AGI
ASSOCIATION OF GEOSPATIAL INDUSTRIES

POTENTIAL OF GEOSPATIAL TECHNOLOGIES FOR THE WATER SECTOR IN INDIA

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EXECUTIVE **SUMMARY**

As the severity of the water crisis in India increases every year, central and state government agencies are using a variety of resources to tackle the water crisis. One among them is the adoption of Geospatial technologies supported by various government, private and academic institutions in India.

It has been widely seen that precise, real-time, and continuous data that geospatial sources provide for the water sector have a significant impact in the prognosis of water related projects. It enables better measurement, management, and maintenance of assets, monitoring of resources and even providing predictive and prescriptive analysis for forecasting and planned interventions.

For the geospatial ecosystem, water sector has been an active user that has implemented several projects and programmes using satellite based remote sensing, other in-situ survey data, GIS and spatial analytics, 3D modelling and precise positioning data.

This report intends to understand the water sector in our country and provide an outline of the scope, budgets and stakeholder ecosystem of various national level water-related programmes and projects. It goes on to provide an overview of geospatial technologies, its relationship and place in the digital world and deep dives into assessing the use geospatial technologies in the water-related programmes and projects, highlighting the potential capabilities at various points.

Several recommendations have been given in the report to strengthen the relationship between water related organizations in our country with the geospatial industry and other stakeholders for better understanding and adoption of technology. It also gives few case studies highlighting the use of geospatial technologies in different contexts. Lastly, some openly available geospatial and digital tools that are widely used by the global, national, and sub-national level agencies have been given as annexure.

FOREWORD

Water is intrinsically related to human life. Civilizations have depended on the availability of water to flourish since time immemorial. However, as the world around us undergoes developmental and natural processes, access to this elixir of life has increasingly become difficult. To the extent that water is now being traded as a commodity, like gold or silver.

India has about 17% of the world population, but only about 4% of the world's freshwater reserves, and is currently facing a severe water challenge. Hence, ensuring water security is a high priority for the Government of India.

As providers of geospatial content, services, solutions and platforms, the geospatial industry is geared to assist the government in accomplishing this critical goal. Availability of clean water to all for personal, industrial, and agricultural use will not only ensure India reaches its vision of becoming a USD 5 Trillion economy but will also enable our country to achieve the United Nations Sustainable Development Goals.

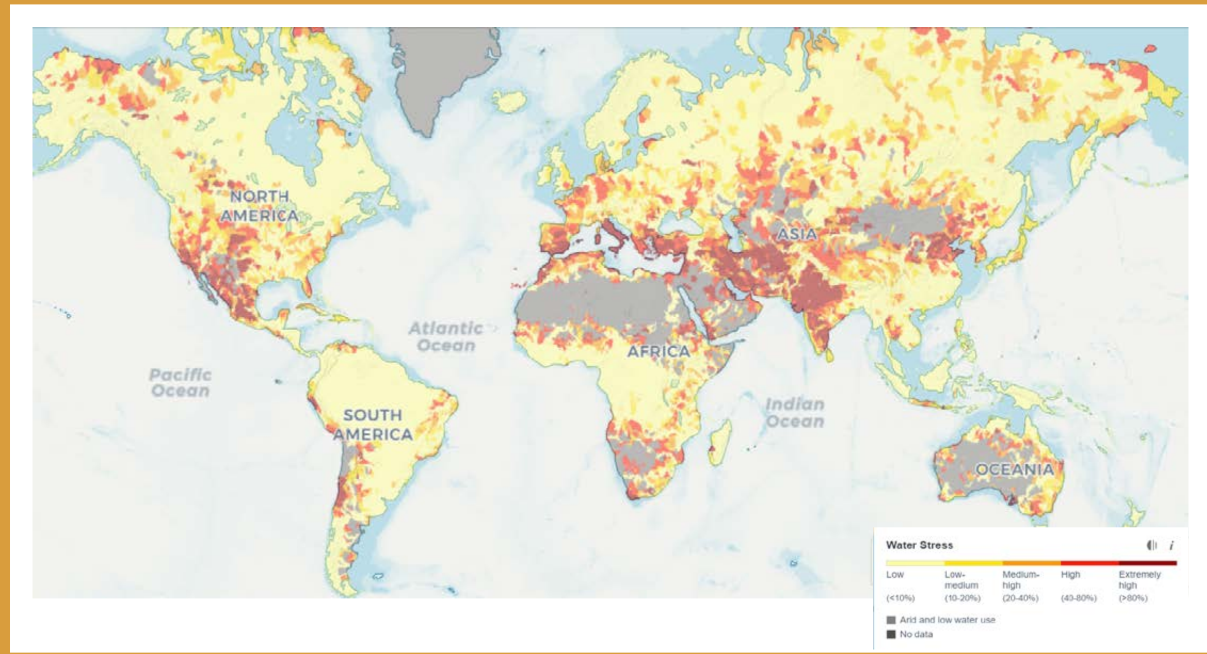
Through this report, AGI India endevours to highlight the benefits of using Geospatial technologies for the on-going water programmes in India and how the industry can work with the government to deliver better results.

Agendra Kumar
President
Association of Geospatial Industries

OVERVIEW OF **WATER SECTOR IN INDIA**

Water is the source of life - an essential for all human activities, however, with increasing agriculture, commercialization, rapid population explosion and changing consumption patterns, the need for water, especially clean water, is at an all-time high. India is no exception to this demand. As a fast developing and second most populous country in the world, India is facing a severe water crisis that is becoming a critical issue. Home to about 17% of the world population, and around 20% of world's livestock population, India has access to only about 4% of the world's freshwater reserves.

Figure 1: Aqueduct Global Water Stress Index[1]



This visual representation prepared by Aqueduct , presents the global water stress index. Baseline water stress measures the ratio of total water withdrawals to available renewable surface and groundwater supplies. Water withdrawals include domestic, industrial, irrigation, and livestock consumptive and non-consumptive uses. Available renewable water supplies include the impact of upstream consumptive water users and large dams on downstream water availability. Higher values indicate more competition among users. India is one of the most severely water stressed countries in the world.

KEY CONCERNS FOR THE INDIAN WATER SECTOR

India receives 3,000 billion cubic metres of water every year through rainfall or other sources such as glaciers; of this, only 8% is collected. Total capacity of India's reservoirs stands at 250 billion cubic meters (bcm), while its total water bearing capacity over the surface is around 320 bcm. As the country that withdraws the largest quantity of underground water, India fills ground water aquifers at the rate of 458 bcm per year, while it extracts around 650 bcm of water from the earth. 89% of India's water resources are used for agriculture, out of which 65% is withdrawn from under the ground. Industry too obtains around 80% of their water requirements from underground sources. Thus, one of India's biggest challenges is to conserve groundwater.

As per a NITI Aayog report, currently nearly 820 million people in 12 major river basins of India face extreme water stress situation. India also performs poorly in almost all aspects of Environment Performance Index as assessed by the Yale University that includes parameters like Sanitation and Drinking Water and Water Resources. Further, there has been a 136 per cent increase in the number of grossly polluting industries between 2011-2018, according to the State of India's Environment (SoE) In Figures, 2019.

Of the 189 million households in Rural India, only 51 million (26%) have household tap water connection. India also has insufficient water storage capacities. While some countries have capacities up to 5000 mt cube per person storage infrastructure, India only has about 200 mtr cube per person. This results in droughts even in years that experience good monsoons.

Adding to the issue of lack of water availability is the issue of water quality. Even the water that is available is not fit for direct consumption. Groundwater in one-third of India's 600 districts is contaminated mainly through fluoride and arsenic. India's economic burden through water borne diseases is approximately USD 600 million a year. Less than 50 percent of India's population has access to safe managed drinking water, and that too is inequitable. A big concern for the water utilities is the high levels of revenue loss in terms of Non-Revenue Water or water that is unaccounted for. This is mostly due to an almost non existing water metering in the country.

Lastly, the science in water resources management is very complex and dynamic. The implication of an applied strategy is not known in the short run. The gestation period for any quantifiable change is upwards of a decade, hence adoption of appropriate technology tools and analytics to assess the situation and simulate various possibilities is critical for sustainable development in the water sector.

Figure 2: Aspects of Water Resources & Utilities Management

KEY STAKEHOLDERS OF WATER SECTOR

In view of the challenges that pervade the water resources sector and water utility services in our country, the Government of India has taken numerous steps to address the issue, while emphasizing on the use of technology for the purpose. Previously, water was a subject which was dealt by almost nine Ministries. The present government has integrated the work of these various Ministries and brought them under the Ministry of Jal Shakti with two Departments i.e. Department of Water Resources, River Development and Ganga Rejuvenation (Jal Sansadhan, Nadi Vikas Aur Ganga Sanrakshan Vibhag) and Department of Drinking Water and Sanitation (Peya Jal Aur Swachhata Vibhag). Hon'ble Prime Minister has also set a revolutionary goal of bringing piped drinking water to all households, for which the Centre and the states will together spend 3.5 lakh crore rupees. This initiative will play a big role in making India a 5 trillion-dollar economy. This initiative is integrated with ensuring source sustainability and gray water treatment.

Figure 3: Key Water Sector Stakeholders

Ministry of Jal Shakti

Central Government Organisations

Attached Offices

1. Central Water Commission (CWC)
2. Central Soil & Materials Research Station (CSMRS)

Subordinate Offices

3. Central Ground Water Board (CGWB)
4. Central Ground Water Authority (CGWA)
5. Central Water & Power Research Station (CWPRS)
6. Bansagar Control Board (BCB)
7. Ganga Flood Control Commission (GFCC)
8. Farakka Barrage Project (FBP)
9. Farakka Barrage Project Control Board
10. Sardar Sarovar Construction Advisory Committee
11. Upper Yamuna River Board (UYRB)
12. National Water Information Centre (NWIC)

Statutory Bodies

13. Tungabhadra Board (TB)
14. Betwa River Board (BRB)
15. Brahmaputra Board (BB)
16. Godavari River Management Board (GRMB)
17. Krishna River Management Board (KRMB)

Corporate Bodies

18. Narmada Control Authority (NCA)
19. Cauvery Water Management Authority

Registered Societies/ Autonomous Bodies

20. National Water Development Agency (NWDA)
21. National Institute of Hydrology (NIH)
22. North Eastern Regional Institute of Water and Land Management (NERIWALM)
23. National Mission for Clean Ganga (NMCG)
24. National River Conservation Directorate
25. National Water Informatics Centre (NWIC).
26. Polavaram Project Authority (PPA)

Public Sector Undertakings

27. National Projects Construction Corporation Limited (NPCC Ltd.)
28. Water & Power Consultancy Services Limited (WAPCOS Ltd.)

State Government Departments

- Irrigation
- Flood Control
- Water Resources
- Watershed Management
- River Development
- Water Supply
- Urban Local Bodies

Training and Research Institutes

- NWA
- WALMI
- NERIW
- WALAMTARI
- CWRDM
- Rajiv Gandhi National Ground Water Training and Research Institute

OVERVIEW OF PAST WATER PROJECTS IN INDIA

The Government of India has been investing heavily into water related projects, be it for water resource management, watershed development or agriculture and irrigation projects since Independence. Here is a brief snapshot of the projects undertaken in the last decade, that have now been merged into various national level programmes.

Accelerated Irrigation Benefit Programme (AIBP)

Scope

Provide central assistance to major/medium irrigation projects in the country, with the objective to accelerate implementation of such projects which were beyond the resource capability of the States or were at an advanced stage of completion.

Budget: INR 55,196 Crore

Launch Year: 1996

Responsible Ministry

Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR,RD&GR)

Outcome

Since its inception, 297 Irrigation / Multi-Purpose Projects have been included for funding under AIBP. Out of these 143 projects have been completed and 5 projects were foreclosed. An irrigation potential of 24.39 Lakh ha has been created through the completed projects

Merged Into

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) in 2015-16

Rationalisation of Minor Irrigation Statistics (RMIS)

Scope

The main objective of the RMIS scheme is to build a comprehensive and reliable database in Minor Irrigation (MI) sector for effective planning and policymaking. The major activity under the scheme is the Census of MI schemes conducted in the States/UTs covering all groundwater and surface water schemes.

Budget: INR 17.84 crore incurred during 2017-18

INR 257.78 crore allocated for next census

Launch Year: 1987

Responsible Ministry

Minor Irrigation (Stat.) Wing of Department through State governments

Outcome

All India Censuses of Minor Irrigation (MI) schemes have been conducted under RMIS scheme in 1986-87, 1993-94, 2000-01, 2006-7, and 2013-14. A dedicated online portal for 5th Minor Irrigation (MI) Census has been developed which facilitated online data entry, updation, validation and tabulation. Data can be accessed by both Central level and State level users in real time.

Merged Into

Now called Irrigation Census, under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) since 2017

Repair, Renovation and Restoration (RRR) of Water Bodies

Scope

- Comprehensive improvement and restoration of water bodies thereby increasing tank storage capacity.
- Groundwater Recharge.
- Increased availability of drinking water.
- Improvement in agriculture/ horticulture productivity.
- Improvement of catchment areas of tank commands.
- Environmental benefits through improved water use efficiency; by promotion of conjunctive use of surface and groundwater.
- Community participation and self-supporting system for sustainable management for each water body.
- Capacity Building of communities, in better water management.
- Development of tourism, cultural activities, etc.

Budget: INR 300 crore (2002-7)

INR 5,009.16 crore (2007-12) including external and domestic support.

INR 9,050 crore for PMKSY (HKKP)

Responsible Ministry

Ministry of Water Resources

Launch Year: 2005

Outcome

2002-7: Covered 1098 water bodies in 26 districts of 15 States created 0.78 lakh ha of additional irrigation potential.

2007-12: 3341 water bodies (with domestic support) with CCA of 3.094 lakh ha and 10887 water bodies in four States namely Odisha, Karnataka, Andhra Pradesh and Tamil Nadu (with external support) with CCA of 8.25 lakh ha were covered.

