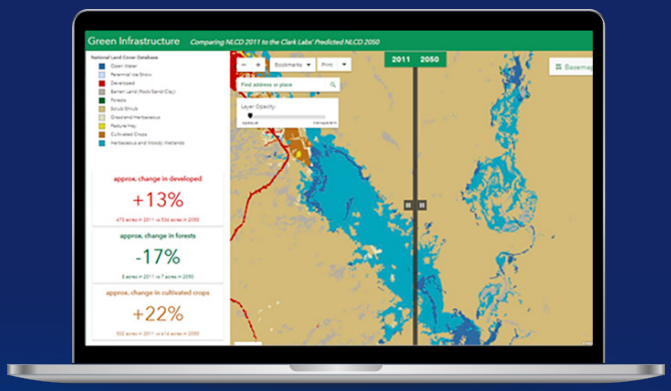
SECURING WATER FOR FUTURE GEOSPATIALLY

Water is undoubtedly one of the vital elements for existence of life on the earth. But today this very lifeline is under serious threat due to human activities of the past. With about 4% of worlds water resources and 18% of world population, India has a bigger problem on its hands.

India receives a good rainfall during monsoon season, but changing economic, demographic, and climatic conditions are reshaping the water situation rapidly. According to the World Resources Institute's report, India ranks 13 out of 17 countries facing extremely high water stress. In an average year, agriculture, industry, and municipalities are consuming 80 percent of the available surface and groundwater. Reuters reports that more than a third of India's population



lives in water-stressed areas and this number is set to grow due to depleting groundwater and rising urbanisation. As per the 2030 Water Resources Group, if we continue to consume water at the

current rate, India will have only half the water it needs by 2030. A potential crisis that's only few years from now.

Recognizing the gravity of the situation, water has been at the top of governance agenda in recent years. Government of India's National Water Mission (NWM) (2009) advocates conservation of water, water wastage, equitable distribution through integrated water resources development and management. Jal Shakti Abhiyan, Swajal scheme, Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and Pradhan Mantri Krishi Sinchai Yojana are some of the other initiatives from central government with a thrust on sustainable water management. Water being a state subject, state governments too have been proactive and have rolled out initiatives to address the water related challenges in their respective states.

However, water challenges are intricately related with the hydrologic cycle and related processes and cannot be addressed in isolation. They are multi-disciplinary and involve interactions between the hydrosphere, atmosphere, lithosphere, and biosphere; and have local, regional, national, and global dimensions. Physical, biological, economic, and social processes too have a strong bearing on the water ecosystems which unless addressed in totality will not help in addressing the problem holistically. Spatial and temporal diversity of all these factors brings to the fore importance of a) knowledge of the linkages among the components (rivers, wetlands, groundwater, uplands, urban/rural water supplies, industries, consumption patterns, etc), b) understanding of the processes operating at different spatial and temporal scales and c) availability of actionable intelligence for taking informed decisions.

While an Integrated Water Resources Management (IWRM) approach is need of the hour, India continues to battle with a) Non-confirming administrative and basin/catchment boundaries, b) Inadequate per capita storage to tide over spatial and temporal variations in water availability, c) Inadequate cross sectoral cooperation and integrated approach, d) Poor data and information exchange between stakeholders, and e) Lack of human capacities in monitoring water use and water quality as per National Water Academy. Time has come to work collectively to overcome these constraints.

An Integrated Water Resource Management (IWRM) approach promotes coordinated development and management of water from "source to tap" while taking into consideration all the processes for maximising economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment. "Science of Where" becomes important more than ever for understanding these constraints and managing linkages and processes.

By harnessing geographic context, GIS technologies provide unmatched capabilities to discover insights from within data and transform how governments and communities see, think and act towards integrated water resource management. While conventional GIS offers powerful tools for the collection, storage, management, and intuitive visualization of data from multiple disparate sources, advanced GIS capabilities like spatial modelling and predictive analysis using artificial intelligence, machine learning and big data provide enhanced situational awareness for accurate forecast of likely water scenarios to mitigate, plan and respond, including the impact of changing economic, demographic and climatic conditions.

Simulation models provide decision-makers with interactive tools for understanding the physical system and judging how actions on the ground can affect the overall ecosystems. Mobile GIS tools play a vital role in democratizing geo-information and empowering stakeholders with real-time information for informed decisions and risk mitigation. With powerful collaboration capabilities, geospatial infrastructure promotes collective problem-solving and perhaps most critical of all, building robust water resilience based on data and insights.

