauge locations, supporting operational water management and decision-making. The model

effectively captured the impact of upstream storage on downstream inflows, ensuring reliable reservoir inflow forecasts for operational decision support.

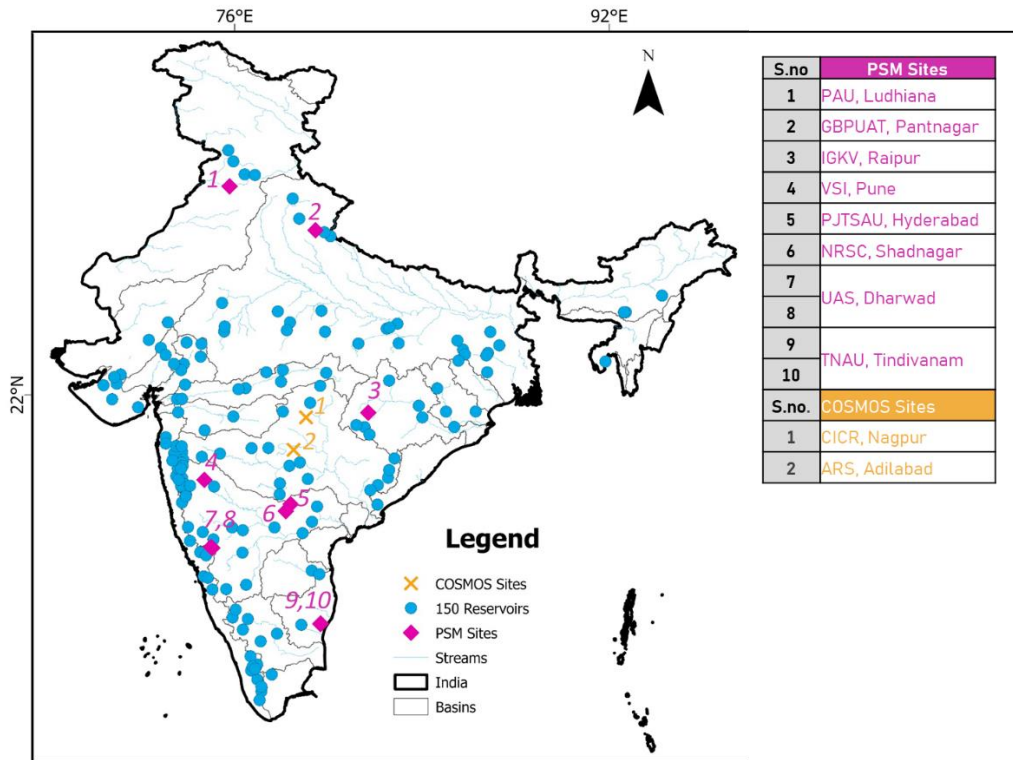


Figure 21: Study area with locations of PSM, COSMOS and 150 important reservoirs

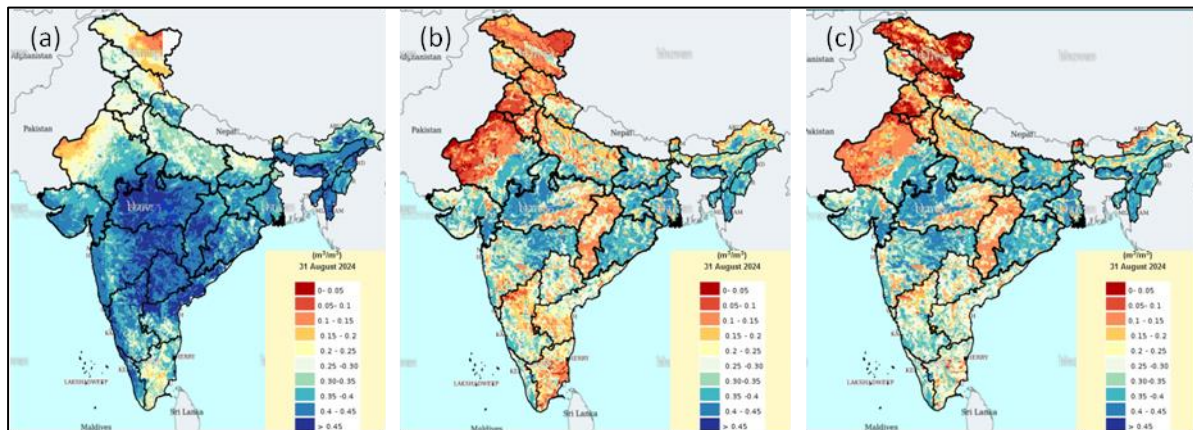


Figure 22: Sample Soil Moisture at different depths for the entire India as on 31st August 2024

The Soil Moisture Availability Index (SMAI), defined as the ratio of Available Water Content (AWC) to Water Holding Capacity (WHC) was calculated using the root zone soil moisture (0-50 cm depth) estimates. The SMAI was spatially averaged at the district level, providing spatially distributed soil moisture anomalies, aiding in drought assessment.

3.6 Web-enabled SWAT Modelling System

The objectives of this study are

- Develop a web enabled interactive hydrological modelling system which facilitates online computation of hydrological fluxes at watershed scale for all river basins of India

- Develop customized analysis tools in the system to plan for water harvesting structures, irrigation planning and water availability assessment.
- Capacity Building through seminars and workshops for the utilization of web enabled hydrologic modelling system, in collaboration with NRSC.

Recognizing the need for efficient hydrological modelling, the National Remote Sensing Centre (NRSC) and the Indian Institute of Technology Madras (IIT-Madras) collaborated to develop the Hydrologic Unit Model for InDia (HUMID). This web-based interactive hydrological modelling system (Figure 23) is designed to streamline watershed modelling for India's river basins, leveraging the capabilities of the Soil and Water Assessment Tool (SWAT). HUMID offers a user-friendly and efficient platform by integrating preloaded geospatial datasets, including land cover, soil properties, topography, and meteorological parameters, sourced from Indian databases. This integration significantly reduces the burden on users, allowing them to focus on hydrological analysis rather than data pre-processing. The system supports real-time computation of hydrological fluxes, enabling stakeholders to analyse water resource availability and assess the impact of different land and water management practices (Figure 24). Additionally, customized analytical tools are embedded within HUMID to facilitate irrigation planning, evaluation of water harvesting structures, and hydrological scenario assessments. These features (Figure 25) empower users with enhanced decision-making capabilities in water resource management.



Figure 23: HUMID web based interactive water quantity modelling system
(<https://bhuvan.nrsc.gov.in/humid/>)

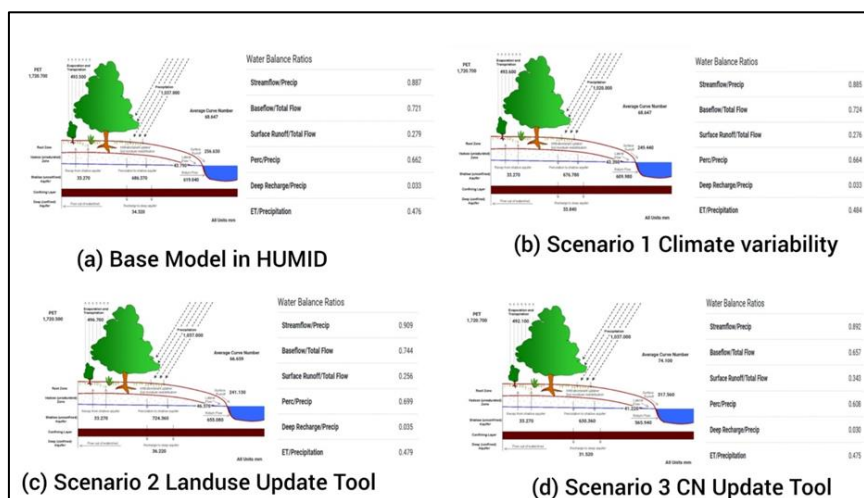


Figure 24: SWAT Check Water Balance Ratios for Base model and different Scenarios in HUMID

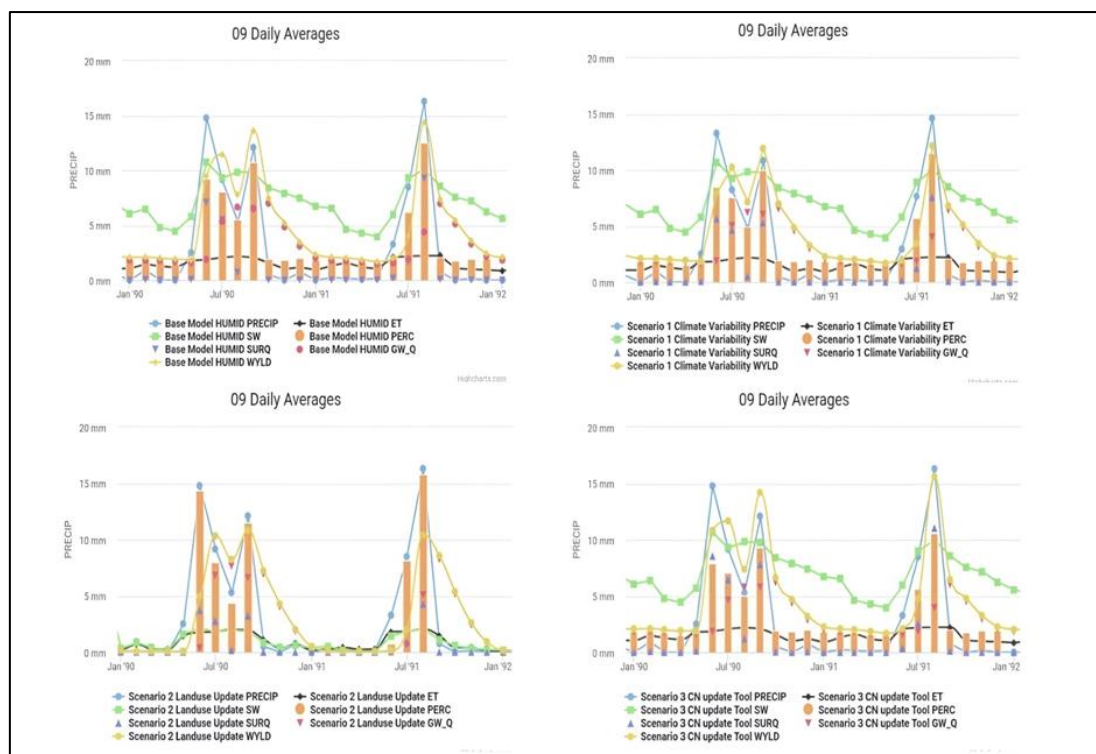


Figure 25: Plots showing the water balance components for base model vs. different scenarios

Over the years, the project has achieved significant milestones. During the 2021–22 periods, foundational activities such as geomorphological analysis, automated crop calendar development, and database preparation for SWAT modelling were successfully completed. By 2022–23, the HUMID system was fully developed, rigorously tested at IIT-Madras, and deployed on the Bhuvan server—a geospatial data portal developed by NRSC. The first version of HUMID was officially launched in July 2022, introducing multi-scenario hydrological analysis capabilities. In the subsequent phase (2023–24), efforts were initiated to develop HUMID version 2.0, which extended the model framework to the Indus, Ganga, and Brahmaputra basins and incorporated additional analytical tools to refine water resource assessments.

Training and outreach have played a crucial role in the success of the HUMID project. Two Regional workshops were organized for state and central agencies, offering hands-on experience with the system. These workshops not only facilitated knowledge transfer but also strengthened institutional capacity in hydrological planning and water resource management. By equipping users with the necessary technical skills, the initiative has fostered a more data-driven approach to water resource planning.

3.7 Real-time Spatial Flood Early Warning for Godavari and Tapi

The overall objective this study to provide flood forecasts and inundation maps using models and satellite inputs. The specific objectives are

- To develop medium-range flood early warning models for the major floodplains of Godavari and Tapi river basin using space-based inputs through hydrological modelling approach.
- To develop spatial flood inundation simulation models using high resolution ALTM DTM in the major floodplains of the rivers and Carto 10 m DEM for other prominent flood plains.
- To develop web-enabled real-time spatial flood early warning system.