PMKSY (HKKP) component targets to create 21.0 lakh ha of irrigation potential including 1.50 lakh ha from RRR of water bodies scheme.

Merged Into

Scheme has become a part of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) Har Khet Ko Pani since 2015

Integrated Watershed Management Programme (IWMP)

Scope

Drought Prone Areas Programme (DPAP), Desert Development Programme (DDP) and Integrated Wastelands Development Programme (IWDP) were integrated and consolidated into a single modified programme called Integrated Watershed Management Programme (IWMP).

The main objectives of the IWMP were:

- Harnessing, conserving and developing degraded natural resources such as soil, vegetative cover & water
- Restoring the ecological balance
- Prevention of soil run-off
- Regeneration of natural vegetation
- Rainwater harvesting & recharging of ground water table
- Introduction of multi-cropping & diverse agro-based activities
- Promoting sustainable livelihoods.

Budget: INR 11,250 crores

Launch Year: 2009

Responsible Ministry

Department of Land Resources (DoLR)

Outcome

DoLR sanctioned, 8214 watershed development projects covering an area of about 39.07 million hectare in 28 States (except Goa) [now 27 States and UTs of Jammu & Kashmir and Ladakh) during the period 2009-10 to 2014-15. During the year 2018, 1832 projects (345 uninitiated and 1487 in preparatory stage) were transferred to various States for implementation from the Budget of the concerned States. Thereafter, DoLR is implementing 6382 projects.

Merged Into

Consolidated as the Watershed Development Component of Prime Minister Krishi Sinchayee Yojna (WDC-PMKSY) in 2015-16.

Flood Management Programme (FMP)

Scope
The project aimed to take up works related to river management, flood control, anti-erosion, drainage development, flood proofing works, restoration of damaged flood management works, anti-sea erosion and catchment area treatment.

Budget: IINR 8,000 crores from 2007-2012 and INR 10,000 crore from 2012-2017

Responsible Ministry
Ministry of Water Resources

Launch Year: 2007

Outcome
In total during XI and XII Plans, 522 works with a total estimated cost of INR 13,238.36 crore were approved under FMP.

Merged Into
Merged with River Management Activities & Works related to Border Areas (RMBA) to form the Flood Management and Border Areas Programme (FMBAP) in 2017

River Management Activities and Works related to Border Areas (RMBA)

Scope
The project's objective was to take up non-structural measures such as Hydrological Observation and Flood Forecasting works on common border rivers, payment to neighboring countries (viz. Bangladesh, Nepal, China, Pakistan and Bhutan) for supplying HO data on common rivers, investigation of WR projects in neighbouring countries, activities of GFCC and Pancheswar Development Authority (PDA).

Budget: INR 820 crore from 2007-2012; INR 740 crore from 2012-2017

Responsible Ministry
Ministry of Water Resources

Launch Year: 2007

Merged Into
Merged with River Management Activities & Works related to Border Areas (RMBA) to form the Flood Management and Border Areas Programme (FMBAP) in 2017

MAJOUR ONGOING WATER PROJECTS IN INDIA

Jal Jeevan Mission - Rural

Scope
Provide Functional Household Tap Connections (FHTC) to every rural household by 2024 with a service level of 55 litres per capita per day (lpcd). The scheme is also known as Har Ghar Nal Se Jal (HGNSJ). It also includes source sustainability – Rain water harvesting, groundwater recharge, and other water conservation measures along with grey water management. The following programmes of GoI have been subsumed in JJM:

- Rural Water Supply and Sanitation Project for low income States (RWSSP-LIS)
- National Water Quality Sub-Mission (NWQSM)
- Water quality earmarked allocation (JE-AES)
- Swajal Water Quality Monitoring & Surveillance (WQM&S)

Budget: INR 3.5 lakh crore for 2019-2024

Duration: 2019 - 2024

Geographic Coverage
Country wide

Responsible Agency
Department of Drinking Water and Sanitation, Ministry of Jal Shakti

Other Stakeholders
- State Water and Sanitation Mission (SWSM) at the state level
- District Water and Sanitation Mission (DWSM) at the district-level
- Village Water and Sanitation Committes (VWSC) at the Gram Panchayat (GP) level

Jal Jeevan Mission - Urban

Scope

- Universal coverage of water supply to all households in 500 AMRUT cities
- Aim to provide tap water connection to 28.6 million urban households, as well as liquid waste management in 500 AMRUT cities.

Budget: INR 2,87,000 crore for 2021-2026

Duration: 2021 - 2026

Geographic Coverage
500 AMRUT cities

Responsible Agency
Ministry of Housing and Urban Affairs

Other Stakeholders

- State Governments and Urban Local Bodies

Namami Gange

Scope

- Effective abatement of pollution, conservation and rejuvenation of National River Ganga. Components include:
  - Sewerage Treatment Infrastructure
  - River-Front Development
  - River-Surface Cleaning
  - Bio-Diversity
  - Afforestation
  - Public Awareness
  - Industrial Effluent Monitoring
  - Ganga Gram

Budget: INR 20,000 crore

Duration: 2014 onwards

Geographic Coverage
Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Himachal Pradesh, Rajasthan, Madhya Pradesh, Chhattisgarh

Responsible Agency
National Mission for Clean Ganga (NMCG)

Other Stakeholders

- State & District Governments

Dam Rehabilitation and Improvement Project (DRIP)

Scope

To improve safety and operational performance of 198 dams, along with institutional strengthening. Key activities included Design Flood Review, publication of important Guidelines as well as Manuals dealing with Dam Safety Management, preparation of O&M Manuals, Emergency Action Plans, development of web-based asset management tool i.e. Dam Health And Rehabilitation Monitoring Application (DHARMA), Seismic Hazard Mapping along with development of Seismic Hazard Assessment Information System (SHAISYS), Risk Assessment of few selected dams. At the close of DRIP-1 project, The World Bank has outlined the following achievements:

- 197 project dams with the improved ability (structural or non-structural) to safely cater for the design floods
- 198 project dams with acceptable stability and seepage
- 198 project dams with basic dam safety facilities in place
- 150 project dams with need-based O&M plans operationalized
- 150 project dams where emergency response plans have been prepared and disseminated to the population.

Budget: INR 3,466 cr

Duration: 2012-2020

Geographic Coverage
Jharkhand, Karnataka, Kerala, Madhya Pradesh, Odisha, Tamil Nadu, and Uttarakhand

Responsible Agency

- Central Water Commission (CWC)
- Uttarakhand Jal Vidyut Nigam Limited
- Odisha Water Resource Department
- Tamil Nadu Water Resources Department
- Kerala State Electricity Board
- Karnataka Water Resources Development Organisation
- TANGEDCO Tamil Nadu
- Kerala Water Resources Department

Other Stakeholders

State Dam Safety Organizations & State Project Management Units & Institutions like Central Water and Power Research Station, NIT Calicut, College of Engineering Trivandrum, MANIT Bhopal, MNNIT Allahabad, College of Engineering Chennai, IIT Madras, IISC Bangalore, IIT Roorkee, CSMRS

Dam Rehabilitation and Improvement Project (DRIP) Phase 2 & 3

Scope

To improve safety and operational performance of 736 dams, along with institutional strengthening with system wide management approach.

Budget: INR 10,200 cr
(World Bank INR 7,000 Crore + State Agencies INR 2800 Crore + Central Agencies INR 400 Crore)

Duration: April 2020 - March 2031

Geographic Coverage

19 states covering 22 state agencies:

Andhra Pradesh, Chhattisgarh, Goa, Gujarat, Jharkhand, Karnataka (WRD), Karnataka (KPCL), Kerala (WRD), Kerala (KSEB), Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Odisha, Punjab, Rajasthan, Tamil Nadu (WRD), Tamil Nadu (TANGEDCO), Telangana, Uttar Pradesh, UJVNL, West Bengal

3 central agencies:

Bhakra Beas Management Board (BBMB), CWC, Damodar Valley Corp.

Responsible Agency

Central Water Commission (CWC) and Bhakra Beas Management Board (BBMB)

Other Stakeholders

State Project Management Units (SPMUs)

National River Linking Project (NRLP)

Scope

Large-scale civil engineering project that aims to effectively manage water resources by linking Indian rivers by a network of reservoirs and canals to enhance irrigation and groundwater recharge, reduce persistent floods in some parts and water shortages in other parts of India.

Components:

- Northern Himalayan rivers inter-link component
- Southern Peninsular component
- Intrastate rivers linking component

Budget: INR 22,495.62 Crore

Geographic Coverage

- Ken-Betwa Link - Completed
- NWDA identified 14 links under Himalayan Rivers Component and 16 links under Peninsular Rivers Component
- Ken-Betwa Link Project Phase-II
- Damanganga-Pinjal Link Project
- Par-Tapi-Narmada Link Project
- Mahanadi – Godavari Link Project
- Godavari-Cauvery(Grand Anicut) link project
- Manas-Sankosh-Teesta-Ganga link
- NWDA has received 47 proposals of intra-state links from 9 States viz. Maharashtra, Gujarat, Jharkhand, Odisha, Bihar, Rajasthan, Tamil Nadu, Karnataka and Chhattisgarh

Responsible Agency

National Water Development Agency (NWDA)

Other Stakeholders

Govt proposes to set up an independent agency - National Interlinking of Rivers Authority(NIRA)

Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

Scope

The purpose of AMRUT is to:

1. Ensure that every household has access to a tap with the assured supply of water and a sewerage connection.
2. Increase the amenity value of cities by developing greenery and well-maintained open spaces (e.g. parks)
3. Reduce pollution by switching to public transport or constructing facilities for non-motorized transport (e.g. walking and cycling).

In specific the scope related to water supply, sewage and storm water drainage are:

- Water supply systems including augmentation of existing water supply, water treatment plants and universal metering.
- Rehabilitation of old water supply systems, including treatment plants.
- Rejuvenation of water bodies specifically for drinking water supply and recharging of ground water.
- Special water supply arrangement for difficult areas, hill and coastal cities, including those having water quality problems (e.g. arsenic, fluoride)
- Decentralised, networked underground sewerage systems, including augmentation of existing sewerage systems and sewage treatment plants.
- Rehabilitation of old sewerage system and treatment plants.
- Recycling of water for beneficial purposes and reuse of wastewater.
- Construction and improvement of drains and storm water drains in order to reduce and eliminate flooding.

Budget: INR 50,000 crore for 2015-2020, INR 7,300 crore for 2021-22

Geographic Coverage

500 AMRUT cities

Responsible Agency

Ministry of Housing and Urban Affairs

Other Stakeholders

State Governments and Urban Local Bodies

National Hydrology Programme

Scope

To improve the extent, quality and accessibility of water resources information and to strengthen the capacity of targeted water resources management institutions in India. Objectives include:

- To establish and integrate a country-wide hydromet monitoring network system.
- To provide upto date and reliable hydromet data to stakeholders
- To develop systems for improved flood forecasting.
- To develop tools for improved river basin assessment and planning.
- Capacity building of the Implementing Agencies.

Budget: INR 3,680 crore

Duration: 2016-2024

Geographic Coverage

Country wide

Responsible Agency

49 Implementing Agencies.
9 Central agencies, 35 State agencies, 3 River basin agencies and 2 UTs agencies

Other Stakeholders

National Water Informatics Centre (NWIC)

Pradhan Mantri Krishi Sinchayi Yojana (PMKSY) - Accelerated Irrigation Benefit Project (AIBP)

Scope

The major objective of PMKSY is to achieve convergence of investments in irrigation at the field level, expand cultivable area under assured irrigation, improve on-farm water use efficiency to reduce wastage of water, enhance the adoption of precision-irrigation and other water saving technologies (More crop per drop), enhance recharge of aquifers and introduce sustainable water conservation practices by exploring the feasibility of reusing treated municipal waste water for peri-urban agriculture and attract greater private investment in precision irrigation system. PMKSY has been conceived amalgamating ongoing schemes viz.

- Accelerated Irrigation Benefit Programme (AIBP) of the Ministry of Water Resources, River Development & Ganga Rejuvenation (MoWR,RD&GR)
- Integrated Watershed Management Programme (IWMP) of Department of Land Resources (DoLR).
- On Farm Water Management (OFWM) of Department of Agriculture and Cooperation (DAC)

Budget:

INR 5,300 crore - 2015-16

INR 11,506 crore - 2020-21

INR 11,588 crore - 2021-22

Duration: 2015 onwards

Geographic Coverage

Country wide

Responsible Agency

Ministry of Rural Development

Ministry of Jal Shakti

Ministry of Agriculture

Other Stakeholders

- State Level Sanctioning Committee (SLSC) chaired by the Chief Secretary of the respective States are authorized to sanction projects, oversee its implementation and monitoring.
- National Executive Committee (NEC) under the Chairmanship of Vice Chairman, NITI Aayog.
- At National level, programme is to be supervised and monitored by an Inter-Ministerial National Steering Committee (NSC) under the Chairmanship of Hon'ble Prime Minister with Union Ministers concerned Ministries as a members.
- NRSC

Neeranchal National Watershed Project

Scope

The project supports WDC-PMKSY through technical assistance to improve incremental conservation outcomes and agricultural yields for communities in selected sites, and adoption of more effective processes and technologies into the broader PMKSY in participating states. The project will contribute to enhanced watershed management activities in two districts in each participating state, covering 450 sub-watersheds, each of about 5,000 ha and reaching approximately 482,000 farmer households and 2.0 million people. The project would initially focus on 90 sub-watersheds with intensive technical assistance. After this first phase, the project would then help scale up best practices into IWMP operations in an additional 360 sub-watersheds in the eight focal states, within the original two districts per state.