Given the complex multidisciplinary nature of the processes, geospatial infrastructure offers unmatched capabilities for revealing deeper insight in relationships and patterns, answer complex questions, and informed decisions for fostering sustainable water resource management from "source to tap" including water ecosystems, water supply, water quality and water resilience.

Protecting & Restoring Water Ecosystems

Water ecosystems are critical to the global water security and resilience. While India has a wealth of water ecosystems that have been lifeline for economic development for centuries, these are under tremendous stress today due to rapid urbanization, industrialization and agricultural intensification, manifested by the shrinkage in their areal extent, and decline in the hydrological, economic and ecological functions they perform.

Traditionally, use of GIS for water related ecosystems has been limited to localized mapping restricted at large by the administrative boundaries. More needs to be done to safeguard these transboundary natural resources. With geography knowing no boundaries, it is imperative to visualize and understand the water ecosystems holistically including their interconnections and interdependencies at a national, regional, and local levels. Decision support for such complex scenarios mandates scientific knowledge of resources information including precipitation, runoff, geology, soil, topography, climate, sediment yield and many other factors.

Playing a central role, a GIS based Water Management platform brings together all the processes and sub-systems of the water related ecosystems on a unified platform. It aids to monitor, plan, implement and improve various processes from "source to tap". By virtue of their capabilities to present relationship between the spatial and hydrological processes of the watershed in an efficient manner, GIS based hydrological models are valuable tools for surface-water and ground-water management at an ecosystem scale. With multiple stakeholders responsible for the overall success of water-ecosystem management, real-time insights and collaboration become very crucial.

GIS offers unmatched capabilities to effectively and efficiently plan, design and manage protection and restoration of water ecosystems including a) Watershed development and strengthening of distribution network from source to the tap b) Improvement in water management and distribution system for water bodies c) Diversion of water from high-

India-WRIS

A well-developed information system, for water related data in its entirety is a prime requisite for sustainable water resource management of a nation.

Powered by ArcGIS, the generation of a database and the implementation of a web enabled Water Resources Information System popularly known as India-WRIS was conceived as a single window solution for all water resources data and information in a standardized national GIS framework. Developed jointly by Central Water Commission (CWC) and the Indian Space Research Organization (ISRO), this centralised platform is now India's national repository of water resources and associated data with administrative granularity. This data includes hydrological, hydro-meteorological real time information and data acquired using public funds available for legitimate use, enabling better decision making and meeting society's needs.

India-WRIS allows users to Search, Access, Visualize, Understand and Analyse comprehensive and contextual water data for the assessment, monitoring, planning and development of water resources for Integrated Water Resources Management (IWRM). It has four key elements:

(1) Data input/entry/collection system

(2) Data storage, analysis, and transformation into 'user friendly' information

(3) Interactive system for geo-visualization and temporal analysis and

(4) Information dissemination system in public domain, processing tools and data downloads

Providing holistic information on the state of water resources, India-WRIS platform aids in decision support for water resource planning and management strategy. By creating public awareness about the crucial issues related with water and attract wider participation in water resource management, India-WRIS aims to strengthen India's water resilience in times to come.

Managed by the National Water Informatics Centre (NWIC), India-WRIS also provides value added products and services to all stakeholders for its management and sustainable development.

available sources to deficient water scarce areas d) Water conservation and rainwater harvesting e) Renovation of traditional and other water bodies/ tanks and f) Intensive afforestation.

Increasing water-use efficiency & ensuring freshwater supplies

Nearly 80% of India's freshwater is used in agriculture and over half of India's cultivated land is under water-intensive crops. India draws nearly 25 percent of the world's groundwater and Indian agriculture relies heavily on groundwater (60% of the irrigated area in the country). India uses at least twice the amount of water to grow one unit of food versus comparable countries. This is a cause of concern which needs immediate attention.

With depleting water resources, the focus needs to shift on the water-use efficiency for a sustainable future. Improving water efficiencies becomes critical more than ever and geospatial technologies have a critical role to play. Use of GIS for agricultural and water conservation interventions aid in identification of causes for inefficiencies and support in optimizing the water utilization, while improving crop yields and efficiencies.