- To develop workflow mechanism for issuing flood advisory to the concerned disaster management authorities during the flood event.
- Scientific assessment of flood prone areas in Godavari River under different return periods

The development of medium-range spatial flood early warning models for large catchments, such as the Godavari Basin in India, presents a considerable challenge. Recognizing the national importance of such efforts, the National Remote Sensing Centre (NRSC) has developed spatial flood forecast models for the Godavari (Figure 26) and Tapi (Figure 27) Basin using space-based inputs. These models have been meticulously calibrated and validated with historical discharge and rainfall data provided by the Central Water Commission (CWC) and the India Meteorological Department (IMD). The use of very high-resolution DTMs in spatial flood early warning models represents a significant advancement in flood risk management. This technology enables the generation of spatial flood alarms prior to flood events, offering sufficient lead time for preventive measures. Web-enabled fully automated spatial early warning systems are developed for Godavari (Figure 28) and Tapi (Figure 29) River and are run on operational basis in real-time with data support from CWC and IMD. The results are disseminated through NDEM and Bhuvan-NHP geoportal. One of the key innovations in this field is the integration of reservoir operations and the use of very high-resolution Digital Terrain Models (ALTM DTM) in spatial flood early warning systems. Additionally, these advanced systems are designed to operate autonomously, minimizing the need for manual intervention.

Spatial flood early warning using very high-resolution Digital Terrain Models (ALTM DTM) is a new dimension to the conventional flood early warning. These models can give spatial flood alarm prior to the flood event with sufficient lead time that can minimize the damage to property and life. Apart from this, these models also provide flood depth and its velocity in spatial domain, which are very vital inputs in flood damage assessment. Flood discharge forecast accuracy is found to be more than 87% with a lead time of 36-50 hours at downstream forecast station (Koida). Inundation simulation accuracy (simulated using ALTM DTM) is also found to be more than 85% (Figure 30). This study will help in improving the flood forecasting lead time (2 days and more) with more accurate flood discharge computations in spatial domain. Flood early warning systems provide critical information to stakeholders, including government agencies, emergency services, businesses, and the public. They enable efficient resource allocation, protect assets, enhance safety, support preparedness, and relief and rescue operation, ultimately reducing the impact of floods on lives and infrastructure.

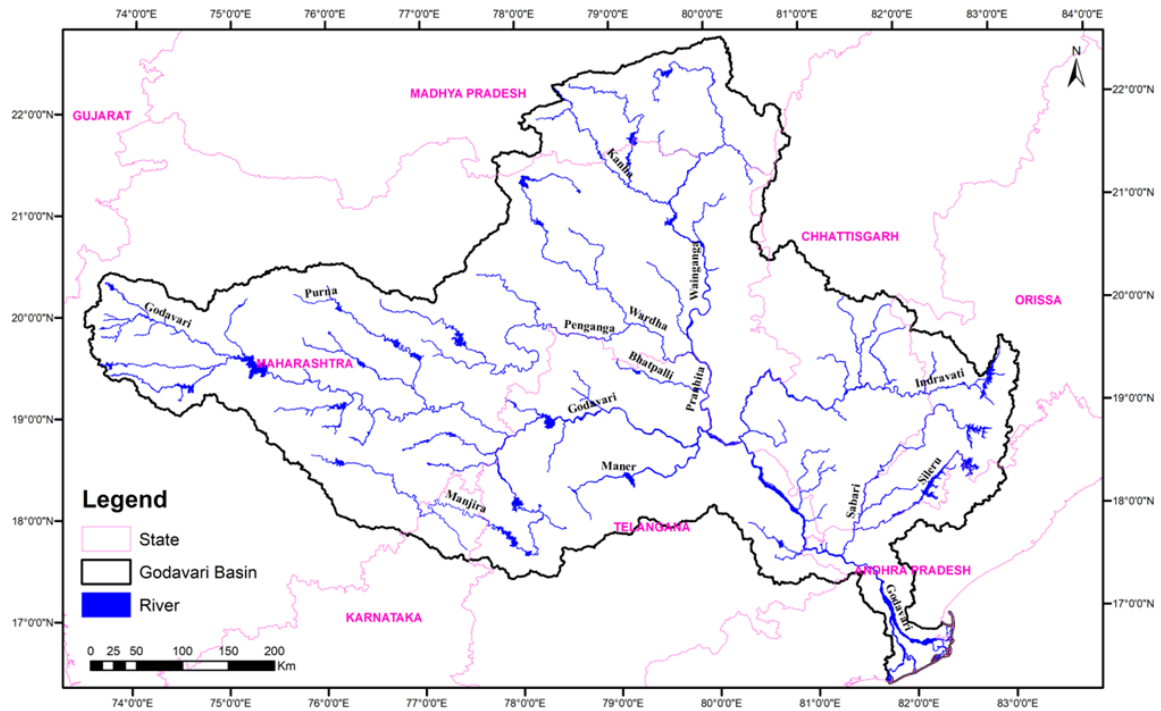


Figure 26: Geographical and Hydrological setting of Godavari basin

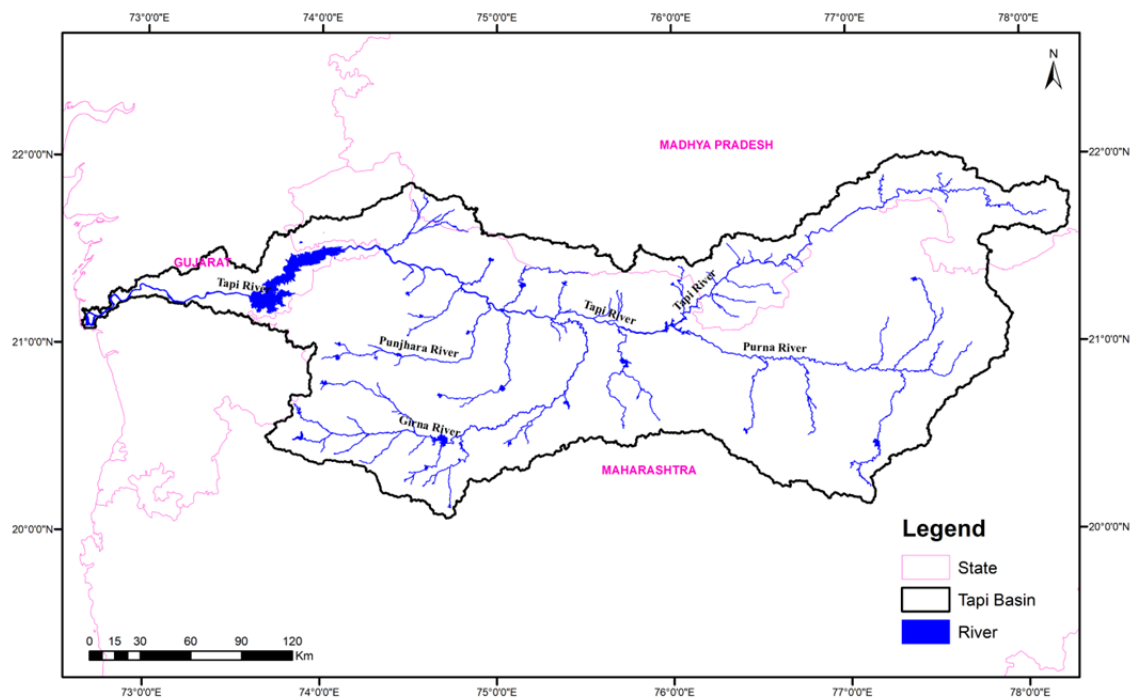


Figure 27: Geographical and Hydrological setting of Tapi basin

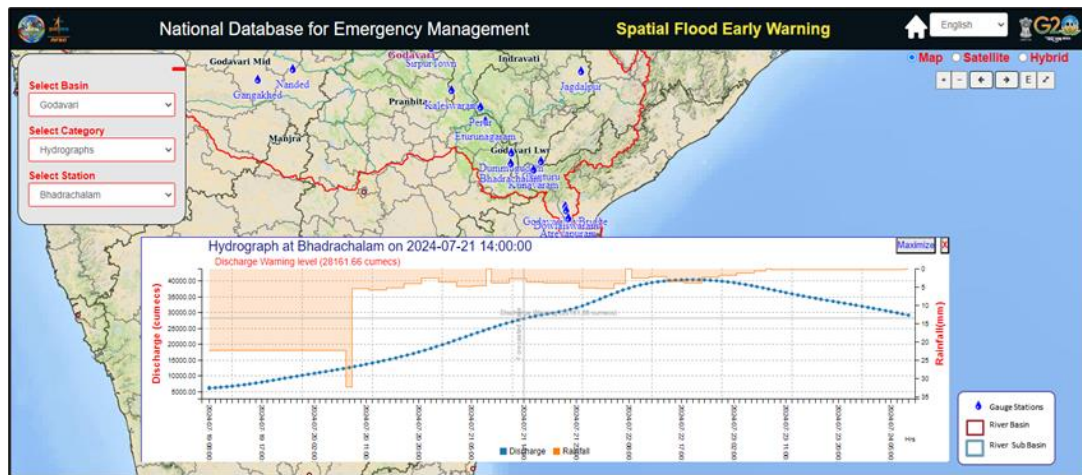


Figure 28: Flood forecast for Godavari River at Bhadrachalam station (21 July-2024)

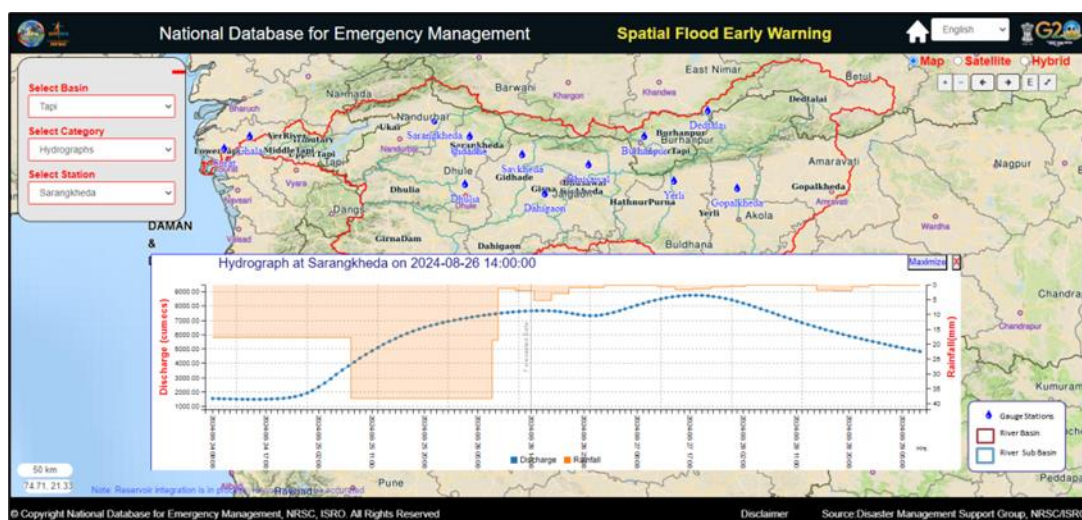


Figure 29: Flood forecast for Tapi River at Gidhade station (26 July-2024)

3.8 Operational Hydrological Drought Assessment

The objectives of the study are:

- To characterize spatiotemporal variability of hydrological drought for entire India
- To provide hydrological drought indices based on geospatial data, hydrological model outputs and observational/field data
- To provide operational hydrological drought services

This study aims to provide a comprehensive and accurate framework for monitoring hydrologic drought across the Indian region. In this project four standardized indices—Standardized Runoff Index (SRI), Standardized Reservoir Storage Index (SRSI), Standardized Groundwater Index (SGWI), and Standardized Water Spread Index (SWSI)—each representing a critical component of the hydrological cycle were used. Additionally, a Composite Hydrologic Drought Index (CHDI) was developed, which integrates these indices for a holistic evaluation of drought conditions. These indices are derived from specific datasets and geographic scales, allowing for enhanced spatial and temporal resolutions.

