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COVER STORY

GIS for Robust Infrastructure Development

CASE STUDY
JNPA Masters Smart Port Governance with ArcGIS

ARTICLE
ArcGIS - The Backbone of Digital Twins

PRODUCT REVIEW
ArcGIS GeoBIM

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New Delhi - 110025, Delhi

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Shanthala Nagar, Ashok Nagar,
Bengaluru - 560001, Karnataka

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1st Floor, The PARK, 22, Raj bhavan Road,
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KOLKATA
Urbanwrk Private Limited, 8th Floor, Technopolis
Building, BP Block, Sector V, Bidhannagar,
Kolkata - 700091, West Bengal

MUMBAI
AWFIS Space Solutions Private Limited, Auram Qparc,
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Ghansoli, Navi Mumbai - 400710, Maharashtra

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MD'S DESK

Agendra Kumar
Managing Director, Esri India

Recognizing that public infrastructure is the backbone of economic development, enhancing connectivity, trade, and overall quality of life, India has made remarkable progress in infrastructure development over the past decade. The country's total infrastructure spending has grown exponentially, with budget allocations rising to approximately 11.2 lakh crore in 2025-26.

The PM Gati Shakti National Master Plan (NMP), launched in 2021, is designed to bring together various Ministries, including Railways and Roadways, to ensure integrated planning and coordinated execution of infrastructure projects. The initiative aims to provide seamless and efficient connectivity for the movement of people, goods, and services across various modes of transport, thereby enhancing last-mile connectivity and reducing travel time.

A strong emphasis is being placed on expanding and modernizing the country's airport infrastructure as well to support rapid economic and passenger growth. Through public-private partnerships, the government is driving world-class airport design, sustainability, and digital innovation.
Such initiatives clearly indicate that India is on the path to building smarter, intelligent transportation networks, efficient utilities, thriving industrial corridors, and inclusive social infrastructure. However, the complexity underlying these projects is greater than ever—rapid urbanization, environmental risks, increasing demand, and the need for speed and cost efficiency require an integrated, intelligent approach.

This is where GIS is emerging as the core enabler.

Esri's ArcGIS connects data, people, processes, locations, and systems into one unified geographic context. It brings clarity to complexity. By visualizing networks, modelling scenarios, and providing real-time insights, it enables organizations to design better, build faster, and operate more sustainably. From master planning ports and industrial hubs to optimizing gas networks and improving outage response in power utilities, ArcGIS is transforming the way infrastructure is imagined and delivered.

The power of GIS expands further when integrated with BIM, Digital Twins, and IoT. Together, they allow us to move from static planning to dynamic intelligence—where infrastructure assets can be monitored continuously, performance can be predicted in advance, and real-time spatial insights can inform decisions. And now, with the rapid emergence of AI, we are witnessing the next leap: GeoAI. GeoAI, by combining geospatial data, GIS, and AI, is providing insights that enhance efficiency, resilience, and sustainability in infrastructure projects.

Esri India's newly established GIS & AI Competency Center, located at a new facility in Noida, aims to foster broader adoption of AI in GIS applications. Building on Esri India's leadership in GIS, the new center serves as a dynamic catalyst for our focus on GeoAI offerings and empowering customers to enhance their GIS and GeoAI capabilities.

The infrastructure of tomorrow must be designed with foresight, delivered with efficiency, and governed with accountability. With continuous innovations in GIS, we can build not just for today, but for generations to come.

Moving on from supporting planning, design, construction, and asset management by providing accurate location-based insights, tools like ArcGIS are enabling the creation of real-time, data-rich virtual replicas of infrastructure. By infusing AI, it is automating feature extraction, anomaly detection, and predictive analytics, thereby accelerating decision-making in complex infrastructure projects. Together, these technologies are driving futuristic infrastructure, where connected sensors, real-time geospatial intelligence, and autonomous systems will enable smarter, more resilient, and sustainable urban environments.

Department of Posts Signs MoU with Esri India to Strengthen the DIGIPIN Initiative

The Department of Posts (DoP) has signed a Memorandum of Understanding (MoU) with Esri India. Under this MoU, DoP will be able to use Esri India's high-resolution imagery and street basemaps for its DIGIPIN portal. The collaboration will also enable the integration of DIGIPIN with Esri India's Living Atlas portal, thereby making it accessible to the larger GIS community. Further, Esri India will provide technical support to the DoP for seamless integration of their services for DIGIPIN.