Budget: INR 2,611.90 crores

Duration: 2016-2022

Geographic Coverage

Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Rajasthan and Telangana

Responsible Agency

Department of Land Resources

Other Stakeholders

State Level Nodal Agency assigned under PMKSY for watershed development

National Institute of Hydrology (NIH) Roorkee has been partnered under the project for development of Decision Support System (DSS) - Hydrology

National Aquifer Mapping and Management Programme (NAQUIM)

Scope

To support effective management of groundwater resources in the country, the NAQUIM programme involves:

1. Delineation and characterization of aquifers in three dimensions
2. Identification and quantification of issues
3. Development of management plans to ensure sustainability of groundwater resources

Covers around 23.25 lakh Km^2 mappable areas distributed over several States and Union Territories

Preparation of Aquifer maps on 1:50,000 scale by depicting aquifer geometry in 2D/3D

Budget: INR 3,319 crore for 2012-17

Duration: 2012 onwards

Geographic Coverage

Covers around 23.25 lakh Km^2 mappable areas distributed over several States

Responsible Agency

CGWB

Other Stakeholders

NRSC, GSI, SOI, NIH

Flood Management & Border Areas Programme (FMBAP)

Scope

Effective flood management, erosion control and anti-sea erosion. Framed by merging the components of two continuing XII Plan schemes titled "Flood Management Programme (FMP)" and "River Management Activities and Works related to Border Areas (RMBA)".

Budget: INR 3,342 crore for 2017-2020
INR 8,000 crore for 2012-2017

Duration: 2007 onwards

Geographic Coverage
Country wide

Responsible Agency
CWC

Other Stakeholders
State Governments

River Basin Management

Scope

The River Basin Management Scheme comprises of 2 main components namely:

1. Brahmaputra Board
2. Investigation of Water Resource Development Scheme (IWRDS)
   a. CWC component
   b. NWDA component

Brahmaputra Board carries out following major works:

Survey, Investigation & preparation of Master PlanPreparation of DPR of Multipurpose ProjectsDrainage Development SchemesAnti-erosion works including protection of Majuli Island, Balat Village in Meghalaya, Mankachar and Masalabari area in Assam etc from flood and erosionConstruction of Raised Platforms

The aim of IWRDS is to plan and develop our water resources projects in a holistic manner. It has two subcomponents-

CWC component –

To locate a suitable site to establish a project's techno-economic viability it undertakes DPR preparation after detailed survey and investigations and studies on hydrological, irrigation planning, environment aspects, cropping pattern, crop water requirement etc.

NWDA Component –
It carries out various technical studies to establish the feasibility of the proposals of NPP.

Budget: INR 674 crore

Duration: 2017 onwards

Geographic Coverage

Arunachal Pradesh, Assam, Meghalaya, parts of the states of Manipur, Mizoram, Nagaland, Tripura, Sikkim, Jammu and Kashmir and a part of West Bengal

Responsible Agency

Brahamputra Board, CWC, CGWB, NWDA

Other Stakeholders

State Governments

Atal Bhujal Yojana (ABHY)

Scope

Improve management of groundwater resources through community participation and demand side interventions in seven states of the country. The scheme has two components, viz. i) Institutional Strengthening and Capacity Building Component, aimed at strengthening the groundwater governance mechanism in the participating States and ii) Incentive Component, aimed at rewarding/ incentivizing the States for various measures aimed at ensuring the long-term sustainability of groundwater resources.

Budget: INR 6,000 cr (INR 3,000 cr from WB & INR 3,000 cr from Central Govt)

Duration: 2020-21 to 2024-25

Geographic Coverage

8353 water stressed Gram Panchayats of Haryana, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh

Responsible Agency

The National Program Management Unit (NPMU) at Department of Water Resources, River Development and Ganga Rejuvenation (DoWR,RD&GR), Ministry of Jal Shakti and line departments/State Programme Management Units (SPMUs) established in the participating states

Other Stakeholders

District Implementation Partners (DIPs) , consisting of one or more NGOs / CBOs

National Water Mission

Scope

The main objective of the National Water Mission is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within states through integrated water resources development and management.

Duration
2011 onwards

Geographic Coverage
Country wide

Responsible Agency
Ministry of Jal Shakti, CWC

Other Stakeholders
State Water Resources Departments

Water Resources Projects or Multipurpose River Valley Projects

Scope

Water resources or Multiple River Valley projects are broadly categorized into irrigation projects and hydroelectric projects. These projects are planned for various purposes like irrigation, hydro-power generation, water supply for drinking and industrial purpose, flood control navigation etc. Projects which serve more than one purpose are called as multipurpose projects.

India categorises irrigation projects as under:

- Major Irrigation: Culturable command area (CCA) more than 10,000 hectares
- Medium Irrigation: Culturable command area more than 2,000 hectares but less than 10,000 hectares
- Minor Irrigation: Culturable command area up to 2,000 hectares

Whereas major and medium irrigation works are meant for tapping surface water (e.g., rivers), minor irrigation mainly involves ground water development, e.g., tube-wells, boring works, etc. These projects are basically designed for the development of irrigation for agriculture and electricity through the construction of dams, bunds, canals etc. There are several such water resources projects that are being implemented by state governments.

Responsible Agency
State governments

Geographic Coverage
Country wide

OVERVIEW OF **GEOSPATIAL TECHNOLOGIES AND ECOSYSTEM IN INDIA**

Geospatial Technologies answer two crucial questions – Where and How. These are tools that enable us to present the spatial context of phenomena and provides a platform for developing an understanding of 'what-if' scenarios by integrating various other datasets.

Today, Geospatial technologies are used by governments, scientists, researchers, businesses, and common people alike. The term 'geospatial' refers not to one single technology, but a sleuth of technologies that help to collect, analyse, store, manage, distribute, integrate, and present geographic information. Broadly speaking, it consists of the following technologies:

Remote Sensing

This technology allows us to remotely capture features of Earth's surface by using various sensors that are typically mounted on satellites or airborne vehicles. Remote Sensing sensors record earth's reflectance in different wavelength, and these received reflectance value are processed to create separate image for each wavelength. The reflectance value stored for different wavelength in different layers, which are also called bands present in that satellite images. A sensor can record several wavelengths simultaneously. In general, there are three wavelengths from visible i.e. blue wave length, green wavelength and red wave length, whereas infrared can be further defined as near infrared, mid infrared, far infrared and thermal infrared.

Multispectral satellite data for the water sector is extremely useful as it helps extract detailed information and facilitates more accurate interpretation and classified thematic maps. It helps in assessing depth, water turbidity, understanding aqua culture, assessing water levels, river movement, understanding water-related disaster scenarios, overview of population spread etc.

Survey

This technology is used to make relatively large-scale, accurate measurements of the Earth's surface. It includes the determination of the measurement data, reduction and interpretation of the data to usable form, and, conversely, the establishment of relative position and size according to a given measurement requirements. Thus, surveying has two similar but opposite functions: (1) the determination of existing relative horizontal and vertical position, such as that used for the process of mapping, and (2) the establishment of marks to control construction or to indicate land/water boundaries. Survey equipment include theodolite, total station, 3D scanners, LiDAR etc.

A special type of survey relevant for the water sector is Bathymetric surveys, which allows us to measure the depth of a water body as well as map the underwater features of a water body. Multiple methods can be used for bathymetric surveys including multi-beam and single-beam surveys, ADCPs, sub-bottom profilers, and the Ecomapper Autonomous Underwater Vehicle. Bathymetric surveys are used for many different types of research including flood inundation, contour of streams and reservoirs, leakage, scour and stabilization, water-quality studies, dam removal, biological and spill, and storage and fill in reservoirs and ponds.

GNSS

Global Navigation Satellite System (GNSS) provides precise position or geographic location of people, equipment or things that are attached to a device that includes a GNSS chip. Data about the location is gathered from a constellation of navigation satellites that cover the entire globe. Common applications include navigation, and routing. GNSS is also used in high precision construction.

GIS or Spatial Analytics

A Geographic Information System (GIS) is a conceptualized framework that provides the ability to capture and analyse spatial and geographic data. GIS helps integrate different data layers for enabling spatial based decision making for a variety of users from local governments, transport/logistics, insurance, environment monitoring, telecommunications etc.

Geospatial Technologies in Relation to Digital Technologies

The fourth industrial revolution is marked by the advent of new-age technologies that is revolutionizing the way we live, work, and relate to each other. These technologies include Artificial Intelligence, Big Data Analytics, Internet of Things, Robotics, Virtual Reality, 5G and others.

Geospatial or location information has a critical role to play across these technologies and users from various sectors, including water would need to be able to integrate these into their workflows to derive optimal results from digital technologies. Here is an outline of the interplay between geospatial technologies and other new-age technologies and their relevance for the water sector.

Artificial Intelligence

Artificial intelligence (AI) is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. AI simulates human intelligence in machines that are programmed to think like humans and mimic their actions. A subset of artificial intelligence is machine learning, which refers to the concept that computer programs can automatically learn from and adapt to new data without being assisted by humans. Deep learning techniques enable this automatic learning through the absorption of huge amounts of unstructured data such as text, images, or video.

The scientific field of geospatial artificial intelligence (geoAI) was recently formed from combining innovations in spatial science with the rapid growth of methods in artificial intelligence (AI), particularly machine learning (e.g., deep learning), data mining, and high-performance computing to glean meaningful information from spatial big data. geoAI is highly interdisciplinary, bridging many scientific fields including computer science, engineering, statistics, and spatial science.

GeoAI can help professionals in the water sector to automatically detect terrain features, densely distributed building footprints, extract information from scanned historical maps, cleanse data in subterranean utility networks, interpretation of utility drawings and asset recognition in images. GIS combined with AI is also useful for developing and maintaining decision-making processes like smart water grids, smart sewage systems, and smart waste management systems.

Big Data Analytics

Geospatial data has always been characterised as big data. Geospatial data is being captured from a variety of sources, right from satellites, UAV mounted sensors, other sensors measuring and monitoring water/air quality, traffic patterns, cell phone data, as well as citizen science producing volunteered geospatial data. With expanding network of data inputs, geospatial data is becoming ever more tedious to handle. Geospatial Big Data Analytics is creating significant impact in a wide variety of sectors, including humanitarian projects, marketing, financial services, to name a few.

For the water sector, big data analytics can address issues of data scarcity by consolidating data available from different sources, both traditional and unconventional. Secondly, big data analytics can transform data into usable information that can support groundwater management, especially at a local scale. Big data analytics techniques and methods provide benefits beyond traditional analytics, when dealing with large heterogeneous datasets and are particularly useful when performing data-driven modelling. For the water sector, big geospatial data analytics can help develop algorithms for predictive scenarios used for dam construction, water resource management, river linking projects etc.

Internet of Things (IoT)

The network of physical objects embedded with sensors/software, exchanging data with other devices is called the Internet of Things. These sensors measure with high precision the state of the physical world such as temperature, humidity, radiation, electromagnetism, noise, chemicals, etc. Data collected through IoT when combined with geospatial data provides rich knowledge and analytics about the real world and helps deliver better outcomes.

IoT sensors when combined with GIS technology can be an effective tool for generating flooding models, calculating the expected excess rainwater, identifying groundwater potential zones in hard rock terrain, monitoring the seasonal variation of physicochemical parameters of an urban water stream, generating high-risk floodplain maps, delineating groundwater potential zones in hard rock terrain, assessing the spatial variation of groundwater quality and producing salinity hazard maps. Large-scale location measurements are also important in management of construction sites and operations, by means of real-time monitoring of the position of assets and materials for day-to-day management and planning, thereby holding potential for the dam construction and rehabilitation work.

5G

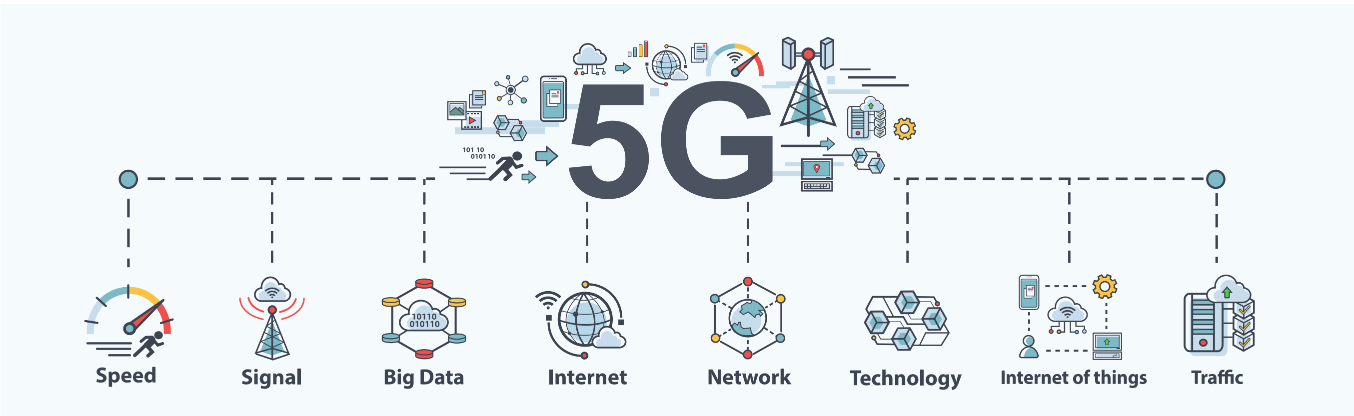
5G or fifth generation technology standard for broadband cellular networks is set to be about 100 times faster than the currently available 4G networks. The higher networks can transmit much more data, much faster than present. 5G wireless promises higher capacity, more reliability, lower latency, and improved coverage, thus bringing greater accuracy in positioning services. 5G technologies will make data transfer from IoT devices and sensors much faster.