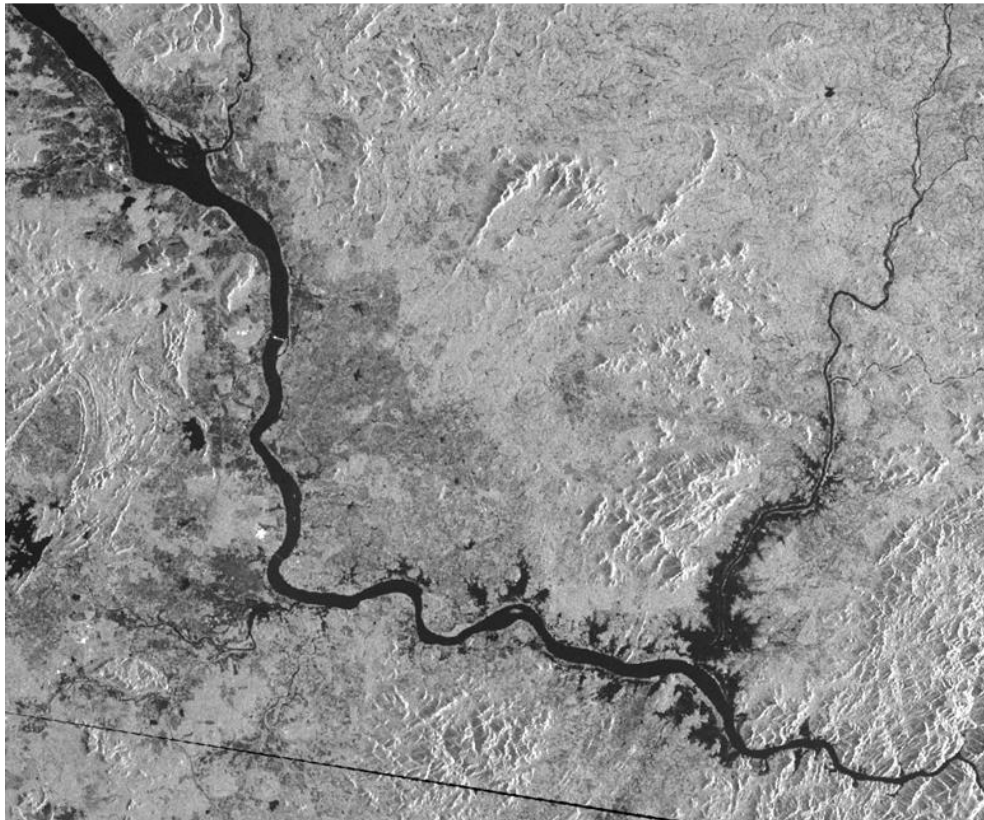
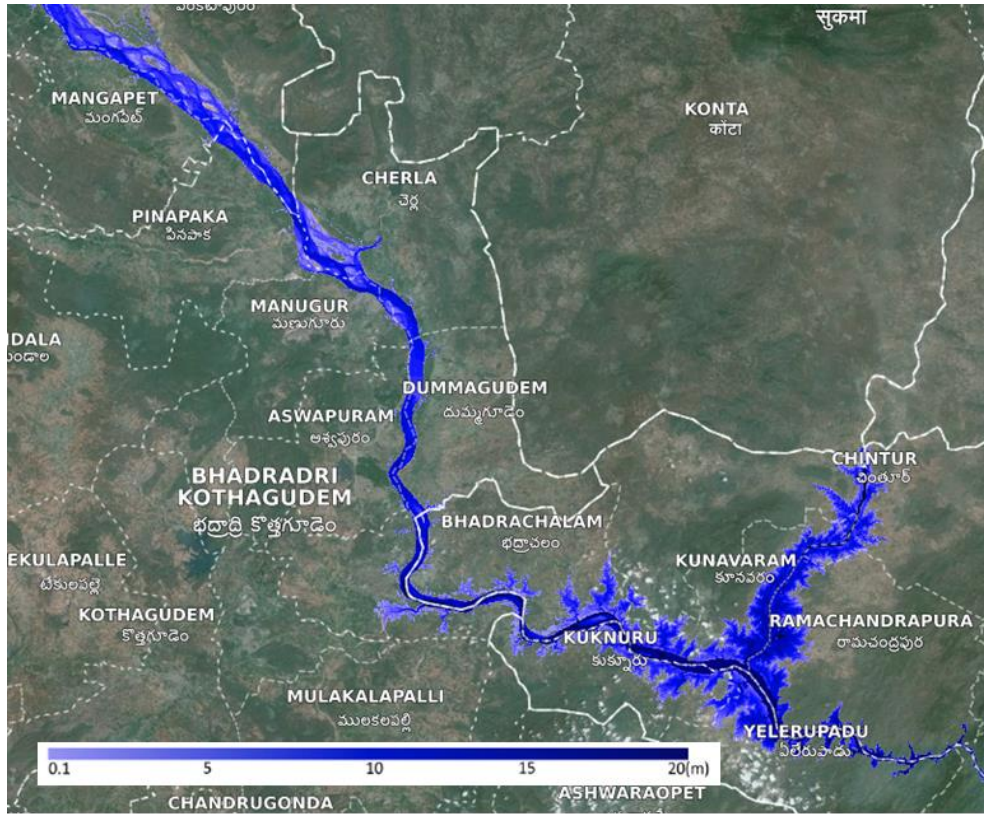


Figure 30: Sentinal-1 SAR image and modelled spatial flood inundation of main floodplains of Godavari on 27 July 2024

The SRI was developed using runoff data from the VIC hydrological model framework and covers the entire Indian region (Figure 31). With a spatial resolution of 3' x 3' (~5.5 km²) and a fortnightly temporal resolution, it provides timely assessments of drought conditions related to surface runoff. The SGWI focuses on groundwater levels in Telangana and Andhra Pradesh, with a monthly temporal resolution (Figure 32 & Figure 33). It employs a multi-model framework to improve accuracy, using Akaike Information Criteria (AIC) for optimal model selection. This ensures robust groundwater drought detection in a region heavily reliant on groundwater for agricultural and domestic use. The SRSI, derived from daily reservoir water levels monitored by the Central Water Commission (CWC) at 156 major reservoirs, captures variations in storage levels in reservoirs. By standardizing these levels, the SRSI (Figure 34) ensures comparability across reservoirs with differing capacities, offering a detailed view of drought based on the water availability in the reservoirs. The SWSI, which assesses water using AWiFS satellite-derived water layers, spans the entire Indian region (Figure 35). It incorporates advanced water detection algorithms, providing a monthly assessment of surface water bodies. Additionally, SWSI was developed using water spread layers derived using microwave remote sensing data (Sentinel 1) for Telangana State.

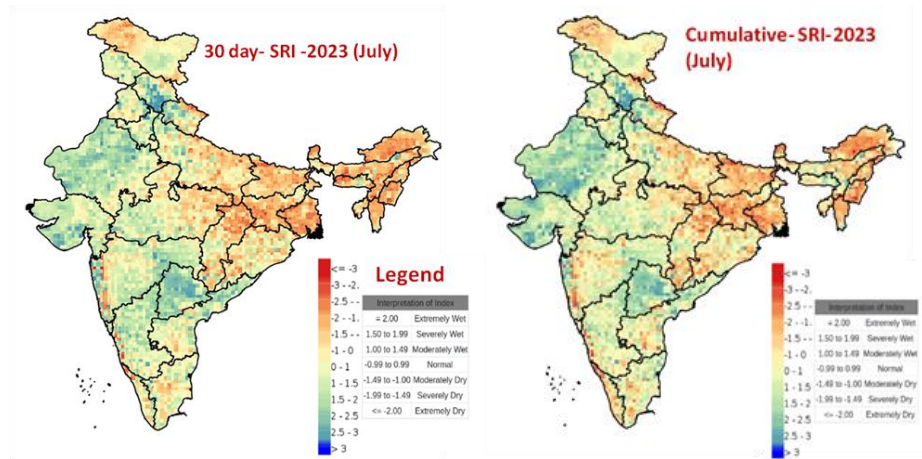


Figure 31: Sample SRI Products

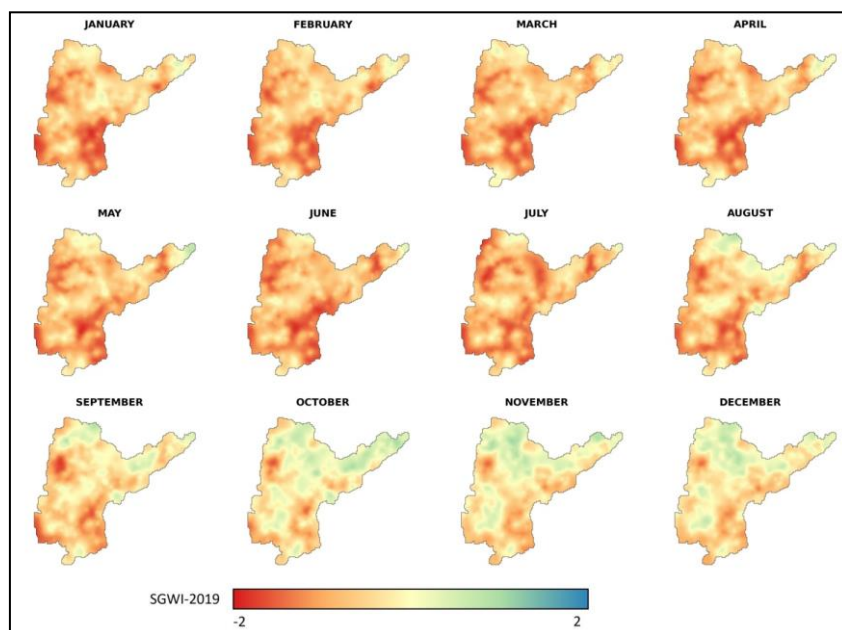


Figure 32: SGWI for AP and Telangana States – 2019 (dry year)

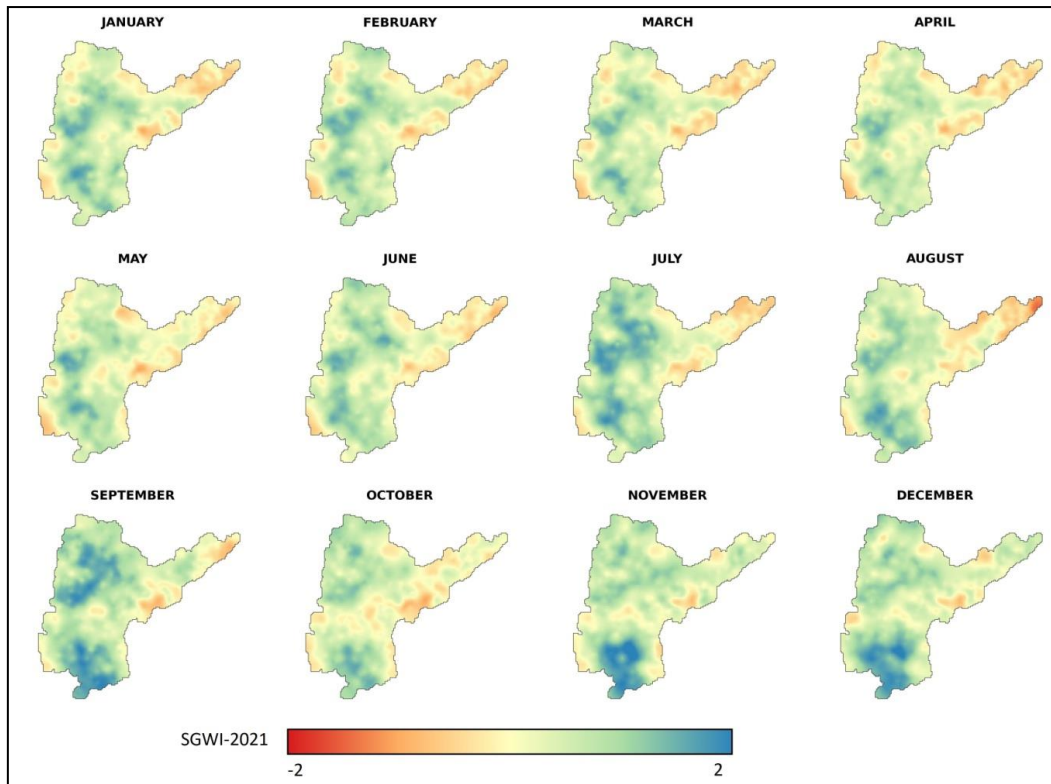


Figure 33: SGWI for AP and Telangana States – 2021 (wet year)