With agriculture being major water consumer, right information on suitability of a crop, inputs, land conditions, weather conditions, market conditions, etc. in right time can optimize the irrigation and thus utilization of water. By integrating location intelligent IOT based devices, and farm infrastructure, precision agriculture offers transformative potential for sustainable water-smart-agriculture, while improving crop yields and minimizing risks for the farmers.

Government of India's initiatives for improving water use efficiency 'More crop per drop' can be benefitted greatly by use of GIS technologies for source creation, distribution, management, field application and extension activities. GIS based farmer decision support systems can facilitate better choice of the crops to the farmers keeping in view the water availability and future challenges. Precision water application devices like drips, sprinklers, pivots, rain-guns can be deployed judiciously with a better understanding of the context and local conditions.

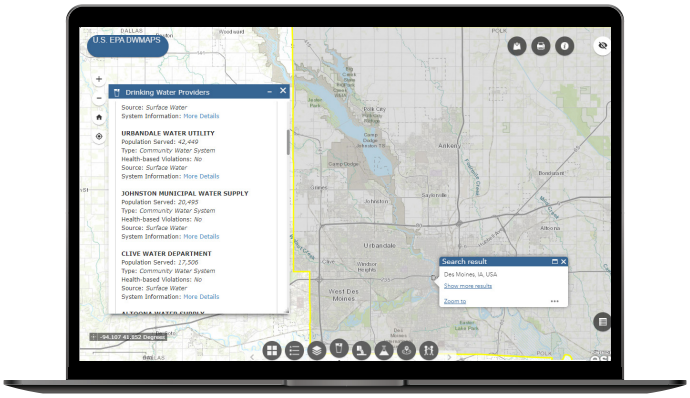
With heavy reliance on natural resources for water especially in rural parts, water conservation efforts will be the lifeline for future sustainability. 3D Village Contour Maps serve as very effective tools for planning interventions. GIS technologies can assist the stakeholders in various interventions viz. a) Water harvesting, ridge area treatment, b) Water conservation plans c) Soil and moisture conservation d) Rainfall management e) Minor Irrigation (both surface and ground water) and micro irrigation and f) Agronomic measures to maximise use of water while minimising irrigation requirement.

Achieving safe & affordable drinking water

Depleting water ecosystems have been constantly adding pressure on the urban and rural water supply systems. This clubbed with the increasing population and economic activity have been adding to the water demand keeping the governments and agencies on their toes.

As per the National Statistical Office (NSO), Ministry of Statistics and Programme Implementation, about 57.5% in the urban areas and 48.6% of the households in the rural have exclusive access to principal source of drinking water. Further about 94.5% of households in rural and about 97.4% in urban areas used 'improved source of drinking water' viz. bottled water, piped water into dwelling, piped water to yard/plot, piped water from neighbour, public tap/standpipe, tube well, hand pump, protected well, public tanker truck, private tanker truck, protected spring and

rainwater collection. Along with the hardships, this also implicates a huge economic cost to the nation. Not a desired situation after 70+ years of independence.



In urban environments, with open systems still prevalent, water utilities are seldom in a position to accurately assess the non-revenue water (NRW) which in turn introduces redundancy and impacts their operational efficiencies. Lack of proper maintenance of existing infrastructure causes further losses of almost 40 per cent of piped water in urban areas. In rural environment sustainability of water availability and supply, drop in ground water tables, and water contamination continue to be major challenges. Many villages in rural India continue to depend on the traditional sources of drinking water viz. community managed open wells, private wells, ponds, river, lake, and irrigation reservoirs.

GIS technologies have wide applicability in ensuring safe and affordable drinking water supply in urban and rural environments. Leveraging the context of location GIS aids in design, model, planning and maintenance of water distribution networks helping the utilities to optimize costs and improve turnaround times. A geo-enabled water supply platform supports asset management, outage management, leakage / pilferage management, and emergency response management across the water distribution life cycle.

GIS platform integrated with IoT, SCADA and other components of the distribution systems by leveraging machine learning and artificial intelligence offer numerous opportunities for automation and operational improvement. Efficient systems and seamless flow of data and

Data Driven decision support for ensuring uninterrupted water supply

With more than 50% of non-revenue water and other operational problems, Thrissur municipality decided to challenge the status quo and take the bull by its horns. Water Efficient Thrissur (WET) initiative was conceived on ArcGIS Enterprise platform to address these problems by enhancing the situational awareness of the water utility network and assets and arm the administration with real-time actionable intelligence and decision support.