This understanding aims to leverage Esri India's mapping solutions to support the development and implementation of DIGIPIN, thereby making the DIGIPIN system more robust and citizen-friendly.

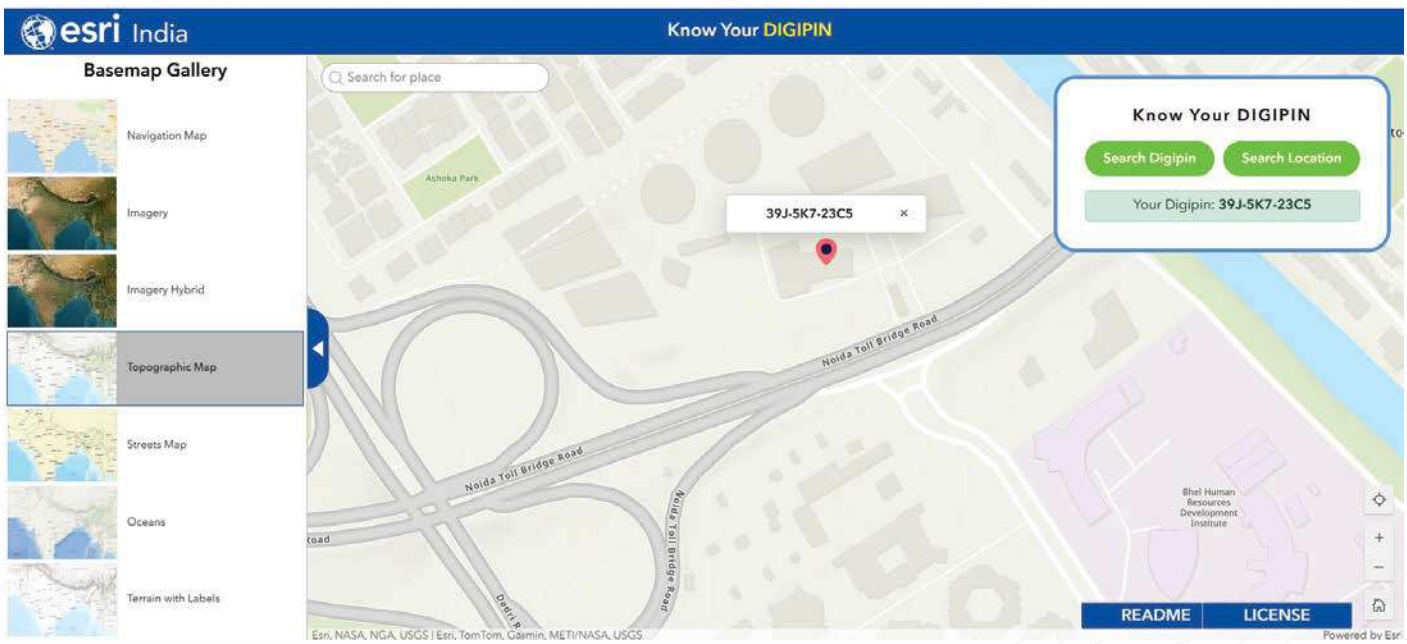
The MoU was signed by designated representatives of the Department of Posts and Esri India at an event held at Dak Bhawan, New Delhi.

Speaking on the occasion, **Shri. Harpreet Singh, Member (Operations), Department of Posts, said:**

"This collaboration with Esri India marks a major step forward in realizing the vision of the DIGIPIN initiative. With Esri's robust base maps and geospatial technology, DIGIPIN will empower citizens and government services with accuracy and accessibility."

Agendra Kumar, Managing Director, Esri India, said, "We are proud to collaborate with the Department of Posts on this landmark initiative. Esri India's GIS expertise and advanced mapping solutions will support DIGIPIN to become a robust digital addressing system, driving efficiency in various sectors and supporting India's broader digital transformation."

The MoU represents a significant step towards the effective ground-level implementation of the DIGIPIN initiative. By integrating Esri India's advanced mapping capabilities with the Department of Posts' extensive nationwide network, DIGIPIN will become more precise, accessible, and user-friendly—further enabling efficient service delivery and improved citizen engagement.