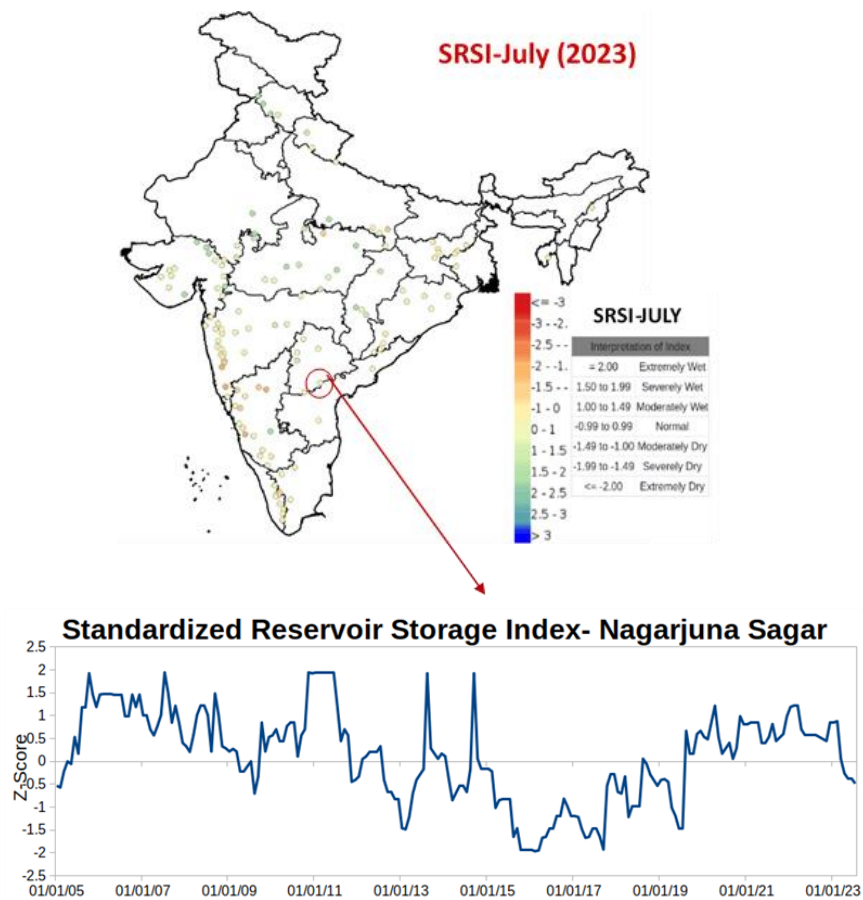


Figure 34: Sample SRSI Product and Time-Series Variation for Nagarjuna Sagar Reservoir

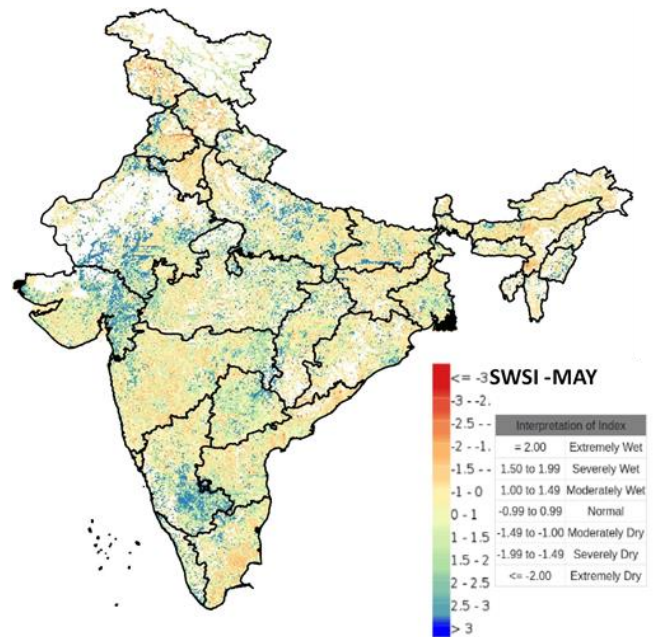


Figure 35: Sample Product of SWSI

Another significant achievement of this project is the development of the CHDI, which integrates SRI, SGWI, SWSI and SRSI using an improved Principal Component Analysis (PCA) with constrained optimization. This composite index (Figure 36 & Figure 37) captures the synergistic effects of surface, reservoir, and groundwater-based drought, offering a comprehensive drought assessment for Telangana. The CHDI enables policymakers to assess drought severity more effectively by combining multiple hydrological factors into a single, actionable metric.

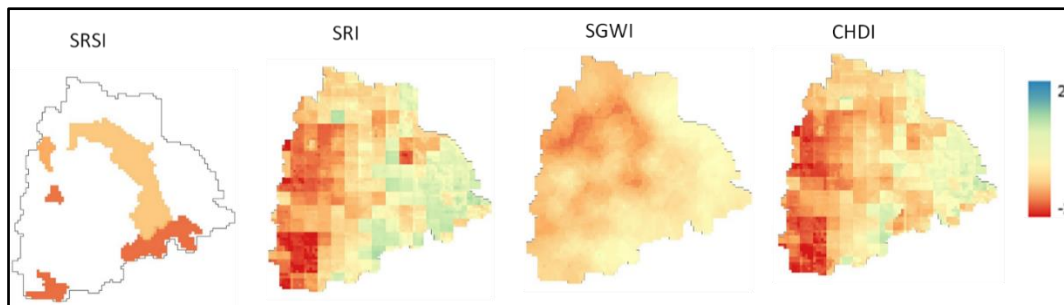


Figure 36: Sample CHDI Product and Corresponding Individual Indices (August 2015)

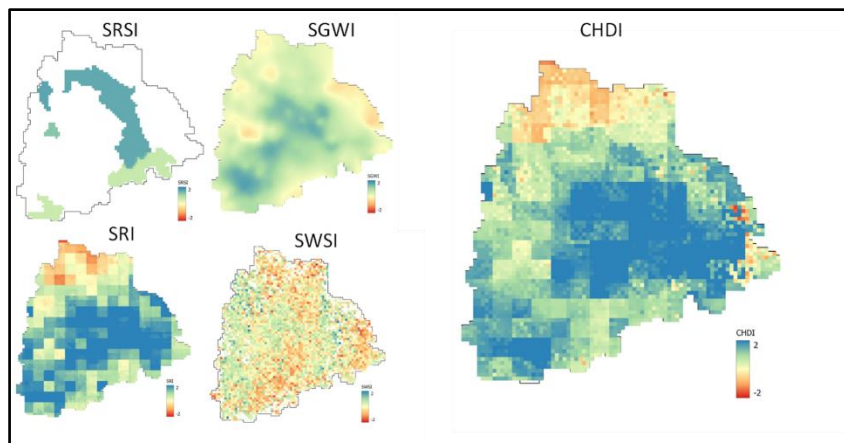


Figure 37: Sample CHDI Product and Corresponding Individual Indices (November 2020)

All indices were delivered in standardized formats such as GeoTIFF and Shapefiles, ensuring compatibility with GIS and remote sensing applications. The products have minimal latency times, ranging from 3 to 10 days, making them suitable for near-real-time drought monitoring. The project's methodological framework emphasizes accuracy and operational utility, integrating advanced statistical techniques and remote sensing technologies to enhance the precision of drought assessment. The outputs of this project support proactive water resource management, enabling stakeholders to respond promptly to hydrological droughts. The long-term information on the hydrological drought situation enables in developing better drought mitigation plans for the country.

3.9 Customized RS&GIS Training and Capacity Building

The objectives of the capacity building programs are as under:

- To conduct two training programs (one week) per year on RS & GIS fundamentals (2017-18 to 2023-24)
- To conduct two customized training programs (two weeks) per year on RS & GIS applications in water resources management (2016-17 to 2023-24)
- Hand holding/Technical support of satellite/GIS data handling to States/UT's

Under NHP, the National Remote Sensing Centre (NRSC) organized capacity building training programs comprising of Remote Sensing & GIS technologies and customized applications on water resources. These programmes were aimed at capacity building of all the stake holders in understanding and effective utilization of space technology in the field of water resources.

NRSC organised four training programs (2 – one week and 2 – two weeks) per year from 2017 onwards. About 32 training programs as on February 2025 are organised and about 739 Officers from 47 Implementing Agencies were trained. The distribution of trainee's participation in courses covers almost from all parts of the country. In overall, about 16 one-week training programs (Figure 38) and 16 two weeks training programs (Figure 39) were conducted with 341 and 398 participants trained respectively (Annexure B). Under the category of one week training programs (16), two types of courses were conducted. Under the category of two-week training programs (16), three types of courses were conducted. In some of the courses, subject experts from reputed Organisations were invited to deliver special invited talks from across the country. In few courses depending on the need field visits were arranged to trainee Officers for ground truth to validate the satellite data interpretation. The overall feedback obtained from the trainee Officers of all the courses was about 90.36 % (Annexure C).

3.10 HydroSight: Geoportal for NHP Products

HydroSight – Bhuvan NHP Web Portal, accessible at <https://bhuvan.nrsc.gov.in/nhp/>, has been developed to host the geospatial products and services generated under the different NHP studies carried out at NRSC and disseminate them to the stakeholders.

The HydroSight platform (Figure 40) serves as a central repository and interactive portal for accessing critical water resources information. This initiative addresses the need for a unified platform that integrates disparate hydrological datasets, enhancing accessibility and usability for water resource professionals, researchers and policymakers. This report provides a detailed technical overview of HydroSight, highlighting its pivotal role in supporting the National Hydrology Project. The scope of this report encompasses the platform's architecture, features, functionalities, and underlying technologies. It details the application's functionality, external interfaces, performance metrics, attributes and design constraints. This comprehensive overview

aims to provide clarity and guidance for both users and developers, ensuring the platform's effective utilisation.