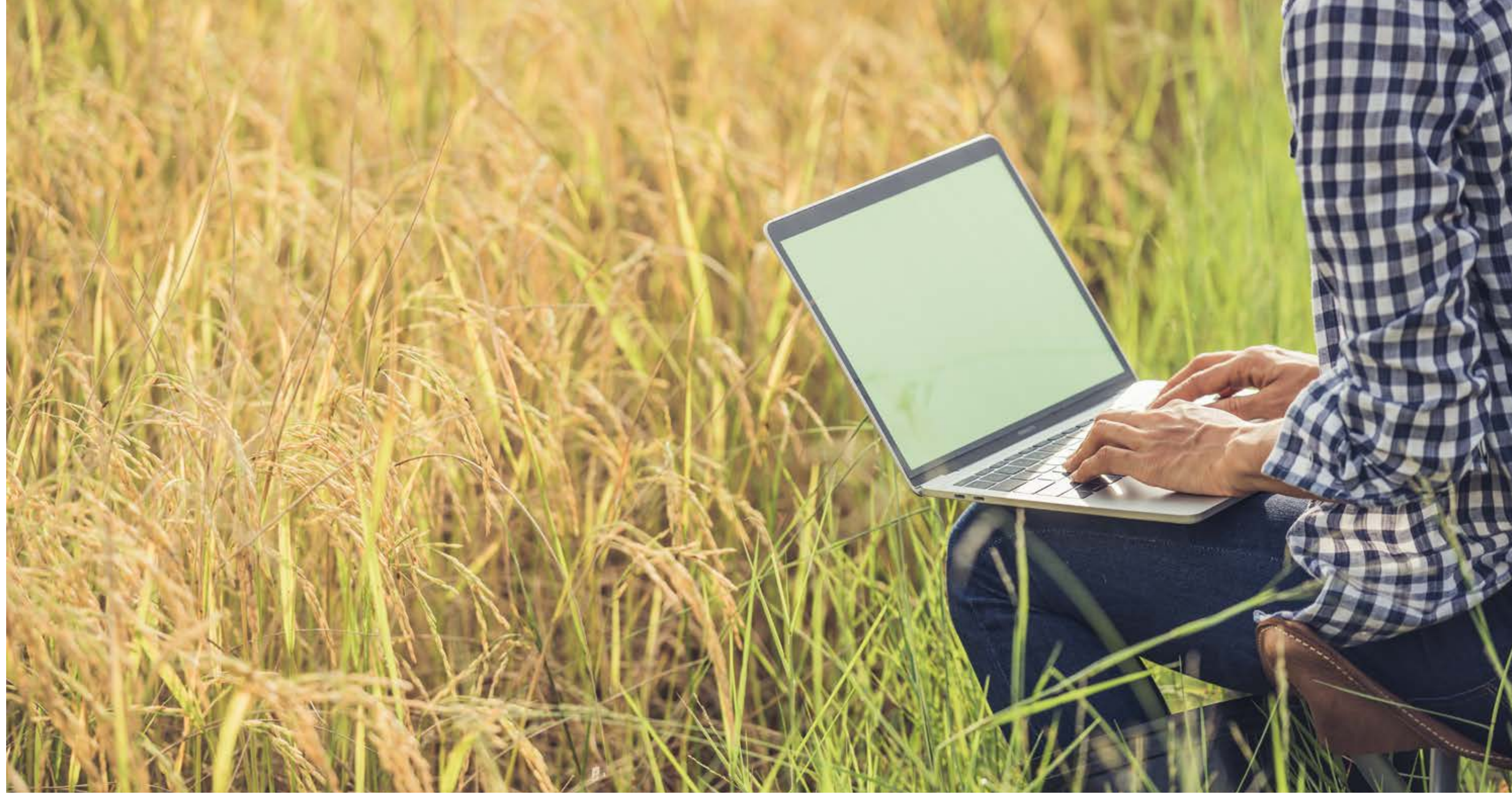
With positioning data expected to improve to sub-meter accuracy to even support 3D location estimates, 5G enabled IoT devices will provide precise location about water supply, sanitation, incidents related to leaks or emergencies in real-time basis. As 5G will enable faster machine-to-machine communications, these incoming data from various sensors can be integrated in a GIS based control centre that will process location information in real time and AI systems will analyse and trigger actions, thereby enhancing the ability of decision makers to better monitor and manage water related assets and resources.

Robotics

With improvements in the field of robotics, geospatial domain has also gained a new instrument for data collection that offers flexibility and convenience to map a large area in a faster, consistent, and a more precise manner. Robotic mapping has significantly contributed to the field of localization and mapping, by increasingly becoming independent and automated.

Low-cost robots for remote surface data collection support water balance computations and hydrologic understanding where water availability data is sparse. Data derived from these sources produce local, high-resolution representations of bathymetry and topography and enables water balance computations at small-watershed scales, which offer insight into the present-day dynamics of a strongly human impacted watershed.



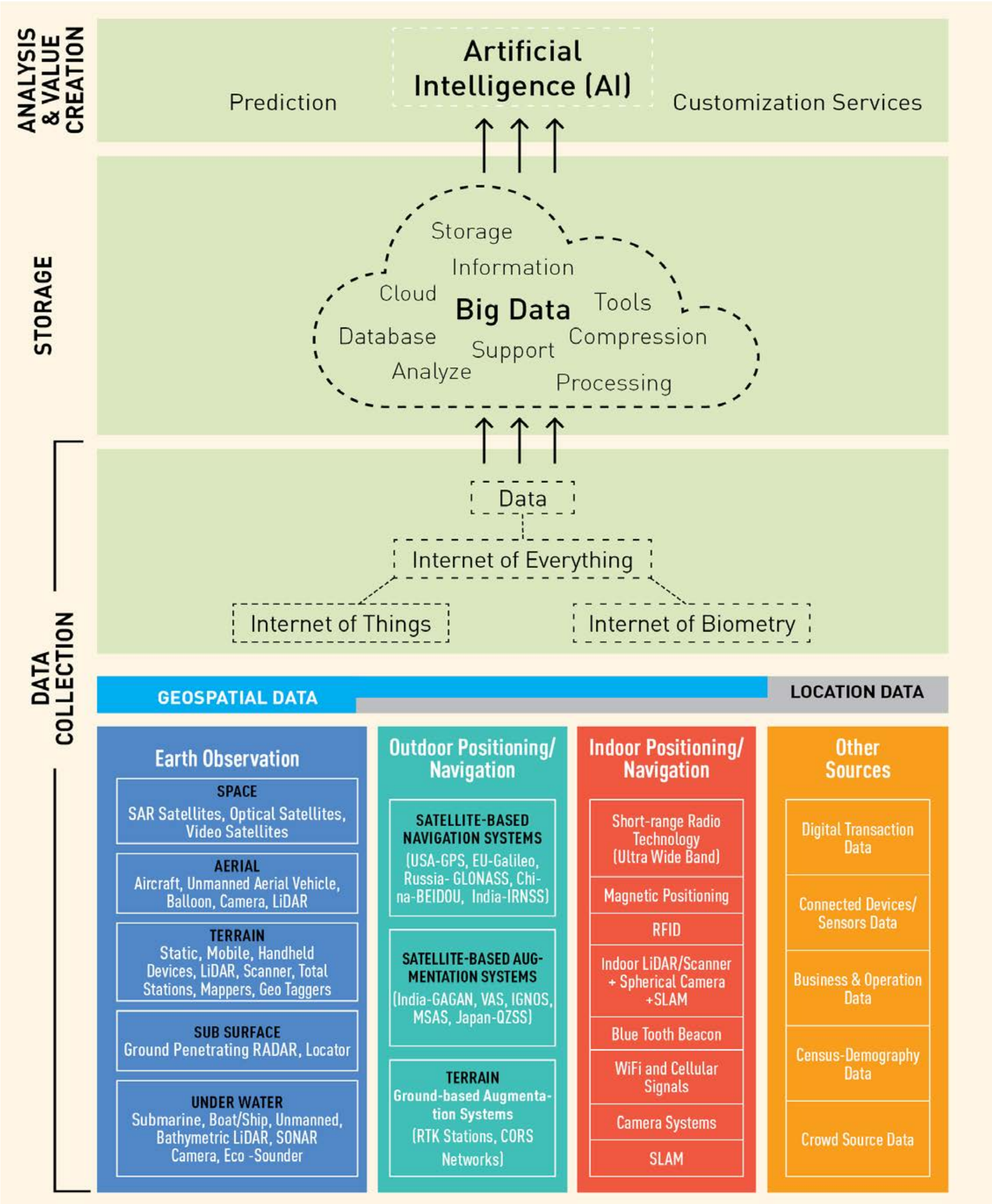


Digital Twin

Another critical technology, which has rapidly evolved in recent times is Digital Twin technology. As the name suggests, a Digital Twin is a virtual replica of the physical world, its dynamics, and processes, which allow us to simulate real life situations and analyse its impact. Digital twins are composed of three parts - the physical entities in the physical world, the virtual models in the virtual world, and the connected data that tie the two worlds. Geospatial technology, when combined with Building Information Modeling (BIM), AI, Big Data Analytics can provide very precise simulation of the real world, which has great potential for the water sector. Geospatial digital twins are means for monitoring, visualizing, exploring, optimizing, and predicting behaviour and processes related to the corresponding physical entities.

Digital Twins not only integrate the digital representation of physical assets, like physical systems of pipes, pumps, valves, and tanks, but also include historical data sets such as weather records and real-time dynamic interactions, which allow them to be used for multiple analyses. By combining operational technology with information technology, digital twins allow users to create simulations and optimisations that can improve performance. Most importantly, digital twins allow accurate modelling of multiple scenarios executed virtually to test their effectiveness before changes are implemented in the physical asset base. With the application of multi-physics and multi-scale models, Digital Twins can also provide prescriptive insights to solve real-world problems, related to assets of a water, wastewater, stormwater, or river system etc.

Figure 4: Geospatial Data in Industry 4.0



Source: National Think Tank (2020), Geospatial Strategy for New India, Geospatial World

Key Geospatial Stakeholders

The Geospatial ecosystem operates under policies directed by the Department of Science and Technology. The principal National Geospatial Agencies that provide fundamental datasets to both government and private sector users are National Remote Sensing Centre, ISRO that provides access to all satellite-based imageries required for any project, and Survey of India, which undertakes topographical mapping of the country. Besides these, there are several other agencies that provide spatial data useful for the water sector organizations, like Forest Survey of India, Geological Survey of India, Soil and Land Use Survey of India.

The other significant part of the ecosystem is the Geospatial Industry. In India, there are companies that provide all kinds of data/content, products, software, solutions and services for the water sector users. These include providers of spatial data captured from various platforms including satellites, aircrafts, drones, LiDAR and total station. Then there are services companies that provide data digitisation services, application development, system architecture development etc.

Funding agencies, like the World Bank, JICA and others also form a part of this ecosystem, as most of their funded projects emphasize the use of modern ICT and Geospatial Technologies.

Figure 5: Overview of Geospatial and Water Sector Ecosystem

GEOSPATIAL TECHNOLOGY **FOR WATER SECTOR**

Geospatial Technologies are extremely critical for the water sector. It helps not only to collect data about assets and resources, but also enables analysis and interpretation, reporting and monitoring, planning and decision making and to take informed action. Geospatial technologies help in increasing process efficiencies, reducing time for project deployment, ensure better resource management, and offers an integrated platform for assimilating data from varied sources to enable informed decision making.

With advancements in technological innovations, the current capabilities of the Geospatial industry have expanded too. Today, the Geospatial industry can deliver:

- Daily/sub-daily revisit satellite imagery
- Analysis ready base maps
- Cloud free coverage of satellite imagery
- Delivering satellite data within 24 hours of data capture and reducing the delivery gap to less than an hour
- Creating the whole world in 3D with Accuracy of 3m in absolute spherical error
- Capturing entire land mass of India in 3D in 1mt in relative and 3mt in spherical error within 3 months
- Robotic sensors for capturing data of inaccessible places
- Integrating historical data, for example, water level changes, rainfall, etc.
- Automatic feature extraction tools
- Global and local view allowing better management of water resources
- IoT integration and predictive analytics
- Available ready to use configurable GIS based solutions template and models
- Process Support
- IoT integration results in real-time alert management
- Dashboards for monitoring and decision making - mapping leakage hotspots
- Training modules

Growing sophistication of Geospatial technologies when combined with digital technologies allow users to undertake a variety of visualisation and analytics. From understanding water quality and turbidity, risk assessments, change detection to mapping underground water assets, helping high precision digital construction of dams to developing prescriptive modelling of scenarios.

Here's a quick snapshot of the various applications of Geospatial and Digital technologies for the water sector available today.