Designed and built on an authoritative spatial repository integrated with non-spatial data and sensors (Smart meters and IoT devices), Esri's geo-enabled decision support platform has taken the centre-stage in delivering data driven insights and rapid decision support to all the WET stakeholders. Some of the benefits reaped by Thrissur municipality being:

- Reduction of water losses, pilferages, and leakages
- Geo-enabling of billing systems and customer feedback for advanced analytics
- Reduction in response time to citizen grievances / disruptions through outage management and workforce management system
- Real-time dashboards with map-based interfaces and real-time statistics for decision support
- Hydraulic modelling and simulation of water network for predictive demand and supply studies

Given the water scarcity challenges cities are staring, WET strengthens Thrissur's water governance and resilience by helping them to prepare strategically, respond rapidly and recover methodically in the event of any disasters or disruptions.

information from sensors and smart devices enables utilities to respond faster to operational contingencies. Be it regulating water supply, identifying drop in pressure and leakages, maintenance and repair of pipelines and revenue planning and recognition, with enhanced situational awareness and actionable intelligence on finger tips, GIS enables the utilities to provide improved water services, while improving the operational efficiencies. Real time data delivered via easy to understand maps and apps create transparency and understanding improving citizen engagement and citizen services.

District Metered Area (DMA) is an effective tool to manage water supply and NRW Management. GIS driven DMA approach aids in better management of the water distribution systems by bringing together all the relevant subjects together on a single platform enhancing the situational awareness while providing actionable intelligence for improving operations. These can benefit in reduction of non-revenue water, improvement of water quality, optimize energy consumption, mitigate leakages, pilferages, and contaminations.

Improving water quality, wastewater & safe reuse

One of the major factors contributing to water stress in India is water pollution. Almost 70% of India's surface water resources and an increasing percentage of groundwater reserves are contaminated by biological, toxic, organic, and inorganic pollutants. Many of these sources have become unsafe for human consumption, irrigation and industrial needs. Excessive withdrawal of ground water in coastal regions is resulting in intrusion of salt water into freshwater bodies thus rendering them unsuitable for consumption. According to NITI Ayog as much as 70% of water being contaminated, lack of access to safe water causes staggering 2 lakh deaths every year. This challenge clubbed with the depletion of the water resources poses a huge challenge to the development agenda and needs addressing on war footing.

Traditional methods of water sample collection and testing are expensive and time consuming and in turn delaying the remedial efforts. Geospatial technologies play a vital role in rapid water quality assessment and monitoring. Using remote sensing and geospatial modelling, water quality indicators such as chlorophyll, algae bloom, turbidity, suspended sediments, and mineral content in water bodies can be assessed and monitored with greater accuracy. Integration of water quality indices (WQI) in a geospatial environment offers multiple advantages including evaluation of the impact, planning for water quality interventions and decision support. Using advance techniques, simulation and modelling of the water ecosystems using these WQI aid in generating predictive scenarios of potential pollution and water quality deterioration and thus helping in arresting the problems before they manifest.

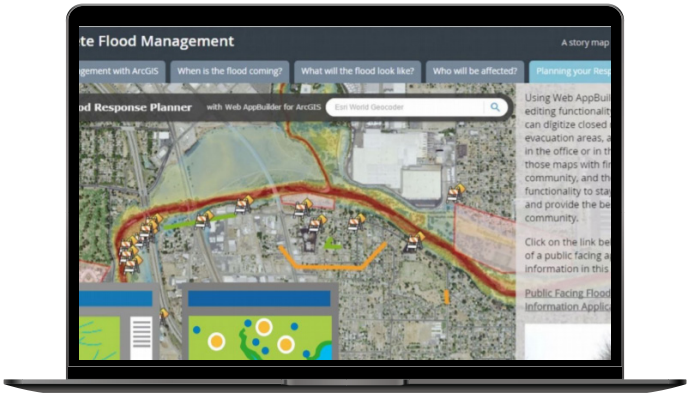
Sewerage and industrial waste are one of the big contributors to the water quality deterioration. In a country like India with unorganized waste management, this is a huge challenge. In the absence of geographical context, understanding of interrelations and interdependencies it is impossible for agencies to address these problems and implement sustainable solutions. With its power to bring together multiples disparate subjects, Geospatial technologies can be force-multiplier in wastewater and sewerage management including planning design and management of a) Networked sewerage systems and sewage treatment plants b) Water recycling, removal of contaminants and reuse / release wastewater and c) Storm water drainage to regulate water flows.