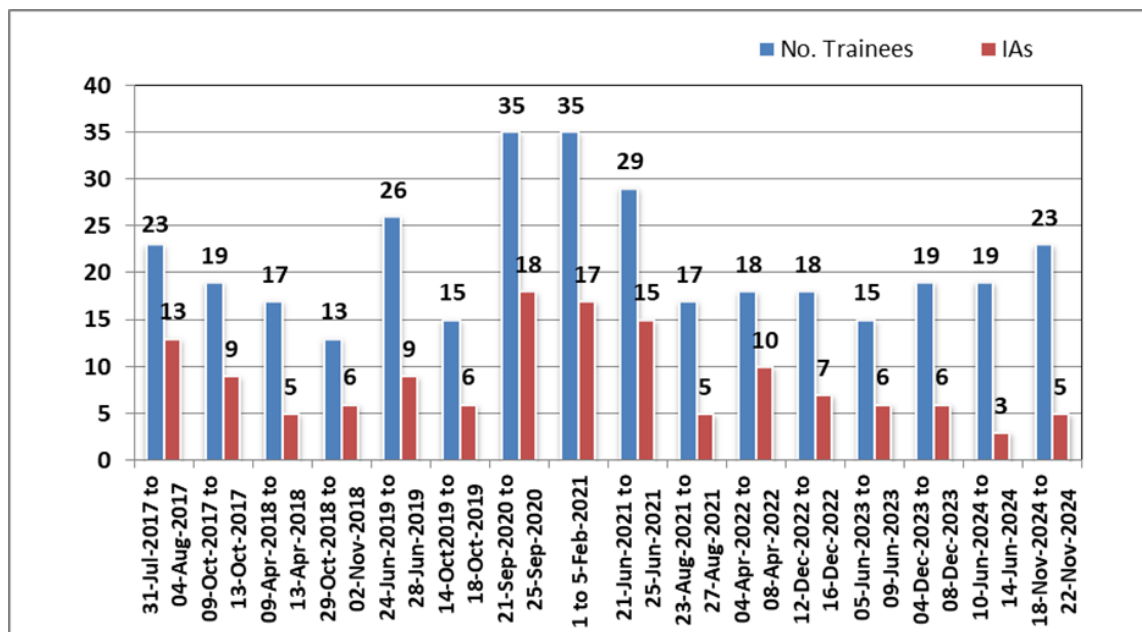


Figure 38 Details of one week training programs organised by NRSC

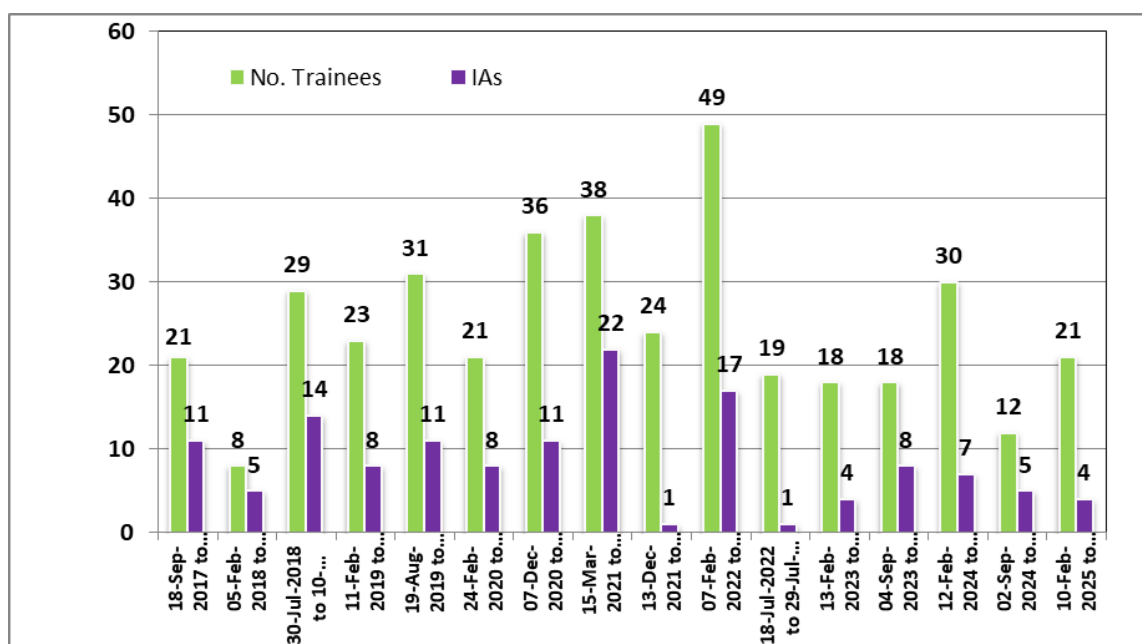


Figure 39 Details of two-week training programs organised by NRSC

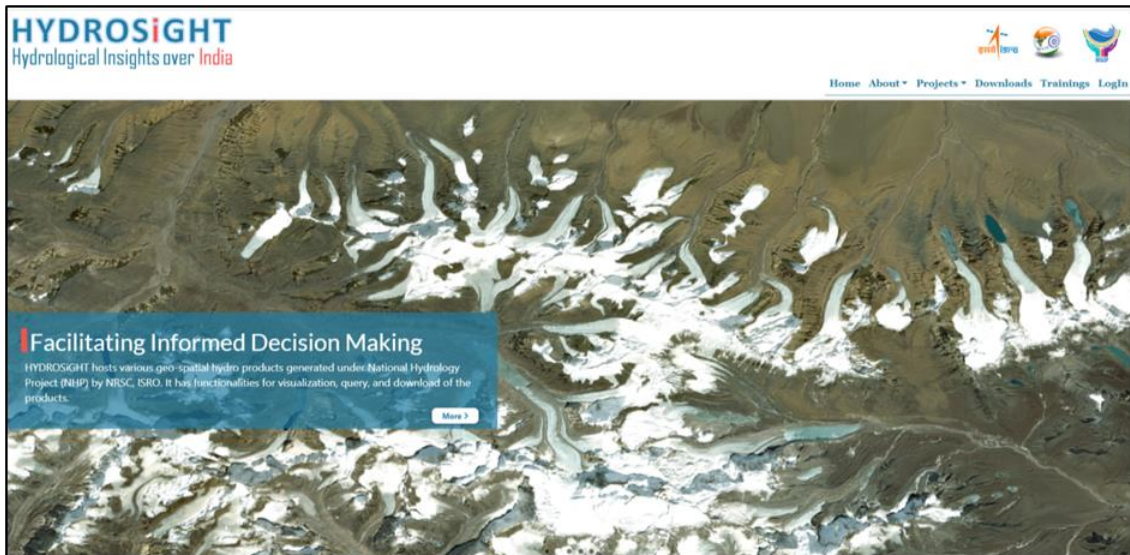


Figure 40: HydroSight Landing Page

HydroSight is built upon a robust, web-based, multi-tiered architecture that facilitates browser-based client access over the public Internet. This architecture ensures scalability, reliability and accessibility, catering to a wide range of users. The platform adheres to W3C and OGC compliance standards for interoperability, enabling seamless integration with other geospatial systems and datasets. Developed using open-source technologies, HydroSight is integrated within the ISRO-NRSC's premier geospatial platform, Bhuvan. This integration allows users to visualise (Figure 41), analyse (Figure 42) and download information products, enhancing the platform's analytical capabilities. The use of open-source technologies promotes transparency, flexibility and cost-effectiveness.

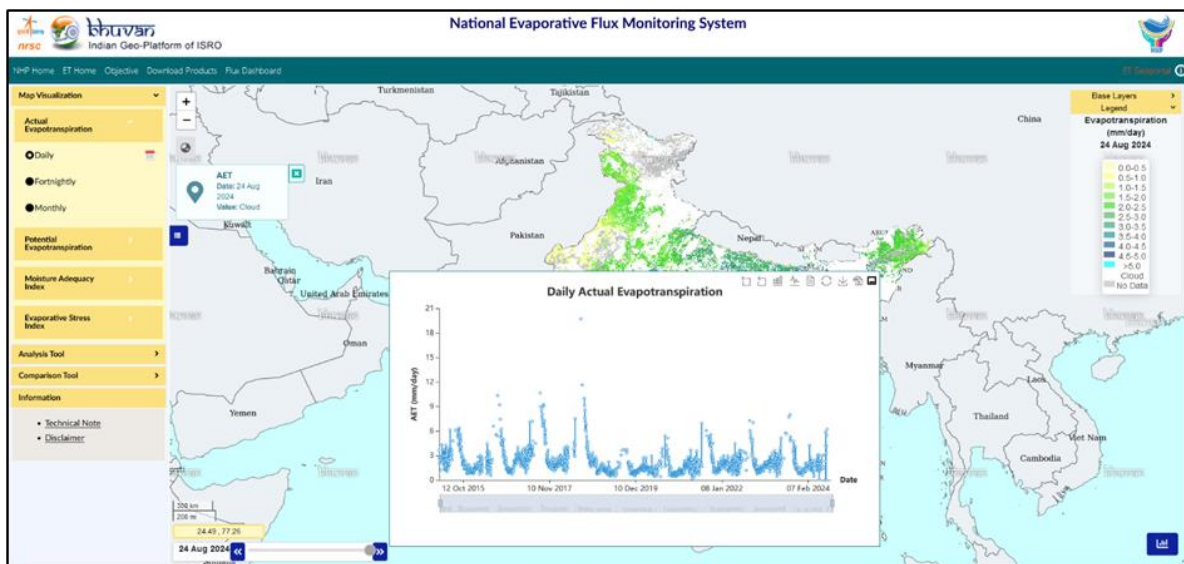


Figure 41: Daily AET time series visualisation

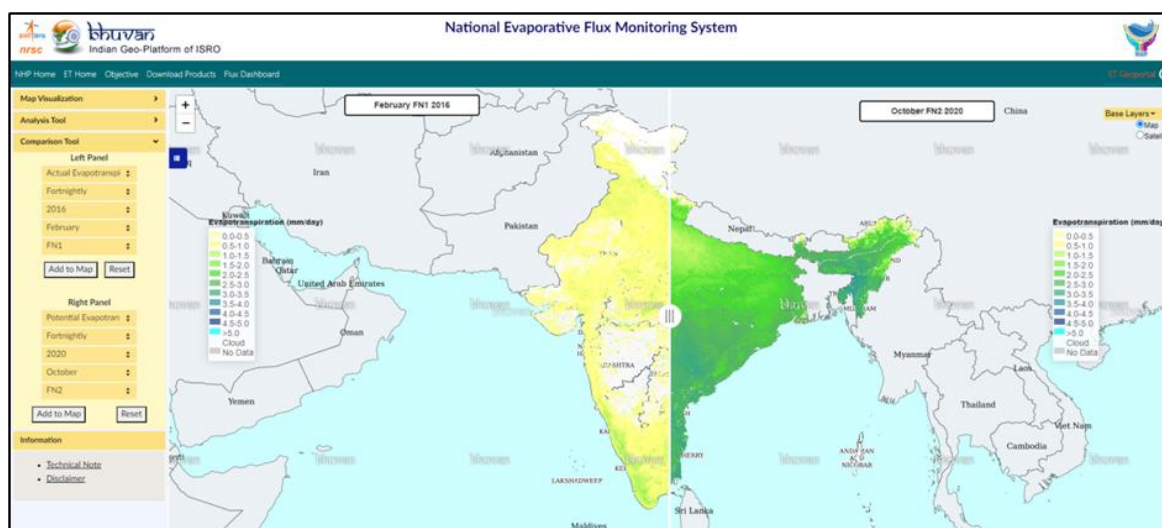


Figure 42 : Comparison tool showing two different products side-by-side

The platform comprises of eight sub-modules, each addressing specific hydrological needs: Spatial Flood Early Warning System, National Evaporative Flux Monitoring System, Himalayan Glacial Lakes Information System, Himalayan Snow Cover Information System, National Hydrological Modelling System, Irrigation Decision Support System, National Hydrological Drought Information System and Hydrologic Unit Model for India (HUMID). These modules serve as a vital tool for a wide range of stakeholders, including water resource professionals, researchers, policymakers, and disaster management agencies. Through continuous development and integration of advanced geospatial technologies, HydroSight contributes significantly to sustainable water resource management in India. It addresses critical challenges related to water availability, flood management, drought mitigation and irrigation efficiency. The portal is an invaluable asset for the nation and is capable of being expanded for future needs.

Since the operations of the web portal in 2021, over 18 million hits have been recorded and a considerable number of downloads have been observed, reflecting the portal's effectiveness and relevance to a diverse range of users, including government organisations, academic institutions and NGOs. With thousands of downloads across various products (Figure 43) users are actively engaging with the portal to access valuable geospatial information for improved decision-making in water resource management, agriculture, and disaster response. This high engagement underscores the portal's role in providing essential, timely data to stakeholders for enhanced operational efficiency and informed planning.