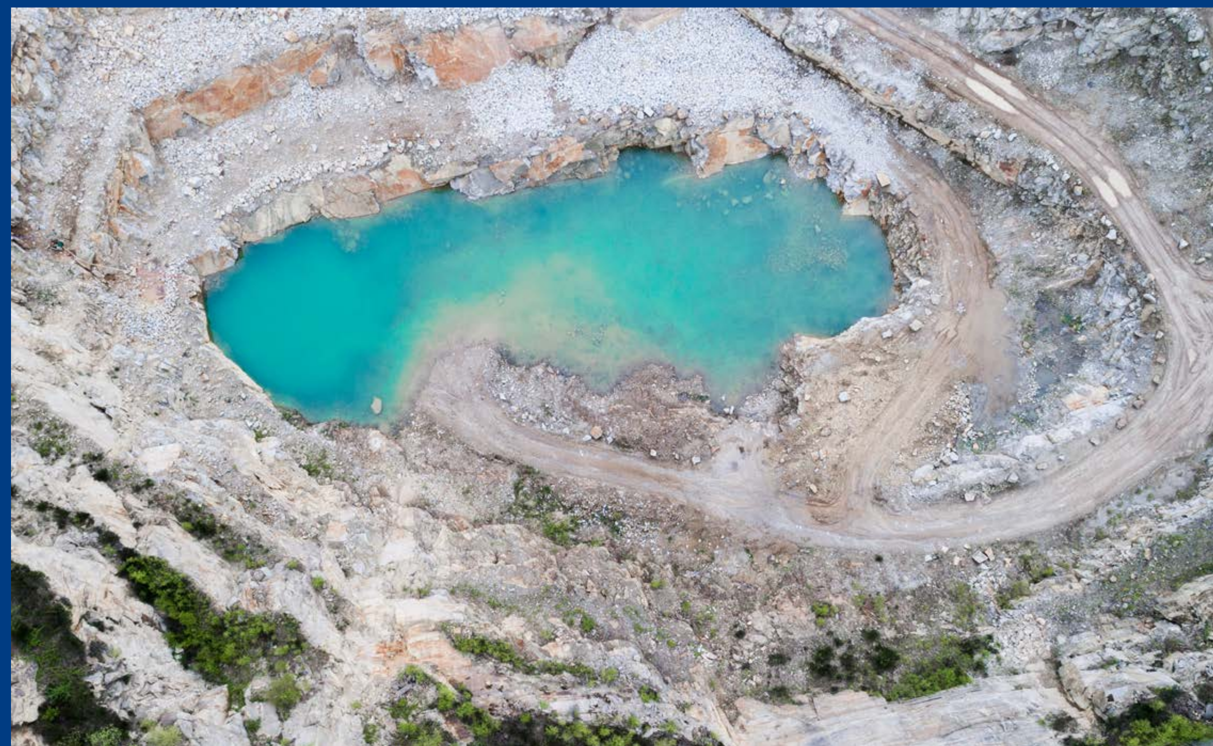
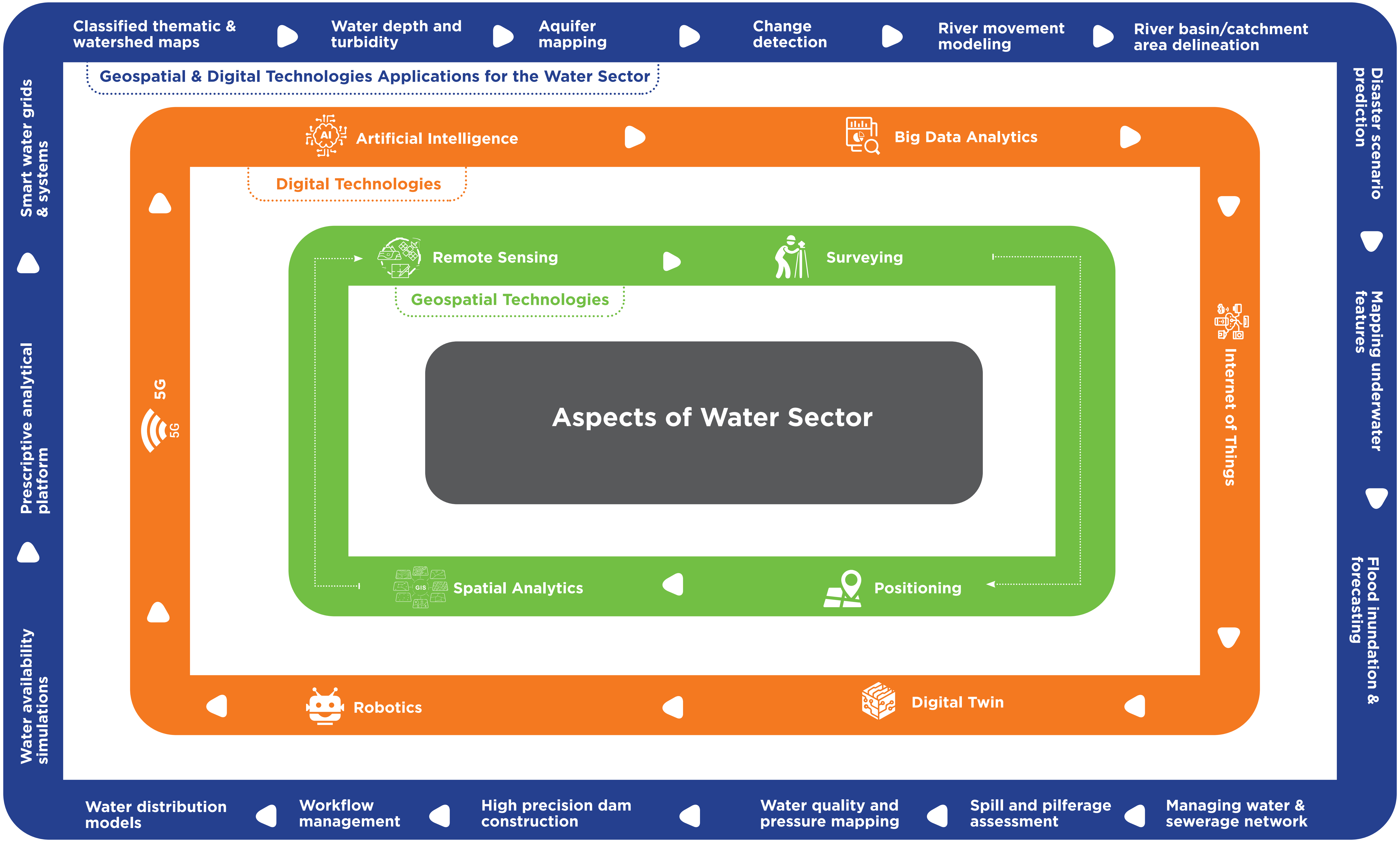


Figure 6: Application of Geospatial and Digital Technologies for the Water Sector



Indian Remote Sensing Portals for the Water Sector

Bhuvan–WBIS: Multi satellite / sensor derived water bodies information is being utilized to generate monthly / fortnightly spatial map of surface water bodies. This information is hosted on Bhuvan and for visualization and analysis for the assessment of water availability and hydrological drought.

Bhuvan-SatAIBP: This facility enables CWC Officials to undertake periodic inventory of irrigation infrastructure created and assess its status including the canal wise physical progress and identification of gap areas before proceeding on field visit. It also assists in identifying the critical areas requiring field verification thus significantly reducing the period of visit. Based on the satellite derived irrigation infrastructure information, monitoring report can be prepared. The facility provides near real time online monitoring of funded irrigation projects, including report generation and viewing of spatial irrigation infrastructure information pertaining to 103 projects.

TWRIS for I&CAD: Telangana Water Resources Information System (TWRIS), comprises of online tools, geospatial data creation, display, and query by integrating water resources data from different sources. TWRIS has modules on Minor Irrigation Systems (geospatial data covering minor irrigation tanks and their attributes such as hydraulic, hydrologic, structural, irrigation/command particulars), Major & Medium Irrigation Systems (project location, reservoir details, command area, water spread area, canal infrastructure, etc.), River Basins Information, Monitoring and Evaluation of Irrigation Systems (use satellite images as part of performance evaluation of irrigation systems after implementation of any modernisation/ improvement schemes of Government) and an easy to use Dashboard for Planners & Decision Makers.

India-WRIS: This portal contains information related to Water Resources through dashboards for rainfall, water levels & discharge of rivers, water bodies, ground water levels, reservoir storages, evapotranspiration and soil moisture, as well as modules on water resources projects, water bodies, hydro-met data availability and tools for GIS layer editing. India WRIS is, at present, receiving data from many central and state agencies like CWC, CGWB, IMD, NRSC, Andhra Pradesh, Uttar Pradesh, and Gujarat etc. on regular basis.

NICES portal: National Information System for Climate and Environment Studies (NICES) provides national level accurate, consistent, and long-term climate database generation, derived from Indian and other Earth Observation satellites from both polar and geostationary missions for climate change impact assessment and mitigation.

Other offerings from NRSC, ISRO include National Wetland Inventory, Large Scale Soil Moisture Map of India, Bhoonidhi - ISRO Open Data Access Visualisation of Earth Observation Data and Archival System (VEDAS) and more.

GEOSPATIAL TECHNOLOGY FOR VARIOUS ON-GOING WATER PROJECTS

The value of Geospatial technologies has been well recognised by the Government of India; thus a strong emphasis is laid on its adoption for various projects at different levels. The following section captures the current and potential application of geospatial technologies in various mission mode water-related projects in the country.

Jal Jeevan Mission - Rural

Current Geospatial Adoption

- MoHUA released an Advisory on GIS Mapping of Water Supply and Sewerage Infrastructure in Apr 2020 to facilitate implementation of JJM
- Baseline map
- Population density map
- Land use map
- Projecting future population changes and impact on rural infrastructure
- GIS Based Hydrologic Model
- Mapping sewerage system
- Identifying location of sewerage wet wells
- Household mapping
- Identifying available sources of drinking water and areas that need more attention
- Water consumption in various land use classes and sectors

Potential Geospatial Application

- Mapping population density vis-a-vis water source/pipelines
- Mapping of piped water network
- Water metering
- Coverage Analysis for planning Gaps
- IOT integration for water quality and pressure
- Identification of extraction sites
- Simulation for water availability data

Jal Jeevan Mission - Urban

Current Geospatial Adoption

- GIS based Hydraulic modeling of water and wastewater systems
- Realtime location data integrated in SCADA system
- Household mapping with types of customers
- Asset mapping - above and underground
- IoT based sensors for calculating NRW losses integrated with GIS systems

Potential Geospatial Application

- Mapping population density and water source/pipelines
- Mapping of piped water network
- Water metering
- SCADA Integration with GIS system
- IOT sensors integration with GIS system
- Online Workflow for Connection establishment and Complaint Registration.
- Online Alert generation to the effecting households by Upstream/ Downstream tracing during any maintenance activity.
- Allocation of tasks and monitoring of field workers through mobile apps

Namami Gange

Current Geospatial Adoption

- Preparation of BaseMap, high-resolution DEM and GIS ready database of wetlands, springs, flood plain with 10 km buffer on both sides of river Ganga using LiDAR
- Use of BaseMap and DEM for 3D visualization and analysis like flood mapping, water flow
- Change detection analysis to identify changes using temporal images
- Water quality mapping using IoT sensors into GIS system
- Mapping of sewerage, industrial waste flow, biodiversity profile, forestry, culture, aquifer
- Identification of flooded area using SAR images
- Land Use Land Cover Map preparation to study change pattern for Land Use planning
- Centralized GIS system to centrally manage all the data
- GIS based modelling for basin management and flow analysis
- Preparation of a Ganga Monitoring Centre connected to SCADA system
- Real-time river water quality
- Estimation of river suspended sediments
- Quantification of bedform dynamics and bedload sediment flux in sandy braided rivers
- Broad area monitoring
- River morphology
- Route alignment
- Reassessment of basin wise water resources of the country including rainfall, temperature, LULC, command area details, cropping patterns, crop type, cropping seasons, ground water in spatial scales
- Water accounting

Dam Rehabilitation and Improvement Project (DRIP)

Current Geospatial Adoption

Geospatial technologies implemented for the DRIP project include:

- Remote Sensing and GIS for dam site selection and monitoring progress
- Optical sensors, GNSS and hydrological sensors for assessing risks involved in monitoring and managing dams
- GIS & BIM integration for entire construction lifecycle - Plan, Design, Build, Operate & Maintain
- Improving dam drainage
- Improving the ability to withstand higher floods
- Structural strengthening of dams
- Non-structural measures to cater for higher design floods
- Rehabilitation and improvement of different dam parts - spillways, head regulators, draw-off gates stilling basins etc.
- Improving dam safety instrumentation
- Hydrological assessments
- Asset management plans
- Emergency preparedness plans
- Emergency warning systems
- Floodplain mapping
- Simulation of waterflow based on various scenarios like various DAM gates opening
- Simulation to calculate inundated areas based on level of water in the DAM
- Command and control system to centrally manage all resources for effective monitoring of DAMs

The above interventions resulted in:

- Assessment of revised dam flood hydrology and actions agreed to address changes in design parameters
- Necessary remedial measures have been reviewed and addressed
- Registration and data upload in Dam Assets Management System (DHARMA)
- Updation and approval of dam operational manuals
- Preparation and approval of emergency response plans

Dam Rehabilitation and Improvement Project (DRIP) Phase 2 & 3

Current Geospatial Adoption

- High-res DEM for water storage capacity, reservoir capacity, slope analysis, where to build check dams, 3D simulation modeling
- DPR for road and pipeline projects
- Online continuous monitoring to analyse the structural integrity of Dam
- Physical movement trigger alarm
- Realtime flood control system
- Identify sites through precision surveying for water shortage
- Communicate it through GIS based real-time telemetry and flood forecasting to know the amount of water that can be expected in reservoirs and work out the demand
- Estimation of sedimentation and loss of reservoirs in the country helped to upgrade storage capacity
- Reservoir operation, reservoir sedimentation assessment in live storage zones
- Thermal freely available data are used for reservoir assessments

National River Linking Project (NRLP)

Current Geospatial Adoption

- Understand the characteristic of rivers during monsoon and non-monsoon season
- Prepare Detailed Project Reports of various interstate and intrastate river links projects
- Prepared water balance study reports and analyzed 137 basins and sub-basins and 71 diversion points
- Remote Sensing technology helped to understand 16 link projects under peninsular components and 14 Himalayan components

Potential Geospatial Application

- DEM and High-Resolution Satellite Imagery datasets coupled with land-use/land -cover, geomorphology, soil and interpolated rainfall surface maps can be used to identify the potential routes in geospatial domain for interlinking
- Satellite imagery can be used for delineating drought prone areas
- GIS based analytics and modelling for scenario
- Change detection using temporal images
- Geospatial data management to manage huge volume of data (images, vectors, Point cloud, DEMs etc)

Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

Current Geospatial Adoption

- MoHUA released Advisory on GIS Mapping of Water Supply and Sewerage Infrastructure in Apr 2020 to facilitate implementation of JJM
- Baseline household map
- Population density map
- Asset mapping
- Mapping of underground assets/ losses/contamination source/ leakages
- Land use map
- Projecting future population changes and impact on city infrastructure
- GIS Based Hydrologic Modelling of water and waste water
- Realtime data available through SCADA
- Mapping sewerage system
- Identifying location of sewerage wet wells
- IoT and sensor based meters for calculating NRW

Potential Geospatial Application

- Mapping of piped water network distribution and movement of water
- Real-time communication and collaboration platforms for city administrations
- Scanning of underground utilities using GPR
- Scanning of above ground utilities using mobile apps and GPS

National Water Mission

Current Geospatial Adoption

- Mapping of catchments and surveying and assessing land use patterns with emphasis on drainage, vegetation cover, silting, encroachment, conservation of mangrove areas, human settlements and human activities and its impact on catchments and water bodies.
- Developing digital elevation models for flood prone areas of forecasting flood, and mapping areas likely to experience floods and developing schemes to manage floods.