Improving water related disaster management and strengthening resilience

India has been highly vulnerable to water related disasters including floods, droughts, and cyclones over last many decades. Increasing temperatures, shifting rainfall patterns and resultant water related extremes (disasters) are some of the most visible impacts of the climate change. With a large network of rivers, a good part of Indian subcontinent is flood prone. Every event of flood result in huge losses of life and property. In recent years urban flooding has become a very common phenomenon, paralyzing cities in no

time. Contrastingly, about 42% of India's land area is facing drought, while tropical cyclones continue to ravage the coastal regions of India very frequently.

More than one extreme can occur together, triggering simultaneous shocks and stresses across the water ecosystems. Water related disasters have a significant impact the water availability for human consumption, industrial production, and social wellbeing. To strengthen resilience and adaptability of nation and its communities, there



is a compelling need to explore and understand these interconnections, contextualize location, and analyse the interdependencies spatially and temporally. Geospatial technologies are vital to governments, non-profits, and businesses to prepare strategically, respond rapidly and recover methodically respond to such extremes.

For ensuring water security, building water resilience is an important step so that governments, and communities can a) anticipate risk, b) prepare to adjust c) share and learn d) integrate, coordinate and collaborate and e) ensure inclusiveness. With its unique ability to integrate data about everything—and, at the same time, ability to provide a platform for intuitively understanding data and knowledge as an integrated whole, GIS becomes an essential and irreplaceable tool for strengthening water resilience. GIS not only helps with a better understanding of the evolving situations, but also provides a platform for collective problem-solving, decision-making, and collaboration.

Spatial modelling and predictive analysis using artificial intelligence, machine learning and big

India Water Tool

Water can only be sustainably managed if data with an appropriate level of granularity is made available publicly in a format easily accessible and usable to all stakeholders. India Water Tool Version 3 (IWT 3.0) is a comprehensive, high-resolution, user-friendly tool that helps companies and other users evaluate, assess and plan their water management interventions.

With ArcGIS at its core, India Water Tool is a decision-support tool for organizations to measure and map water risks associated with their businesses and operations. Targeted at companies and investors who need to understand the water risks for their operations, supply chains, investments and plan their water management interventions. Communities can use the tool to plan collective recharge and conservation efforts.

Presented as intuitive maps, ITW 3.0, includes datasets from key Indian government agencies and other organizations, real-time satellite data of surface water availability from NASA and U.S. Geological Survey (USGS) and Water stress models developed by the World Resources Institute (WRI) and Columbia Water Center (CWC). IWT 3.0 provides access to:

- Comprehensive data on water availability, quality, and water stress,
- Watershed-level water-balance studies providing watershed health information and demand-side management.
- Aids in measuring and map water risk and prioritize locations for further analysis and site-specific water-management improvements

Organizations can use IWT 3.0 to generate reports with key water indicators mandated by corporate disclosure initiatives (GRI, CDP Water, DJSI, Bloomberg and UN CEO Water Mandate).

data can provide enhanced situational analysis and comprehensive impact assessments of water scenarios, thereby helping with accurate assessment of likely impact of the disasters, their geographic spread, hot spots, priority areas, appropriateness and efficacies of interventions. Advanced capabilities for intuitive visualizations, sharing and collaboration and anywhere, anytime access to required information, facilitate seamless intra and inter sectorial interactions between central, state, district administrations, NGO's, and other stakeholders. While this fosters inclusiveness it also promotes multi-fold increase in the efficacy of prevention and mitigation efforts.

In closing

As the geospatial infrastructure continues to play a vital role in integrating physical, social, institutional, and economic infrastructure at national, state and local levels, geospatial thinking offers numerous opportunities to accelerate digital transformation initiatives across the water sector holistically from "source to tap" and rapidly move towards integrated water resource management and strengthen nation's water resilience.

For India to achieve its vision of "Atmanirbhar Bharat (Self-Reliant India)" nations water resilience holds the key. Building a robust water resilience by leveraging strengths to anticipate future trends, prepare, manage, and mitigate the challenges effectively and efficiently, will be one of the critical success factors in our march towards being a US$5 trillion economy.