4. Summary of Outcomes and End-Use

Under the *Development of Spatial Snowmelt Runoff Product in the Indian Himalayas*, NRSC generated snowmelt runoff forecasts and snow cover area products that have proven invaluable for basin planners in optimizing water allocation during the snowmelt season. These products are essential for managing limited summer water supplies for hydropower generation, irrigation, and drinking water. Moreover, they aid in assessing the hydropower potential of proposed projects and support the planning of new multipurpose infrastructure in snow-bound and glaciated river basins. The long-term snow cover database developed as part of this initiative contributes significantly to climate change studies, given snow cover is recognized as an Essential Climate Variable (ECV), and helps in planning transport and infrastructure projects in the challenging Himalayan terrain.

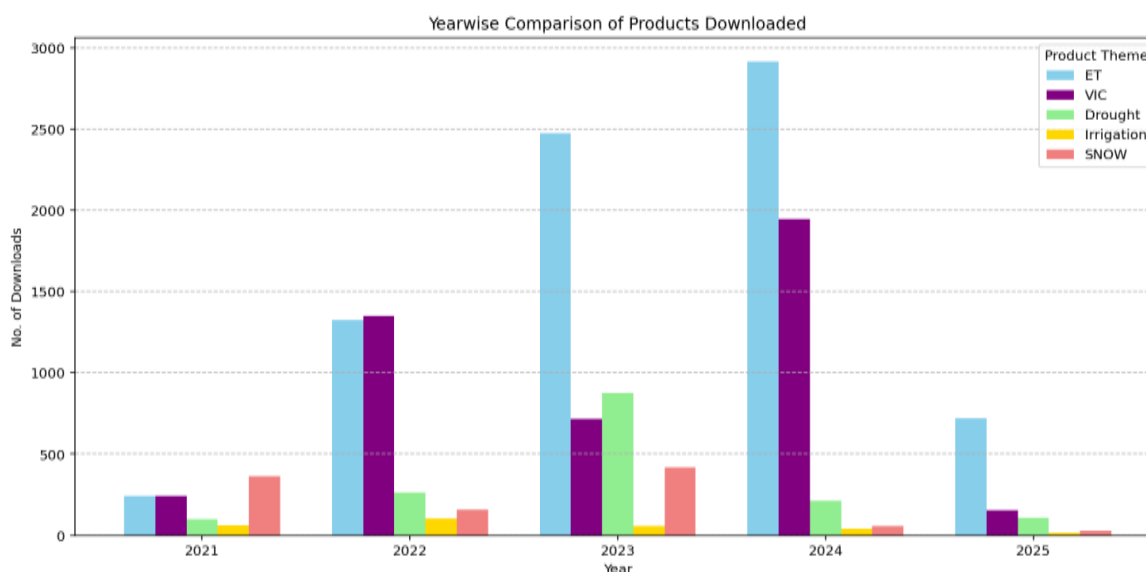


Figure 43: Year wise comparison of product downloads across themes

The *Glacial Lake Outburst Flood (GLOF) Risk Assessment of Glacial Lakes* in the Himalayan region has resulted in a comprehensive inventory of 28,043 glacial lakes, accessible via the Bhuvan-NHP Web Portal. This data supports continuous monitoring of glacial lake dynamics and aids in understanding the impacts of climate change and glacial retreat. Inundation simulations for 15 high-risk lakes offer critical insights into GLOF risk and serve as foundational inputs for the development of early warning systems (EWS) and disaster preparedness strategies. These products are instrumental for government agencies, disaster managers, researchers, and policymakers to plan mitigation measures and enhance community resilience against glacial hazards. The datasets also have significant academic value, encouraging advancements in glaciological studies and remote sensing-based hazard assessment.

Through the *Operational National Hydrological Modelling System*, NRSC has developed products like daily water balance components, runoff forecasts, reservoir inflow predictions, and soil moisture availability indices. These products facilitate comprehensive assessment of water availability and help manage irrigation demand efficiently. They support sustainable water resource planning, reservoir operations, and drought preparedness at a national scale. Furthermore, the modelling system can simulate long-term water availability scenarios under different climate projections, making it an essential tool for addressing future climate-related challenges in water management.

The *Web Enabled Hydrologic Modelling in SWAT (HUMID)* system enables modelling of selected Indian river basins using an interactive, user-friendly interface. HUMID allows users to simulate discharge under various scenarios and visualize outputs at multiple spatial scales—from sub-basin to village-level 5 km grids. This capability makes it a powerful tool for planning reservoir operations, assessing water availability, managing irrigation at localized levels, and designing water harvesting infrastructure. It also supports integrated watershed management and land use planning by evaluating the hydrological impacts of human activities and climate variability across different scales.

In the case of the *Real-Time Operational Spatial Flood Early Warning Systems* for the Godavari and Tapi basins, NRSC developed high-resolution flood forecasts and inundation maps. These tools are vital for disaster management authorities to issue timely alerts and plan evacuations, thereby reducing risks to life and property. Urban planners and infrastructure developers benefit from

these maps in identifying flood-prone zones, while reservoir managers use the forecast data to regulate water releases during heavy rainfall events. Furthermore, these products are valuable for public awareness campaigns and contribute to flood-related academic and research work.

The *Development of a Satellite-based Regional Evaporative Flux Monitoring System* has produced evapotranspiration (ET) products that support a variety of applications in water and agricultural resource management. The ET data aids in precise irrigation scheduling, helping determine when and how much water crops need. It also assists in calculating crop water requirements throughout growing seasons, thereby enhancing yield and conserving water. Additionally, the ET datasets serve as key inputs for hydrological and groundwater models and are useful for drought assessments and climate change studies, offering insights into the changing water use patterns across India.

In *Satellite Inputs Based Irrigation Scheduling for the Narayanpur Command Area*, NRSC developed IRIS—a pioneering system for demand-based irrigation scheduling. The system ensures equitable water distribution, particularly to tail-end distributaries, avoids early-season over-releases, and improves overall canal operation efficiency. It identifies underperforming distributaries and provides actionable insights to boost agricultural productivity. With appropriate geospatial databases and field validation, IRIS can be replicated in other command areas, facilitating large-scale implementation of efficient irrigation practices.

Finally, the *Operational Hydrological Drought Assessment* activity delivered a suite of indices including the Standardized Runoff Index, Groundwater Index, Reservoir Storage Index, and a Composite Hydrological Drought Index. These products are essential for monitoring water scarcity and guiding agriculture water management, enabling authorities to issue early drought advisories. The indices help in prioritizing relief activities by identifying the severity and geographic extent of droughts. They also support strategic planning for water resource allocation and help safeguard agricultural productivity and food security through informed, proactive drought response strategies.

5. Recommendations and Way Forward

For the Development of Spatial Snowmelt Runoff Products in the Indian Himalayas, the way forward lies in operationalizing these products for real-time forecasting, especially during the critical melt season. Integration of snowmelt runoff models with near real-time remote sensing inputs and meteorological forecasts can enhance their utility for daily water management decisions. Further, expanding the spatial extent and temporal frequency of snow cover mapping and linking these products with hydropower and reservoir operation systems can ensure that they serve as dynamic decision-support tools. Enhancing the resolution and automation of snow cover monitoring would also facilitate more precise modelling of melt dynamics under climate variability.

In the case of Glacial Lake Outburst Flood (GLOF) Risk Assessment, the next step involves institutionalizing the early warning systems through real-time monitoring and automated alert mechanisms. Incorporating in-situ data and satellite observations into a unified GLOF monitoring framework can ensure timely risk detection and response. Continued updating of the glacial lake inventory and refinement of inundation modelling with improved elevation and land use datasets will strengthen disaster preparedness. Establishing collaboration with local disaster management authorities and integrating these products into state and national disaster response protocols can ensure their operational effectiveness.

For the Operational National Hydrological Modelling System, the way forward is to scale and customize the system for basin-level water resource authorities, enabling more granular water planning and inter-sectoral allocation. Incorporating ensemble weather forecasts and enhancing model calibration using high-resolution data will improve prediction accuracy. The system should be further developed into a decision-support platform with interactive dashboards, enabling users to explore various water management scenarios under changing climatic and demand conditions. A cloud-based implementation could improve accessibility and scalability across states and sectors.

Regarding the Web Enabled Hydrologic Modelling in SWAT (HUMID), the addition of more datasets relevant to land use, soil, and socio-economic variables will enhance its scope and usability. Integration with real-time rainfall and climate data can turn HUMID into a semi-operational tool for scenario-based watershed planning. Capacity building among user departments, especially at the state level, will be key to mainstreaming HUMID for localized water resource assessments, and it could be linked to national missions focused on watershed development and groundwater management.

The Real-Time Operational Spatial Flood Early Warning System for the Godavari and Tapi basins can be expanded both spatially and functionally. Covering more river basins, improving resolution, and incorporating urban flood modelling will be critical. Interfacing the flood warning system with mobile-based dissemination tools and community alert mechanisms can increase public safety. There is also a need to establish standard operating procedures for integrating these forecasts into district-level emergency planning and response systems. Cross-validation with ground observations and post-event analysis can further refine model accuracy.

For the Satellite-Based Regional Evaporative Flux Monitoring System, the emphasis should be on enhancing the temporal resolution of evapotranspiration estimates and integrating them with crop models to support adaptive agricultural practices. The ET products should be linked with irrigation advisory systems and water budgeting frameworks at the district and panchayat levels. Automating the data processing chain and disseminating outputs through web portals and mobile platforms will help reach end-users such as farmers, irrigation planners, and extension agencies. Incorporating feedback loops from field validations will also improve product reliability.

Regarding the Satellite-Based Irrigation Scheduling for the Narayanpur Command Area, the path forward includes replicating the IRIS system in other irrigation commands across India with suitable customization. Standardizing data requirements and building state capacity in geospatial database creation, model calibration, and field data collection will be essential. Integration of IRIS with existing irrigation management systems and canal automation frameworks can help optimize water delivery and enhance agricultural productivity. Real-time feedback mechanisms and decision-support interfaces should be developed to assist irrigation officials in timely decision-making.

Finally, for the Operational Hydrological Drought Assessment, the drought indices need to be institutionalized as part of national and state-level drought monitoring frameworks. Ensuring regular updates of these indices with near real-time satellite data and operational hydrological inputs will increase their relevance. These products can be embedded within agricultural risk advisory services and linked with crop insurance programs to support climate-resilient farming. Visualizing drought scenarios through interactive web platforms and integrating them with relief planning protocols will enhance the responsiveness of governance systems during drought events.

In addition to the achievements under NHP, NRSC, leveraging the expertise gained during the project, has proposed several advanced activities for the upcoming phase of the National Hydrology Project. These proposed initiatives aim to address emerging challenges in water resource management and disaster risk reduction through cutting-edge geospatial technologies. The proposed activities include:

- Development of medium-range forecasts for reservoir inflows and river discharge.
- Estimation of glacier mass balance and melt runoff using satellite data.
- Assessment of utilizable water resources in river basins through coupled surface and groundwater modelling.
- Monitoring of surface water storage dynamics in smaller water bodies using satellite observations.
- Development of an Early Warning System (EWS) for Glacial Lake Outburst Floods (GLOFs).
- Remote sensing-based benchmarking of irrigation project performance.
- Estimation of groundwater usage by integrating satellite data with field-based observations.
- Urban flood modelling to support disaster risk reduction efforts.
- Dam break analysis and simulation of flood impacts for disaster risk management.
- Groundwater drought assessment across India using GRACE satellite data and in-situ measurements.
- Integrated characterization and assessment of GLOF risks within a geo-hazard framework using Earth Observation data.
- Generation of a high-resolution daily soil moisture product by integrating active and passive satellite-derived data with model-based estimates.