Potential Geospatial Application

- Generation of DEMs and Ortho
- Use of DEMs and Ortho to simulate flood forecasting
- Mapping of flooded area using SAR images (optical images are covered with clouds)

National Hydrology Programme

Current Geospatial Adoption

- India - Water Resource Information System (India-WRIS) ver 1 was released in July 2019 & ver 2 in Aug 2020 for water resource operation and planning systems
- NHP has integrated 82,000 stations and targeting real time data for >14,000 stations
- Monitoring reservoir siltation through Bathymetry
- Nationwide repository of water resources data - NWIC has been established to manage India-WRIS
- Establishment of real time data acquisition system (RTDAS) on pan India basis
- Analytical tools and knowledge products being developed under the NHP such as streamflow forecasting with a long lead time of four weeks, upscaling of flood forecasting to include inundation mapping, sediment transport modelling, framework for water resources assessment, reservoir optimization, glacial lake atlas, Web enabled GIS based spring inventories etc.
- Supervisory Control And Data Acquisition (SCADA) systems are being installed on selected projects for automation of water release process based upon real time data

Modernizing mapping services/elevation of India towards improved precision

- Geoid Model for improved elevation
- CORS for improved geo location
- LIDAR: Airplane and Drone based

- WRMS –Geo-Spatial Technology is at a very initial stage and limited
- WRIS – Standard Level –GIS used for creation of Information System
- WROPS – Initial Level – GIS layers are being used and integrated with attributional information but has scope for adding analytical functionalities in operation management & planning.
- ICE – Standard Level - Central capacity building agencies are using geo-spatial technologies (Eg. NWA/ WALMI/WTC/IRI/NGWTRI) for basis GIS Data creation training whereas NIH is at Advance Level as they use different geospatial tools for Analysis/Modelling Techniques

Potential Geospatial Application

- Analytical system using Geo-spatial technology
- Integration with other systems
- Making Geo-Spatial technology as a base for all Capacity building courses at all levels

Pradhan Mantri Krishi Sinchayi Yojana (PMKSY) - Accelerated Irrigation Benefit Project (AIBP)

Current Geospatial Adoption

- Geo-Tagging of Pradhan Mantri Krishi Sinchayee Yojana-Per Drop More Crop (PMKSY-PDMC) Assets
- Bhuvan-PDMC Android App designed exclusively for the Field Data Collection
- Srishti is a GIS based Geo-portal developed by ISRO/NRSC to assist in monitoring, evaluation, change assessment and provide inputs in planning for watershed management and preparation of Detailed Project Reports (DPR)
- Drishti is the Mobile Application tool prepared by ISRO/NRSC to capture data including visuals from the field for real time monitoring of IWMP projects. The tool can also be used for community monitoring of IWMP works
- Irrigation planning and studies related to morphological changes also use geospatial inputs
- Evapotranspiration for crop water assessment
- Irrigation benchmarking

Potential Geospatial Application

- Pipeline Distribution Network using DEM - Optimum route analysis
- GIS mapping of entire pipeline network
- GIS based analytics

Flood Management & Border Areas Programme (FMBAP)

Current Geospatial Adoption

- NITI Aayog proposed National Water Model for India which can be built with the help of some scalable models. NWM is a hydrologic modelling framework that simulates observed and forecast streamflow over the entire geographical region
- Advanced technology like artificial intelligence, satellites, remote sensing, drones and GIS for flood forecasting, flood plain zoning, flood proofing and warning systems will be deployed
- Formation of Flood Management Plans
- Snowmelt forecast
- Glacial Lakes Risk Assessment and Glacial Lake Outburst Flood
- Flood forecasting
- Flood inundation mapping

Potential Geospatial Application

- DEMs and Ortho image generation using satellite images and aerial images.
- Use of DEMs and ortho images to map the flood plains
- Mapping of flooded areas using SAR images and overlaying it on archive images to identify effected areas
- Using dashboards for project monitoring

Neeranchal National Watershed Project

Current Geospatial Adoption

- Hydrological decision support and monitoring systems are developed, and guidance provided to SLNAs for design of database systems, GIS and mapping through NIH
- Use of GIS for monitoring and evaluation of the project
- Establish IT ad GIS enabled land resource inventory and data bases in participating States.

National Aquifer Mapping and Management Programme (NAQUIM)

Current Geospatial Adoption

- Hydrogeology & geophysics data integrated to delineate aquifers and characterize quality and potential
- Preparation of aquifer maps for characterization of aquifers providing spatial variation (lateral & vertical) in reference aquifer extremities, quality, water level, potential and vulnerability (quality & quantity)
- A conceptual and mathematical model developed, calibrated and validated for a pilot area simulating the field situation
- Tested various scenarios in the model to study the response of the aquifer to various stress conditions and predictive simulations have been carried out up to the year 2025
- Aquifer Response Model has been utilized to identify a suitable strategy for sustainable development of the aquifer in the area

Water Resources Projects or Multipurpose River Valley Projects

Current Geospatial Adoption

Geospatial technologies are used to determine the location of building the structures (dams/canals/bunds), they are also used for preparing DPRs and to determine how much area could be irrigated etc.

Atal Bhujal Yojana (ABHY)

Current Geospatial Adoption

- The scheme encourages use of innovation and technology: through use of remote sensing and GIS
- Aerial photography and satellite imagery for identifying potential groundwater zones
- Groundwater estimate meteorological variables such as temperature and precipitation, assess hydrological state variables like soil moisture and land surface characteristics. It can also help to estimate fluxes like evapotranspiration
- Groundwater basin models for conjunctive use of surface water & groundwater and application of remote sensing /GIS in groundwater management

Potential Geospatial Application

- High res multi-spectral & multi-temporal data for understanding terrain, soil texture, GW potential zones, rainwater infiltration capacity, site selection for water extraction, rainwater harvesting
- GIS to integrate and analyze varied datasets from geology, land use, lineaments, interconnected fracture zones, pediment plains
- Assessment of environmental flows
- Reservoir sediments assessment
- Irrigation planning
- High-res DEM for watershed delineation and drainage network to study parameters like its flow direction, drainage network, and slopes
- Better knowledge of linkages between various watershed components along with knowledge of useful indicators of water resource conditions and quantitative method to assess land use and watershed management practices that can yield better understanding of risks for better decision-making
- Terrain modeling, flow modeling, and debris flow probability to understand the condition of watersheds
- Building hydraulic modeling using remote sensing technologies for analyzing the available resources and plan distribution accordingly
- Mapping of catchments and surveying and assessing land use patterns with emphasis on drainage, vegetation cover, silting, encroachment, conservation of mangrove areas, human settlements and human activities and its impact on catchments and water bodies
- Geospatial coupled with system engineering techniques, simulation and optimisation and processing of big data to simulate and analyse scenarios and strategies

RECOMMENDATIONS

Geospatial technologies have been well recognised by the water sector for its ability to provide accurate, contextual, and timely data. Most major water sector programmes include geospatial technology and data use components. Over the years, these have also delivered positive results. However, the potential to expand the scope and usage of geospatial technologies still exists. This chapter elucidates a few recommendations that can ensure that geospatial data and technologies become an integral part of the water projects and deliver maximum results.

1. **Long-term Geospatial Vision:** In order to derive maximum benefit from geospatial technology implementation in various programmes, user departments need to build a long-term vision of the outcomes of geospatial implementation. This will ensure a sustainable infrastructure and human resource investments, as well as better programmes outcomes.
2. **Integrated geospatial platform:** Even when a lot of data and technology is used by various agencies at central and state level, they are still functioning in silos. Since the early 1980s investments into water related data generation and application development has been done by the central and state governments. Now, technology offers an integrative platform to bring together spatial-temporal data on one platform that can be shared between departments/state governments and with central government agencies. An integrated collaborative platform to connect the data and technology used by various organizations need to be developed for seamless access to information both locally and nationally and enable decision making. This platform can then be scaled up to district or village level too, once the requisite data has been added.
3. **Data and system integration:** Data by itself is not useful unless it is contextualised. For this to happen, various datasets including demography, socio-cultural, economic, and other parameters need to be integrated with spatial and non-spatial data related to water, like soil moisture, annual rainfall, rivers, aquifer, groundwater levels, water quality etc. There is also a need to integrate various geospatial information from disparate sources - maps, spreadsheets, social media, sensor network, imagery, DBMS, services and use of big data analytics needs to increase for better outcomes. Further, for optimising results from available data sources, various systems also need to speak with each other and integrate their knowledge. For example, only developing a flood modelling application is not enough. Integrating data about demography, population density, catchment area discharge information, emergency services, agriculture data etc will enable a more comprehensive decision-making tool.
4. **Improving water use efficiency:** Agriculture sector is the largest user of water resources in our country. They use 80-85% of water resources, while have only about 30-35% efficiency of water use. Geospatial technologies can be used for increasing water use efficiency, so that this can be increased to at least 50%. Similarly, the industrial sector too can look into their effluence treatment strategies to improve water use efficiency in the country. Once again, geospatial technologies need to be used as an integrator technology along with digital technologies like sensors and IoT and Engineering solutions for developing simulations to assess, monitor and manage water resources.
5. **Sharing of best practices:** A lot of good work has taken place in pockets within state governments or within programmes related to the water sector. A lot of knowledge exists that can help stakeholders to leverage from and not re-invent the wheel. A central repository of such knowledge base, in the form of a Knowledge Portal can be created and maintained by the Ministry of Jal Shakti that includes case studies, best practices, tools, information on data sources etc. that can be used by

users from across the nation as well as academics too.

6. **Creation of a Geospatial unit within the departments:** One of the most critical challenges faced by the water-sector agencies is the implementation of technology in a sustainable manner. Often the government agencies hire consultants for a short span of time for a specific purpose, but after the engagement period is over, the sustainability of the technology is compromised. In order to address this persistent issue, ministry/state departments/water agencies may consider establishing a dedicated Geospatial unit or a department, with a dedicated budget and a human resource team headed by a Geospatial Information Officer (GIO). SoPs developed for these divisions will ensure that any change in leadership does not impact the project execution or adoption of geospatial knowledge in the long run.

7. **Capacity Development:** Focused initiatives need to be taken up by the central and state agencies in collaboration with the educational institutions and the private sector for capacity development of serving officers at various levels. Capacity development is required not only for increasing understanding of geospatial technologies role and relevance for the water sector, but also on how to increase adoption, how to integrate it with digital technologies, and methods of implementation. The industry specifically needs to play a role of hand holding agencies while implementing a new technology, as they lack relevant human resource in required numbers who are proficient in geospatial or digital technologies.

8. **Domain experts within Industry:** While the government agencies need to develop capacities for geospatial and digital technology integration for sustainable adoption of technology, the industry too needs to employ more subject-matter experts who better understand the pain points of the user departments and help build solutions that speak to the needs of the users more intuitively.

9. **Project specifications:** Unclear specifications on the use of geospatial data and technologies in project RFPs results in proposals that are open for interpretation by the bidders, which leads to variations in quotes and difficulties in assessing the outcomes. The Geospatial Unit in the ministry and state departments can ensure that RFPs are made in a way that can optimally utilize geospatial information in the project scope. The geospatial industry and associations can also provide guidance and support for framing RFPs.

10. **Continuous data update:** Geospatial information is not a static delivery. To be useful, the data must be updated continuously. The ministry and relevant organizations need to make provisions for continuous data update and publish it through open platforms. Further, while one project may develop a certain database for a certain purpose, the same data cannot be used without updates and changes for any other purpose, hence taking care of the quality of data is critical. There needs to be objective driven data collection.

11. **Research and Development:** The government and industry need to collaborate to make available various datasets to the research and professional communities for free, which can be used for R&D purposes. Often funds are available with projects for data purchase, which are not accessible for non-project related activities. However, in order to stimulate the R&D initiatives within central government agencies and other professional bodies, and to aid student research, availability of free data is critical. This applies to both geospatial datasets, as well as dynamic water related datasets, like the amount of water being extracted, for what purpose, location of ground water extractions, number of wells in the country, number of other water structures, etc.

12. **Public Private Partnerships:** There exists lots of opportunities for the public and geospatial private sector to work together in the water sector. Be it for data capture, distribution, analysis, or project implementation. The private sector can also provide training to the public sector professionals on new technology innovations and methods of implementing them.

13. **Bi-lateral and Multi-lateral Initiatives:** India as a dominant country in the SAARC region has much to share with its neighbouring countries in terms of learning, water use planning, project implementation and technology adoption. Developing some focused engagement strategies with our friendly neighbours on water resource management techniques and water utility projects would enable a boost for the industry and also serve as a useful bi-lateral or multi-lateral initiative.