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Annexures

A. Glossary of Technical Terms

AE	Application Efficiency
AET	Actual Evapotranspiration
ALTM	Airborne Laser Terrain Mapping
amsl	Above Mean Sea Level
AOD	Aerosol Optical Depth
AOI	Area of Interest
API	Application Programming Interface
ATBD	Algorithm Theoretical Basis Document
AWiFS	Advanced Wide Field Sensor
AWS	Automated Weather Station
BD	Bulk Density
BR	Brahmaputra River
BT	Brightness Temperature
CART	Classification and Regression Tree
CDAS	Climate Data Analysis System
CE	Conveyance Efficiency
CHDI	Composite Hydrological Drought Index
CM	Contextual Model
CN	Curve Number
CNR 4	Four-component Net radiometer
COSMOS	Cosmic Ray Soil Moisture Observing System
CPC	Climate Prediction Center
CRIDA	Central Research Institute for Dry Land Agriculture
CRNS	Cosmic Ray Neutron Sensor
CRUD	Create, Read, Update and Delete
CSS	Cascading Style Sheets
CWC	Central Water Commission
CWSI	Crop Water Stress Index
DB	Database
DC	Document Completeness
DD	Deputy Director
DEM	Digital Elevation Model
DES	Directorate of Economics and Statistics
DGM	Deputy General Manager
DNB	Day/Night Band
DoWR, RD&GR	Department of Water Resources, River Development and Ganga Rejuvenation
DPD	Deputy Project Director
DPT	Dew Point Temperature
DSS	Decision Support System
DSS	Decision Support System
DTD	Dual Temperature Difference
DTM	Digital Terrain Model
E	Evaporation
EF	Evaporative Fraction
EFR	East Flowing Rivers
ERA5	European Climate Modelling and Weather Forecasting Reanalysis
ESI	Evaporative Stress Index
ET	Evapotranspiration
ET ₀	Reference Evapotranspiration
ET _c	Crop Potential Evapotranspiration
FAO	Food and Agriculture Organization
FC	Field Capacity

FCC	False Colour Composite
FEWS	Flood Early Warning System
FN	Fortnight
FRL	Full Reservoir Level
GAS	Goal Alignment Score
GEFS	Global Ensemble Forecast System
GIAM	Global Irrigated Area Map
GIS	Geographic Information System
GL	Glacial Lake
GLDAS	Global Land Data Assimilation System
GLEAM	Global Land Evaporation Amsterdam Model
GLIMS	Global Land Ice Measurement from Space
GLOF	Glacial Lake Outburst Flood
GOI	Government of India
GR	Ganga River
GT	Ground Truth
GW_Q	Groundwater flow
ha	Hectare
HAWQS	Hydrologic Analysis and Water Quality System
HEC	Hydrologic Engineering centre
HIS	Hydrological Information System
HKH	Hindu Kush-Himalayas
HMS	Hydrologic Modelling System
HP	Himachal Pradesh
HRU	Hydrologic Response Unit
HSG	Hydrologic Soil Groups
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
HUMID	Hydrologic Unit Model for India
I(d)	Glacier Ice-dammed Lake
I(s)	Supra-glacial Lake
IBC	Indi Branch Canal
ICIMOD	International Centre for integrated Mountain Development
IDW	Inverse Distance Weighing
IHR	Indian Himalayan Region
IIT- Madras	Indian Institute of Technology Madras
ILR	Incoming Longwave Radiation
IMD	Indian Meteorological Department
India WRIS	India Water Resources Information System
INS	Insolation
INSAT	Indian National Satellite System
IR	Infrared
IRIS	Irrigation Information System
IRS	Indian Remote Sensing Satellite
ISRO	Indian Space Research Organisation
ISWR	Incoming Shortwave Radiation
JBC	Jewargi Branch Canal
JJAS	June July August September
JK	Jammu& Kashmir (UT)
JSON	JavaScript Object Notation
KBJNL	Krishna Bhagya Jal Nigam Limited
Kc	Crop Co-efficient
KGE	Kling Gupta Efficiency
Km ²	Square Kilometre
LA	Ladakh (UT)

LAI	Leaf Area Index
Landsat	Land Resources Satellite
LISS-III	Linear Imaging Self Scanning Sensor - III
LISS-IV	Linear Imaging Self Scanning Sensor - IV
LST	Land Surface Temperature
LULC	Land Use Land Cover
LUT	Landuse Update Tool
LWIR	Long Wave InfraRed
m	Metre
M(e)	End-moraine Dammed Lake
M(l)	Lateral Moraine Dammed Lake
M(lg)	Lateral Moraine Dammed Lake (with ice)
M(o)	Other Moraine Dammed Lake
MAD	Management Allowable Depletion
MAE	Mean Absolute Error
MAI	Moisture Adequacy index
MBC	Mudhbal Branch Canal
MD	Managing Director
MDDL	Minimum Draw Down Level
MERRA	Modern-Era Retrospective Analysis for Research and Applications
MLC	Maximum Likelihood Classification
MOD16	MODIS Global ET Product
MODIS	MODerate Resolution Imaging Spectroradiometer
MoJS	Ministry of Jal Shakti
MSI	Multi Spectral Instrument
NBSS&LUP	National Board for Soil Survey and Land Use Planning
NCC	Near Constant Contrast
NCEP	National Centers for Environmental Prediction
NDSI	Normalized Difference Snow Index
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
NGO	Non-Government Organisation
NHP	National Hydrology Project
NIR	Near InfraRed
NLBC	Narayanpur Left Bank Canal
NOAA	National Oceanic Atmospheric Administration
NPM	Node Package Manager
NPOESS	National Polar orbiting Operational Environmental Satellite System
NRB	Narmada River Basin
NRC	Natural Resources Census
NRSC	National Remote Sensing Centre
NRT	Near Real Time
NSE	Nash Sutcliffe Efficiency
NSSO	National Sample Survey Office
NWIC	National Water Informatics Centre
O&M	Operation and Maintenance
OCR	Objective Completion Rate
OGC	Open Geospatial Consortium
OLI	Operational Lang Imager
OLR	Outgoing Longwave Radiation
OP	Operational Policy
OPEC	Open-Path Eddy Covariance
OSWR	Outgoing Shortwave Radiation
PBIAS	Percentage Bias
PD	Project Director

PERC	Percolation
PEST	Parameter Estimation and Uncertainty Analysis Tool
PET	Potential Evapotranspiration
PI	Principal Investigator
PM	Penman-Monteith
PMP	Probable Maximum Precipitation
PMS	Probable Maximum Storm
PRECIP	Precipitation
PSM	Permanent Soil Moisture
PSV	Project Schedule Variance
PT	Priestley-Taylor
PWP	Permanent Wilting Point
R ²	Coefficient of Determination
RAS	River Analysis system
RAW	Readily Available Water
RD	Root Depth
RF	Random Forest
RGI	Randolph Glacier Inventory
RH	Relative Humidity
RS	Remote Sensing
RS-2	Resourcesat-2
RSAA	Remote Sensing Application Area
SAC	Space Application Centre
SAM	Spectral Angle Mapper
SAT	Saturation
SBC	Shapur Branch Canal
SCA	Snow Cover Area
SCADA	Supervisory Control and Data Acquisition
SCI	Scope Creep Index
SCS	Soil Conservation Service
SEBAL	Surface Energy Balance Algorithm for Land
SGWI	Standardised Ground Water Index
SHY	Snow Hydrological Year
SLD	Styled layer Descriptor
SLUSI	Soil and Land Use Survey of India
SM	Soil Moisture
SM	Soil Moisture
SMAI	Soil Moisture Availability Index
SMAP	Soil Moisture Active Passive
S-NPP	Suomi National Polar-orbiting Partnership
SOI	Survey of India
SQL	Structured Query Language
SRI	Standardised Runoff Index
SRSI	Standardised Reservoir Storage Index
SRTM	Shuttle Radar Topographic Mission
SS	Stakeholder Satisfaction
SSEBop	Operational Simplified Surface Energy Balance
Suomi NPP	Suomi National Polar-orbiting Partnership
SURQ	Surface Runoff
SVM	Support Vector Machines
SW	Surface water flow
SW	Standing Water
SWAT	Soil & Water Assessment Tool
SWAT- CUP	Soil and Water Assessment Tool Calibration and Uncertainty Prediction
SWIR	Short Wave Infra-Red

SWSI	Standardised Water Spread Index
T	Transpiration
TC	Triple Collocation
TCA	Triple Collocation Analysis
TCO3	Total Columnar Ozone
TCWV	Total Columnar Water Vapor
TD	Transformed Divergence
TM	Thematic Mapper
ubRMSE	Unbiased Root Mean Square Error
UI	User Interface
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UT	Union Territory
UX	User Experience
VCM	VIIRS Cloud Mask
VHRR	Very High Resolution Radiometer
VI	Vegetation Index
VIC	Variable Infiltration Capacity
VIIRS	Visible Infrared Imaging Radiometer Suite
VNIR	Visible and Near Infrared
VSMB	Versatile Soil Moisture Budget
W3C	World Wide Web Consortium
WaPOR	Water Productivity through Open Access of Remotely Sensed Derived Data
WFR	West Flowing Rivers
WFS	Web Feature Service
WHC	Water Holding Capacity
WMS	Web Map Service
WRIS	Water Resources Information Systems

B. Summary of Training Programmes Organised

S. No.	Title	Duration	Start Date	End Date	Number of Participants
1	Remote Sensing & GIS Technologies	One week	31-Jul-2017	04-Aug-2017	23
2	Remote Sensing & GIS Applications in Water Resources	Two weeks	18-Sep-2017	29-Sep-2017	21
3	Remote Sensing & GIS Technologies	One week	09-Oct-2017	13-Oct-2017	19
4	Remote Sensing & GIS Applications in Water Resources	Two weeks	05-Feb-2018	16-Feb-2018	8
5	Remote Sensing & GIS Fundamentals	One week	09-Apr-2018	13-Apr-2018	17
6	Remote Sensing & GIS Applications in Water Resources	Two weeks	30-Jul-2018	10-Aug-2018	29
7	Remote Sensing & GIS Technologies	One week	29-Oct-2018	02-Nov-2018	13
8	Water Resources Assessment using Geospatial Data Inputs	Two weeks	11-Feb-2019	22-Feb-2019	23
9	Remote Sensing & GIS Technologies	One week	24-Jun-2019	28-Jun-2019	26
10	Surface Runoff Modelling using Geospatial Data Inputs	Two weeks	19-Aug-2019	30-Aug-2019	31
11	Remote Sensing & GIS Technologies	One week	14-Oct-2019	18-Oct-2019	15
12	Remote Sensing & GIS Applications for Irrigated Command Area Inventory and Performance Evaluation	Two weeks	24-Feb-2020	06-Mar-2020	21
13	Remote Sensing & GIS Technologies	One week	21-Sep-2020	25-Sep-2020	35
14	Hydrologic Modelling using Geospatial Data Inputs for Water Resources Management	Two weeks	07-Dec-2020	18-Dec-2020	36
15	Remote Sensing & GIS Technologies	One week	01-Feb-2021	05-Feb-2021	35
16	Use of Geo-spatial Technology for Ground Water Exploration, Source Finding and Sustainability	Two weeks	15-Mar-2021	26-Mar-2021	38
17	Remote Sensing & GIS Technologies	One week	21-Jun-2021	25-Jun-2021	29
18	Use of GIS for Ground Water Studies	Two weeks	13-Dec-2021	24-Dec-2021	24
19	Monitoring of Glacial Lakes using Satellite Remote Sensing Data	One week	23-Aug-2021	27-Aug-2021	17
20	RS & GIS Technologies for Sustainable Watershed Management	Two weeks	07-Feb-2022	18-Feb-2022	49

S. No.	Title	Duration	Start Date	End Date	Number of Participants
21	Remote Sensing & GIS Technologies	One week	04-Apr-2022	08-Apr-2022	18
22	Use of GIS for Ground Water Studies	Two weeks	18-Jul-2022	29-Jul-2022	19
23	Remote Sensing & GIS Technologies	One week	12-Dec-2022	16-Dec-2022	18
24	RISAT-1A (EOS-04) Satellite Data & Its Applications	Two weeks	13-Feb-2023	24-Feb-2023	18
25	Remote Sensing & GIS Technologies	One week	05-Jun-2023	09-Jun-2023	15
26	Water Use Quantification and Efficiency Estimation in Irrigated Command Areas using Satellite Data	Two weeks	04-Sep-2023	15-Sep-2023	18
27	Remote Sensing & GIS Technologies	One week	04-Dec-2023	08-Dec-2023	19
28	SWAT Modelling using Hydrologic Unit Model for InDia (HUMID)	Two weeks	12-Feb-2024	23-Feb-2024	30
29	Inventory and Monitoring of Glacial Lakes using Satellite Remote Sensing Data	One week	10-Jun-2024	14-Jun-2024	19
30	Remote Sensing & GIS Applications in Water Resources Management	Two weeks	02-Sep-2024	13-Sep-2024	12
31	Remote Sensing & GIS Technologies	One week	18-Nov-2024	22-Nov-2024	23
32	Remote Sensing & GIS Applications in Water Resources Management	Two weeks	10-Feb-2025	21-Feb-2025	21
Total					739

C. Summary of Training Programmes Feedback

S. No.	Title	Feedback (%)
1	Remote Sensing & GIS Technologies	86.59
2	Remote Sensing & GIS Applications in Water Resources	89.16
3	Remote Sensing & GIS Technologies	85.72
4	Remote Sensing & GIS Applications in Water Resources	88.33
5	Remote Sensing & GIS Fundamentals	91.00
6	Remote Sensing & GIS Applications in Water Resources	86.21
7	Remote Sensing & GIS Technologies	88.72
8	Water Resources Assessment using Geospatial Data Inputs	82.75
9	Remote Sensing & GIS Technologies	79.98
10	Surface Runoff Modelling using Geospatial Data Inputs	91.94
11	Remote Sensing & GIS Technologies	93.60
12	Remote Sensing & GIS Applications for Irrigated Command Area Inventory and Performance Evaluation	96.98
13	Remote Sensing & GIS Technologies	89.50
14	Hydrologic Modelling using Geospatial Data Inputs for Water Resources Management	94.43
15	Remote Sensing & GIS Technologies	82.85
16	Use of Geo-spatial Technology for Ground Water Exploration, Source Finding and Sustainability	91.75
17	Remote Sensing & GIS Technologies	92.00
18	Use of GIS for Ground Water Studies	90.94
19	Monitoring of Glacial Lakes using Satellite Remote Sensing Data	91.11
20	RS & GIS Technologies for Sustainable Watershed Management	91.90
21	Remote Sensing & GIS Technologies	90.80
22	Use of GIS for Ground Water Studies	93.56
23	Remote Sensing & GIS Technologies	90.58
24	RISAT-1A (EOS-04) Satellite Data & Its Applications	88.47
25	Remote Sensing & GIS Technologies	88.84
26	Water Use Quantification and Efficiency Estimation in Irrigated Command Areas using Satellite Data	91.73
27	Remote Sensing & GIS Technologies	91.75
28	SWAT Modelling using Hydrologic Unit Model for InDia (HUMID)	93.23
29	Inventory and Monitoring of Glacial Lakes using Satellite Remote Sensing Data	96.71
30	Remote Sensing & GIS Applications in Water Resources Management	92.07
31	Remote Sensing & GIS Technologies	95.30
32	Remote Sensing & GIS Applications in Water Resources Management	93.25
Overall feedback		90.36

D. Project Management & Implementation Team

Project Management Team (8-May-2023 to 31-Mar-2025)

S. No.	Role	Officer	Responsibility
1	Project Director	Shri. P.V. Raju, Group Director, WRG, RSAA	Overall Project Co-ordination, Management & Execution, Budget Management & Interface with Ministry of Jal Shakti.
2	Nodal Officer & Deputy Project Director	Shri. K. Abdul Hakeem, Head, WRID/WRG, RSAA	Development of Web Enabled Hydrological Modelling in SWAT. Operational Hydrological Drought Services using Remote Sensing Data. Water Information Systems, Development & Dissemination.
3	Deputy Project Director	Dr. K.H.V. Durga Rao, Group Head, DMSG, RSAA	Real-time Operational Spatial Flood Early Warning System Development.
4	Deputy Project Director	Dr. K. Chandrasekar, Head, WRP&DD/WRG, RSAA	Development of Satellite-based Regional Evaporative Flux Monitoring System for India. Satellite data-based inputs for Irrigation Scheduling for a selected Irrigation Project Command Area.
5	Deputy Project Director	Shri B. Simhadri Rao, Head, WRAD/WRG, RSAA	Glacial Lake Outburst Flood (GLOF) Risk Assessment. Development of Spatial Snowmelt Runoff Product in the Indian Himalayas. Operational National Hydrological Modelling System for the entire Country. Customized RS & GIS Training and Capacity Building.

Project Management Team (09-Feb-2018 to 7-May-2023)

S. No.	Role	Officer	Responsibility
1	Project Director	Dr. V. Venkateswar Rao, Associate Director, NRSC	Overall Project Co-ordination, Management & Execution, Interface with MoWR, RD & GR
2	Deputy Project Director	Shri. P.V. Raju, Group Director, WRG	Snow & Glacial Studies, Hydrological Modelling of River Basins of South and Eastern India, Budget Management
3	Deputy Project Director	Shri. K. Abdul Hakeem, Head, WRID	Water informatics & Hydro-information Products (ET, Hydrologic Drought)

4	Deputy Project Director	Dr. K.H.V. Durga Rao, Group Head, DMSG	Flood Early Warning, Modelling Protocols and R & D activities
5	Deputy Project Director	Dr. V.M. Chowdary, Group Director, ASAG	Process based studies and Hydrological Modeling of River Basins of North and Western India
6	Deputy Project Director	Shri. M. Shanker, S/E 'SG', WRAD, WRG (till 25-July-2018)	Capacity Building & Irrigation Water Management

Project Implementation Team (28-Jun-2023 to 31-Mar-2025)

S. No.	Project	Team	Responsibility
1	Development of Web Enabled Hydrological Modelling in SWAT	Ms. Annie Maria Issac, S/E 'SE'	Principal Investigator
		Ms. Asiya Begum, S/E 'SF'	Co-Principal Investigator
2	Operational Hydrological Drought Services using Remote Sensing Data	Shri. K. Bharath Kumar Reddy, S/E 'SD'	Principal Investigator
		Ms. Annie Maria Issac, S/E 'SE'	Co-Principal Investigator
3	Water Information Systems Development & Dissemination	Shri. Anurag Mishra, S/E 'SD'	Principal Investigator
		Shri. K. Sachin Prakash, S/E 'SD'	Co-Principal Investigator
		Shri. J. Sai Rama Krishna, S/E 'SD' (till 19-Jun-2024)	Co-Principal Investigator
4	Real-time Operational Spatial Flood Early Warning System Development	Shri. Amanpreet Singh, S/E 'SE'	Principal Investigator
		Shri. Abhinav Kumar Shukla, S/E 'SE'	Co-Principal Investigator
5	Satellite Data-based Irrigation Scheduling for a Selected Irrigation Project Command Area	Ms. Annie Maria Issac, S/E 'SE'	Principal Investigator
		Shri. K. Sachin Prakash, S/E 'SD'	Co-Principal Investigator

6	Glacial Lake Outburst Flood (GLOF) Risk Assessment	Shri. Saksham Joshi, S/E 'SE'	Principal Investigator
		Shri. C. Sai Krishna, S/E 'SD'	Co-Principal Investigator
7	Development of Satellite-based Regional Evaporative Flux Monitoring System for India	Shri. J. Mohamed Ahmed, S/E 'SF'	Principal Investigator (EC Flux Tower Data Analysis and R&D Studies)
		Smt. Nidhi Misra, S/E 'SE'	Principal Investigator (ET Product Generation & Validation)
		Shri. Anurag Mishra, S/E 'SD'	Co-Principal Investigator
		Shri. K. Sachin Prakash, S/E 'SD'	Co-Principal Investigator
8	Development of Spatial Snowmelt Runoff Product in the Indian Himalayas	Shri. C. Sai Krishna, S/E 'SD'	Principal Investigator
		Shri. Saksham Joshi, S/E 'SE'	Co-Principal Investigator
9	Operational National Hydrological Modelling System for the Entire Country	Shri. Saksham Joshi, S/E 'SE'	Principal Investigator
		Shri. Anurag Mishra, S/E 'SD'	Co-Principal Investigator
10	Customised RS&GIS Training and Capacity Building	Shri. P.V.S.S.N Gopalakrishna, S/E 'SG'	Principal Investigator
		Shri. T.S. Viswanadham, S/E 'SF'	Co-Principal Investigator

Project Implementation Team (19-Mar-2018 to 27-Jun-2023)

S. No.	Project	Team	Responsibility
1	Spatial Flood Early Warning System	Shri. Amanpreet Singh, S/E 'SE', FMD, DMSG	Principal Investigator
		Shri. Abinav Kumar Shukla, S/E 'SE', RC(North)	Co-Principal Investigator
2	Regional Evaporative Flux Monitoring System	Dr. K. Chandrasekar, Head, WRP&DD, WRG	Principal Investigator

		Shri. J. Mohamed Ahmed, S/E 'SF', RC (South)	Co-Principal Investigator
		Smt. Nidhi Misra, S/E 'SE', WRP&DD, WRG	Co-Principal Investigator
		Shri. Anurag Mishra, S/E 'SD', WRID, WRG, RSAA	Co-Principal Investigator
3	Glacial Lake Outburst Flood (GLOF) Risk Assessment	Shri. B. Simhadri Rao, S/E 'SG', Head, WRAD, WRG, RSAA	Principal Investigator
		Ms. Annie Maria Issac, S/E 'SE', WRID, WRG, RSAA	Co-Principal Investigator
4	Spatial Snow melt Runoff Estimation	Shri. B. Simhadri Rao, S/E 'SG', WRAD, WRG, RSAA	Principal Investigator
		Shri. Saksham Joshi, S/E 'SE', WRAD, WRG, RSAA	Co-Principal Investigator
5	Operational Web based National Hydrological Modelling System	Shri. Saksham Joshi, S/E 'SE', WRAD, WRG, RSAA	Principal Investigator
		Ms. Annie Maria Issac, S/E 'SE', WRID, WRG, RSAA	Co-Principal Investigator
6	Satellite data based Inputs for Irrigation Scheduling	Dr. V.M. Choudhary, Group Director, ASAG	Principal Investigator
		Ms. Annie Maria Issac, S/E 'SE', WRID, WRG, RSAA	Co-Principal Investigator
7	Operational Hydrological Drought Services	Dr. A.V. Suresh Babu, Head, FMRAD	Principal Investigator
		Shri. T.P. Girish Kumar, S/E 'SF', RC (Central)	Co-Principal Investigator
		Shri. K. Bharath Kumar Reddy, S/E 'SD', WRID, WRG	Co-Principal Investigator
8	Customized RS & GIS Training and Capacity Building	Shri. P.V.S.S.N Gopalakrishna, Head, TPCD, TEOG	Team Lead
		Shri. T.S. Viswanadham, TOFM, TEOG	Team Member
		Ms. Annie Maria Issac, S/E 'SE', WRID, WRG, RSAA	Team Member
		Shri. P. Hariesh, S/E 'SF', TEOG	Team Member
9	Aerial Data, Acquisition & Processing Team	Shri. K. Venkateswar Rao, S/E 'SG', AS & DM	Team Lead
		Shri. J. Narendran, 'SG', Group Head, NSG, ASDMA	Team Member

		Shri. S. Madhusudhan Reddy, S/E 'SF', ASDMA	Team Member
		Shri. N. Madhusudhan Reddy, S/E 'SF', ASDMA	Team Member
		Shri. C S Narasimham, S/E 'SE', ASDMA	Team Member
		Shri. P Shashivardhan Reddy S/E 'SF', ASDMA	Team Member
		Shri. B Satish, S/E 'SE', ASDMA	Team Member
10	Bhuvan Products & Services	Shri. K Kalyan Deep, S/E 'SF', VASD, CGVAG	Team Lead
		Shri. J Sai Rama Krishna, S/E 'SD', BWSD, BG & WSG	Team Member
		Shri. R S Vijay Krishna, S/E 'SD', BWSD, BG & WSG	Team Member



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