ANNEXURE: WATER TOOLS

WASH Basins

WASH Basins is a Toolkit and App for water, sanitation and hygiene (WASH) professionals, non-governmental organisations and government agencies working in water and sanitation. Built on the principles of Integrated Water Resource Management (IWRM), the app helps practitioners facilitate safe, sustainable and equitable water and sanitation services that meet the real needs of communities. By considering the national and international context including river basin and aquifer pressures, as well as climate change, it aligns with the principles of Sustainable Development Goal (SDG) 6.5 - Water Resources Management. WASH Basins was designed by a team of engineers and WASH professionals from the UK and India, developed alongside two India-based NGO partners, Samerth Charitable Trust and People's Science Institute and tested in more than 40 rural communities in India.

https://www.frankwater.com/wash-basins

Soil & Water Assessment Tool (SWAT)

The Soil & Water Assessment Tool is a small watershed to river basin-scale model used to simulate the quality and quantity of surface and groundwater and predict the environmental impact of land use, land management practices, and climate change. SWAT is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds. SWAT has been developed by Texas A&M University, Texas A&M AgriLife Research and Agricultural Research Service, U.S. Department of Agriculture.

https://swat.tamu.edu/

India Water Tool

The India Water Tool 3.0 brings together datasets and risk indicators from the Government of India and other institutions, to help users understand their water risks and plan interventions for water management in India. The tool gives information on groundwater levels, Surface Water and Stress Indicators (including total annual rainfall, availability index, normalized deficit index (NDI), normalized deficit cumulated (NDC), and baseline water stress. Localised information is also available for select locations.

https://www.indiawatertool.in/

Flood Forecast for River Basins based on IMD Rainfall Forecast

This is a countrywide framework using the hydrological modelling as a one-stop window for real-time flow forecast for all 18 river basins of India. This web-based tool provides access to simulated real-time river flows at any location of one's interest. Using this, one can query, map, chart and summarize key hydrological parameters along with rainfall and temperature. It uses the SWAT hydrological model to simulate the river flows. River basins are divided into sub basins (21,647) and sub basins are further divided into hydrological responses units (1,10,000). All the basins are simulated every day with the updated information on the rainfall forecasts made by the Indian Meteorological Department (IMD). Simulation is being done every day even during the non-rainy days thereby not only providing flood information but also information on all aspects of water balance including low flows, soil moisture, actual evapotranspiration, groundwater recharge, etc. Such flow forecasts can be very useful for a large number of stakeholders such as water managers operating reservoirs, disaster management (NDRF) staff, general public, etc. River basin hydrological information that has become available through this framework can also be useful for many other activities such as formulation of river basin management plans, flood plain zoning, formulation of reliable and comprehensive farmer's advisories, as well as providing feedback for policy making. The framework has been developed by INRM Consultants, a company incubated by IIT Delhi.

https://inrm.co.in/Applications/IMD_FF/leaflet_map_Forecast.html" https://inrm.co.in/Applications/IMD_FF/leaflet_map_Forecast.html#

Water Risk Filter

Launched in 2012, the Water Risk Filter is a practical online tool that helps companies and investors assess and respond to water-related risks facing their operations and investments across the globe. Developed by WWF and the German finance institution DEG, the Water Risk Filter 5.0 enables companies and investors to Explore, Assess, Value and Respond to water risks. Lately, the Water Risk Filter provides scenarios of water risks for 2030 and 2050, integrating climate and socio-economic changes in three different pathways.

https://waterriskfilter.panda.org/en/Explore/CountryProfiles#overview/1

Google Flood Forecasting

For the past several years, the Google Flood Forecasting Initiative has been working with governments to develop systems that predict when and where flooding will occur—and keep people safe and informed. Much of this work is centered on India, where floods are a serious risk for hundreds of millions of people. The goal of this initiative is to provide accurate real-time flood forecasting information and alerts to those in affected regions, which is made possible through AI and physics-based modeling that incorporates data from historical flooding events, river levels, terrain and elevation data. This is used to generate high-resolution elevation maps and run hundreds of thousands of simulations for each location. With information obtained through the collaboration with the Indian Central Water Commission, Google then creates river flood forecasting models that can more accurately predict not only when and where a flood might occur, but the severity of the event as well. This information is then provided to users in different formats, so that people can both read their alerts and see them presented visually in Hindi, Bengali and seven other Indian languages. Google has also made the alerts more localized and accurate; and users can easily change the language or location. In recent months Google expanded their forecasting models and services in partnership with the Indian Central Water Commission, and have extended the system to the whole of India to cover 200 million people across more than 250,000 square kilometers. In addition to improving the alerts, Google.org collaborates with the International Federation of Red Cross and Red Crescent Societies to build local networks that can get disaster alert information to people who wouldn't otherwise receive smartphone alerts directly.

ttps://india.googleblog.com/2020/09/ai-flood-forecasting-update-2020.html

Water Footprint Network

The Water Footprint Network is a platform for collaboration between companies, organizations, and individuals to solve the world's water crises by advancing fair and smart water use. It seeks to promote water footprint education, research, exchange, communication, and knowledge dissemination. The network raises awareness among communities, governments, businesses, and investors of their direct and indirect water footprint and encourage government policies and business strategies that minimize the impact of their water footprint. It brings together governments, businesses, investors, international institutions, non-governmental organizations, and other organizations in their search for water footprint reduction and sustainable and fairer water use.

https://waterfootprint.org/en/

GEOGloWS

Established in 2017 by the Group on Earth Observations (GEO) Water Community to provide greater coordination among the diverse freshwater activities within GEO. GEOGloWS is a voluntary mechanism, created by an informal agreement among multiple partners from inside and outside the UN system. This allows for engagement and greater integration with trans-national organizations not represented in the UN (e.g., ECMWF) and agencies with water responsibilities that are not hydromet services (e.g., SICA/CRRH Central America, CEMADEN-Brazil). GEOGLOWS is governed by an International Steering Committee, which provides the vision, strategy, policy, and guidance to the Initiative's activities. The initiative consolidates elements of freshwater activities in GEO. It ensures that strong coordination and commitment are in place for links among data, information, knowledge, applications, and policy. From research to implementation, GEOGloWS provides the demonstration grounds for user-driven solutions to address water issues.

https://www.geoglows.org/pages/whoweare

WEAP (Water Evaluation And Planning) System

WEAP is a user-friendly software tool that takes an integrated approach to water resources planning. Freshwater management challenges are increasingly common. Allocation of limited water resources between agricultural, municipal and environmental uses now requires the full integration of supply, demand, water quality and ecological considerations. The Water Evaluation and Planning system, or WEAP, aims to incorporate these issues into a practical yet robust tool for integrated water resources planning. WEAP is developed by the Stockholm Environment Institute's U.S. Center.

https://www.weap21.org

Aqueduct

Aqueduct is part of World Research Institute's Water Program and related to the Corporate Water Stewardship initiative. Aqueduct's tools use open-source, peer reviewed data to map water risks such as floods, droughts, and stress. Beyond the tools, the Aqueduct team works one-on-one with companies, governments, and research partners through the Aqueduct Alliance to help advance best practices in water resource management and enable sustainable growth in a water-constrained world. The Aqueduct tools and data were developed in collaboration with research partners at Delft University of Technology, Deltares, Utrecht University, Institute for Environmental Studies (IVM), International Food Policy Research Institute (IFPRI), PBL Netherlands Environmental Agency, and RepRisk.

https://www.wri.org/initiatives/aqueduct

ANNEXURE: CASE STUDIES

National Hydrology Project

1

The National Hydrology Project aims to improve the extent and accessibility of water resources information and strengthen the institutional capacity to enable improved water resources planning and management across India. The Survey of India, as the national mapping agency of the country supported the NHP with required geospatial data and services.

The key components, which Survey of India addresses through NHP are as follows:

- Providing updated digital topographical database on 1:25K scale survey of around 8,35,000 sq.km. area.
- Generation of DEM of 3-5m accuracy of around 8,35,000 sq.km. area.
- Generation of DEM of 0.5m accuracy of approximately 58,472 sq.km. area.
- Establishment of CORS Network in UP and Uttarakhand
- Establishment of Geoidal Model
- Orthometric Heights to Hydromet stations
- Cross section Bathymetry of Rivers
- Training to other Implementing Agencies on Geospatial Technologies.

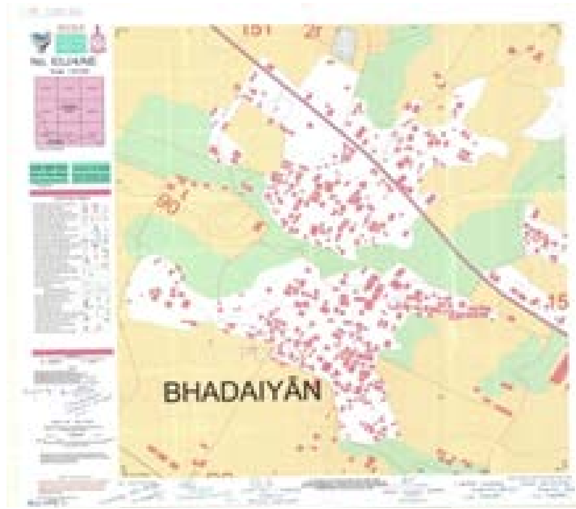
1) DEM of 3-5m accuracy and Geo-Database

Survey of India is creating the geo-database and digital elevation model of 3-5m accuracy of around 8,35,000 sq.km. area. The extent of the area is as shown in figure-7 below. To create the geo-database, ortho rectified satellite imagery of 0.8-meter spatial resolution is being used and contours of Survey of India 1:25K scale maps has been

taken. The spatial data model structure as per requirement of NHP has been standardized and a sample geo-database map is shown in figure 8.

Figure 7: Area of Geo-database and DEM preparation by Survey of India for NHP

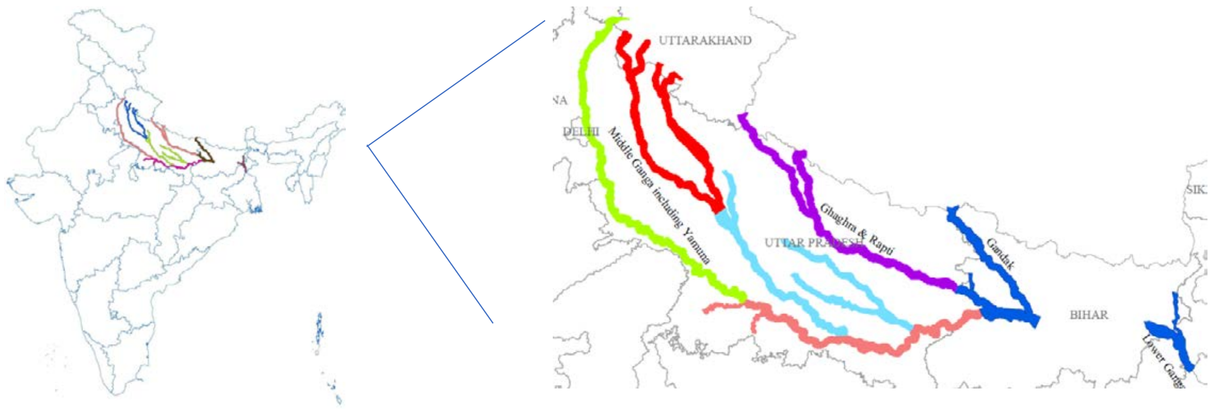
Figure 8: Sample Geodatabase Map



2) DEM of 0.5 m accuracy

Providing Digital Elevation Model (DEM) of 0.5m accuracy covering an area of 5 km. on either side of the riverbank (including river area between the riverbank) of the selected rivers. The area covered for DEM of 0.5m accuracy, is shown as Figure 9. The details of the area covered are also shown.

Figure 9: Area covered for DEM of 0.5m accuracy



Aircraft-based LiDAR is being used to capture the terrain data.

1

3) Establishment of Continuously Operated Reference Stations

A network of Continuously Operated Reference Station (CORS) for UP & UK area is being established in NHP-III Project. CORS is a network, which will replace the traditional Base station used in observation using DGPS. The instant position accuracy using Rover Receiver with CORS network will be approximately 2-4 cm. Apart from Hydrology, it will be extremely useful for precision position for agriculture, construction, mining, transportation, urban map, revenue etc. and many other functional areas.

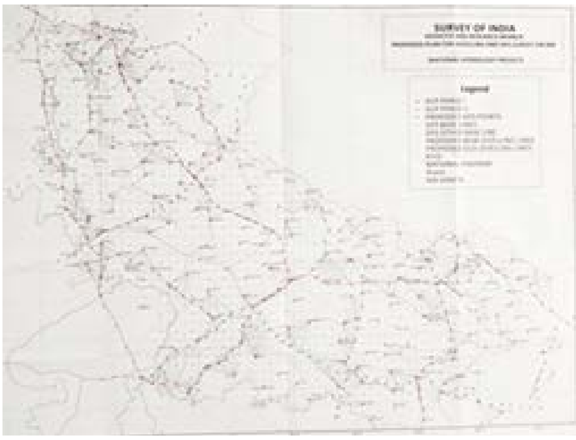
Figure 10: A CORS Network

Figure 11: UP and UK CORS Network

4) Creation of Geoidal Model

To convert the ellipsoidal heights to orthometric heights a high precision geoidal model of better than 10 cm. accuracy is being prepared under the NHP by the Survey of India. The model will considerably reduce laborious levelling work and will enable deducing faster orthometric DEM for the project. Subsequently SOI has prepared Geoid Model for West Bengal, Bihar, Jharkhand, Haryana and that of Punjab, HP and Goa are under preparation. Geoid Model for the entire country will be completed by the end of March 2023.

Figure 12: Planning of Geoidal Model for UP



1

5) Ortho-metric Height to Hydromet stations

In the country, there are more than 60,000 Hydromet Stations of mainly two type i.e., surface water & groundwater. Under NHP-III, levelling height is being provided to all SW Hydromet points. Height to groundwater hydromet points will be provided using Geoidal Model. To facilitate this, Geoidal Model of the entire country is being prepared using high precision levelling and gravity observations.

6) Cross Section Bathymetry of Rivers

This is one of the additional activities of Survey of India under NHP-III Project. So far, there is no activated and observed data regarding the depth of water in rivers. So, under NHP Bathymetry i.e., topography under water for cross-section of designated rivers is being provided under NHP. This will help to estimate the volume of flood water as well as many other hydrological applications.

7) Capacity Building

Under NHP, training is being provided to various Implementing Agencies regarding Digital Elevation Model, use of GPS, Total Station, levelling and use of GIS & Remote Sensing etc. So far, more 100 personnel of various Implementing Agencies have been trained.

Water Efficient Thrissur

2

Thrissur municipal corporation came into being on 2nd October 2000 with a total area of 101.42 sq km. As per provisional reports of Census India, population of Thrissur in 2011 was 315,957. With the intent to modernise its public water supply system, Thrissur Municipal Corporation launched The Water Efficiency Thrissur project on March 2020, as a part of the AMRUT scheme. The primary objective of the scheme was to provide drinking water in a timely and efficient manner, and to tap freshwater depletion sources and water emissions. To achieve this aim, the first step for Thrissur Municipality was to accurately identify and document the existing water supply network. For this purpose, they undertook a massive exercise to map asset data such as pipes, valves, hydrants, meters, and other network features, as well as operational data such as pressure zones, work routes, main breaks, and inspection locations.

The collected data when used on a GIS-based platform provided authorities with the tools to visualize and assess where they stood in terms of water supply infrastructure, while giving citizens an interactive platform to air their grievances. The platform allowed authorities to take charge of their assets and respond to how their city is growing. The platform also helped reduce public water loss by **bringing Non-Revenue Water below 15% while ensuring uninterrupted water supply to the consumers** in Thrissur city.

2

Thrissur Municipality deployed several technology-based solutions to reach its goals, including:

- Developing a **central repository of an authoritative network of water supply pipelines** and consumer networks using Ground Penetration Radars, Drones, GPS and DGPS.
- **Installing smart water meters** at critical network junctions to access pipeline flow that log any drop in water level. These smart utility applications use IoT and sensors to determine pipeline fractures quickly. Such deviations are updated on a real-time basis into the central repository, alerting municipal authorities to the possibility of water loss.
- **Setting up customer redressal and billing systems** that utilises hand-held equipment like POS machines to undertake on-the-spot billing and on-site logging of repairs. A GIS system that integrates flow-meter reading, billing, and complaint redressals helps to identify Non-Revenue Water at the neighbourhood scale. An online portal registers consumer complaint and escalates pending complaints on a periodic basis to higher authorities.
- **Setting up outage management system** via dashboards that provide a view of leaks and outages. They also help trace and isolate leaks so that they do not disrupt the network, or citizen routines. Dashboards provide an interactive visual platform to analyse maintenance requests. Map views, timelines and pie charts communicate data to citizens in the simplest formats.
- **Utilizing GIS predictive analytics for hydraulic modelling** to estimate and ensure the feasibility of new user connections, based on existing consumption loads, water pressure, and other parameters. A geo-tagged digital database ensures that maintenance and future updates to the water network are proactive, and not piecemeal.
- **Establishing a workforce management system** that uses mobile applications to notify maintenance crews of maintenance work. A Water Service Assignment platform connects supervisors to their crew and enables them to communicate field assignments in a prompt and effective manner.

Water Quality Mapping of 27 Districts of Chhattisgarh

3

Over exploitation of groundwater resources leads to source depletion and compromises the water quality by contamination of groundwater with harmful metals and minerals like iron, arsenic, nitrate, salinity, and fluorides etc. Thus, there is a rising need of Water Quality Mapping, its trend and the temporal changes that occur in concentration levels to assess the problem that has severe public health consequences.

The Public Health Engineering Department, Chhattisgarh that has 26 district level, 1 state level and 14 sub-division level water quality check laboratories, undertake water quality checks across the 4.37 lakh drinking water sources in the state. PHED undertook a water quality assessment and development of a GIS of water resources for all the districts to create a sustainable solution.

For the next two years, drinking water samples from all the sources of PHED were collected and tested for 15 parameters. Unique numbering of the sources helped to generate systematic and scientific database for a GIS of water resources in the state. Analysed results were compared as per BIS 10500: 2012, and a sanitation survey of each drinking water source was also carried out for the following purposes:

- Creating a Geospatial database of Pipe Water Supply Schemes by mapping water resources including all components of the scheme.
- Determining the quality of water in its natural form.
- Assessing the impact of various activities performed by human beings up on the quality of water.
- Deeply observing the water sources and to check for the presence of specified hazardous or harmful substances in water.
- Identifing the contaminated source i.e., ground water-based sources and other water bodies.
- Obtaining reliable and useful data of water quality as a whole and to adopt corrective measures to ensure safe supply of drinking water in rural areas.
- Training the villagers for future drinking water quality monitoring.

GIS based services were used for database collection, base map preparation, collection of water samples, unique codification of all sources, field data collection for wells, villages, and sources, water quality analysis at laboratory with the samples gathered, generation of attribute database for all parameters, GIS integration of database with field data, database analysis, preparation of Water Quality Maps and DPR, visualisation and reporting platform for decision making authorities, and developing a data-driven mitigation process.

With the application of GPS and GIS technology water quality maps were generated for all districts. Other significant results included:

- Mapping of area for probable dental and skeletal fluorosis.
- Improvement in sanitation facilities in priority areas.
- It could help authorities to cap highly contaminated drinking water sources.
- Specific parameter wise water quality maps giving the overall situation of drinking water quality in the state.
- Improvement in health statistics.

By completing this activity Chhattisgarh state will prepare the entire water quality database and make it available through the website of the Department of Drinking Water Supply.

Dam Safety and Monitoring 4

Dams are critical infrastructure that require large investments and have multiple uses such as irrigation, power generation, flood moderation and supply of water for drinking and industrial purposes. Safety of dams is, thus, a particularly important aspect which needs to be monitored on a continuous basis for safeguarding national investment and the benefits derived by the nation from these projects. Dam safety is also critical to protect human and animal life.

The Government of India has been investing in Dam safety and has initiated the Dam Rehabilitation and Improvement Project (DRIP) that requires all dam owners to undertake safety inspection of their dam sites and report them to the Government of India on a regular basis.

For the authorities at Ranganadi Hydro Project Power Ltd (RHEP), Kopili Power Project Ltd (Khandom & Umrong Dams), Doyang Power Project Ltd. (DHEP) and Baglihar Dam, Chanderkote, J & K Dams, some of the critical questions that plagued them were as follows:

- How much movement has occurred over a defined period?
- How fast has it accelerated?
- What is the total movement since the beginning?
- Can I get notified when something changes or is unexpected?
- Can I get a notification to confirm if the system is running smoothly?
- How can I measure the frequency of movement according to the amount of movement?
- Is the whole area moving?
- Can we integrate and correlate readings from various sensors and/or measurements?
- How can data support me to archive information for legal issues or claims?

To answer these enquiries, a dam safety monitoring solution was implemented for measurement, detection, archiving, analysis, and publication of results pertaining to stability of the dams. The collected data was integrated to check the stability of the overall structure with careful analysis.

Using various sensors, like Geodetic sensors, Electronic Total Stations, Geo technical sensors, Hydro Meteorological sensors, Seismic sensors etc. and GIS based platform technologies a DAM Safety Solution was implemented that helped the authorities to:

- Predict the behaviour of the structures and detect when movements could be catastrophic to the stability of the overall structure.
- Monitor the dams on a continuous real-time basis, enabling prompt notification of activities thereby advancing understanding of landslide behaviour, and effective engineering and planning efforts.
- Understand the initiation and movement of landslides through high-quality data sets.

Using Geospatial Technology to help Communities Gain Access to Water 5

Mwendo is a small town in Eastern province of the Eastern African country of Rwanda with a community of 3,000 people living at 2,400 meters above sea level. To access water, residents had to walk 30 to 45 minutes carrying 20-liter jerry cans everyday. To address this problem, students of Biosystems Engineering Department at Auburn University through a project run by Engineers Without Borders, decided to rehabilitate a 10,000-liter water tank for water storage and install a pipe directly to the Mwendo Primary School.

The first step for addressing the problem was to map the precise location of the proposed pipeline including the length, breadth, and height of the terrain. Given that the terrain was difficult, following a traditional survey technique or using an auto-level would have been incredibly challenging, hence a GNSS based solution was employed. This data was used to model the water flow to ensure that the water would be distributed as planned. Along the pipeline, areas of interest were also mapped, such as locations of potential springs. This data was fed into a Storm Water Management Model (SWMM) model to determine the flow distribution under a variety of conditions.

However, the team encountered some challenges when they began installing the system, as they realised that the trench did not follow the path that had been laid out because the trench that was dug required water to flow uphill, which would not have worked well. Using a GNSS equipment the team verified the path and using its real-time correction services they could verify elevations at five high points along the pipeline, ensuring elevations were lower than the source point. The data were also viewed on the map screen so that elevation data could be seen.

The adoption of GNSS based technology helped the team to provide easy access of continuous water supply to the residents of Mwendo. The data captured during the project was also used for assessment for future work, like mapping potential locations for pipelines.

Assessment of River Sedimentation 6

At the Central Water Commission, researchers use geospatial data for a variety of purposes. One of the studies included the assessment of reservoir sedimentation to assess the loss of storage capacity of the reservoirs. While in 2018, the studies were conducted using only optical imageries that made the study duration long and uncertain as cloud free images at the required duration was not always available. As a result, studies that were expected to be completed in 6-8 months often took 3-4 years to get finished and then again, the results were not standardised as doing assessments based on data from different years did not always render accurate results. However, since 2019, CWC researchers have been using thermal imageries, which has addressed most of their concerns. Since the staff at CWC were initially not trained in processing these imageries, they collaborated with IIRS, Dehradun for the purpose and got their staff trained in thermal imagery data processing. For the year 2021, CWC has a target of assessing 40 reservoirs in the country.

This is a unique example of technological advancement and collaborative mechanism enhancing research and development in the field of water resources management.

GIS Based Hydrological Modelling for locating Sites for Small hydropower in Nagaland 7

Hydropower plants are classified according to their energy production capacity, expressed in megawatts. Different countries have different size criteria to classify small hydro power project capacity ranging from 10MW to 50 MW. In India, hydro power plants of 25MW or below capacity are classified as small hydro. Small hydropower can provide clean, renewable, and relatively inexpensive energy. They can be constructed in any location where there is enough water flow and head to make energy generation viable, even in rural or undeveloped locations.

The Ministry of New and Renewable Energy engaged a consultancy in a project to identify suitable sites for developing small hydropower plants in the Indian state of Nagaland. To do so, it was important to assess the discharge at the identified sites on the streams and derive the flow duration curves. The concept was to develop a complete accounting system of the river systems. As a first step, the natural drops available in the river systems were identified using satelite imagries and simulations were made to assess the flow and availability of flow in these locations throughout the year through long term rainfall data. The project identified 1500 drop sites, which helped the ministry to take data-based decisions on developing small hydropower projects in the state.

West Bengal Accelerated Development of Minor Irrigation (WBADMI) Project 8

The WBADMI Project is an innovative integrated project functional in the entire state of West Bengal since year 2012. The project objective is to increase the agriculture production of small & marginal farmers particularly tribal & women by providing assured irrigation facility and support services on agriculture, horticulture, and fishery activities through Water Users Associations (WUAs). Using Web GIS based technology the project has been able to leverage identification, selection, and approval of all surface & subsurface Minor Irrigation schemes. Regular system for progress monitoring, evaluation, impact assessment and scheme performance monitoring are done using NDVI assessment on Google Earth database. Application of these technologies significantly improved the effectiveness, judicious use of human & financial resources, success rate of tube wells, minimised risk and helped in creating transparency among various stakeholders. Using various Geospatial data and technology, it has been possible to hand over more than 2000 minor irrigation schemes to Water Users Associations (WUAs). There has been a change in cropping intensity from 122 to 192 percent in the project area. Almost 60 percent of the targeted 75000 ha area has been brought under irrigation and the value of produce has reached up to 282 percent.

Odisha Irrigation Information System (ODIIS) project 9

Odisha Irrigation Information System (ODIIS) project started in the year 2017 and aims to ensure geospatial aided agricultural information system for Odisha that helps to develop a state data repository of the agricultural and irrigated land, irrigation development process, food security, insights about the agricultural land, cultivated areas and cropping system. Other objectives include development of canal asset information system, multiple on-time information to empower authorities for decision making on policy, pricing, procurement, etc., cadastral/village/GP based crop monitoring, land suitability for crop cultivation, irrigation infrastructure mapping etc. The project has successfully built an application of geospatial database of the irrigation network, its asset and functioning status with accurate agricultural information which helps in understanding sustainable agricultural development process and food security.

Mission Water Conservation Government of Andhra Pradesh

10

The "Mission Water Conservation" project under the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) commenced in the year 2017 and covers 1,521 GPs in 88 blocks across five 5 districts located in the Rayalaseema and the Prakasam district of Andhra Pradesh, which are highly drought prone. APSAC's technical team facilitated scientific planning and management of soil and water conservation action plans through the "Ridge-to-Valley" approach. Under this project, APSAC identified 32,000 water conservation locations in 1,521 grama panchayats (GP) for water conservation and management. About 50,000 farmers benefited by adopting these scientific results, and using the Geographical Information Systems (GIS) maps for implementation of conservation measures. The project also enabled state, district, block, village and cluster-level capacity building, through a user-friendly mobile app and web portal WEBGIS.

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The Association of Geospatial Industries (AGI) is an industry-led non-profit non-government professional organization that represents the interests of geospatial industry in India and works towards the advancement of geospatial technologies and their applications. AGI serves as a forum for exchange of ideas, techniques, approaches, and experiences by those who design, implement, and use geospatial technology solutions. Our primary goal is to accelerate the adoption of geospatial industry in India and to ensure that government, industry, academia, and society as a whole understand both the needs of this industry and its contribution to the nation's development. Established in 2009, the Association of Geospatial Industries is headquartered in New Delhi, India.

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