Master's Scholarships in GIS 2025 Winners Announced

The third year of the Master's Scholarships in GIS Program concluded at the Esri India User Conference 2025-Delhi Chapter on 3rd September with the announcement of the 10 recipients of this year's scholarship. This scholarship is available to Indian students entering their second year of postgraduate studies (M.Tech/MSc.) in Geoinformatics or related fields at accredited institutions or universities in India. This year, Esri India received more than 170 registrations from 80 universities across India. The participants included students pursuing courses in Urban Planning, Remote Sensing, Soil Science, Environment and Water Resource Engineering, Geology, Geoinformatics, and other related fields at various prestigious institutes/universities across the country.

After thorough rounds of assessment, 10 students pursuing their post-graduate studies in the following colleges/ universities were selected for the prestigious scholarship:

- IIT Kanpur
- IIT Roorkee
- TERI School of Advanced Studies
- CEPT University
- University of Mumbai
- Savitribai Phule Pune University
- AKTU, Lucknow
- School of Planning and Architecture, Bhopal
- NIIT University

Congratulations to all winners!

Esri India and Dhruva Space Join Hands to Transform Geospatial Intelligence with Space-Powered Solutions

Through this strategic partnership, Dhruva Space will leverage Esri India's advanced ArcGIS technology to enhance its AstraView commercial satellite imagery service that aggregates data from a constellation network of more than 200 satellites, spanning optical, SAR, RF, and hyperspectral sensors, into a unified ecosystem.

This collaboration aims to deliver an integrated software solution, enabling customers to seamlessly access, analyze, and derive actionable insights from AstraView in conjunction with Esri India's robust GIS capabilities.

The collaboration between Esri India and Dhruva Space is expected to open new avenues for leveraging space-based data in critical national initiatives, fostering innovation, and supporting India's growing emphasis on self-reliance in geospatial intelligence and space technology.

Agendra Kumar, Managing Director, Esri India, said, "This partnership with Dhruva Space brings cutting-edge satellite imagery capabilities closer to GIS users in India. It reflects our ongoing commitment to strengthening India's geospatial ecosystem and supporting indigenous innovation in the spacetech sector. By combining the strengths of our ArcGIS technology with Dhruva Space's full-stack capabilities, we aim to empower decision-makers across industries with timely, high-quality geospatial insights. This initiative will also help accelerate the adoption of space-based data in areas such as urban planning, disaster management, agriculture, and infrastructure development. Together, we are creating a robust framework to drive data-driven governance and sustainable growth for the nation."

Krishna Teja Penamakuru, Chief Operations Officer & Co-founder, Dhruva Space, added: "AstraView was launched to make diverse and trusted satellite imagery simple to access and practical to use, bringing together a wide range of sensing capabilities into one service. Partnering with Esri India, a market leader in GIS, ensures that these capabilities are extended into a platform already trusted by millions of users. This integration will make relevant imagery and data more accessible within GIS workflows, where the combination of imagery and analytics allows users to interpret and act on data with greater clarity. The intent is to move satellite data from the background, and place it at the core of everyday decision-making, ultimately improving how organizations plan, respond, and build resilience."

This MoU will be a significant step forward in strengthening the convergence of satellite technology and geospatial intelligence in India. It also lays the foundation for future-ready solutions that will enhance decision-making, improve resilience, and accelerate India's digital transformation journey. This collaboration was formalized at the Esri India User Conference 2025 in Hyderabad, India's largest congregation of GIS professionals, dedicated to advancing the use of geospatial technology for a more sustainable and informed world.

GIS for Robust Infrastructure Development

Building Smarter, Resilient, and Sustainable Infrastructure with Geo-Intelligence

As India makes a larger presence in the global landscape, infrastructure development stands as one of the nation's defining imperatives. With over 1.4 billion people and an expanding economy growing at around 7% annually, the demand for efficient, resilient, and sustainable infrastructure has never been more pressing. The government's ambitious infrastructure investments highlight the nation's recognition that roads, ports, and railways are the backbone of economic growth.

However, rapid urbanization, increasing environmental risks, and the complexity of modern engineering projects demand an equally sophisticated technological response. This is where Geographic Information Systems (GIS) stands out as a transformative technology that integrates geography, data, and design to build infrastructure that is not only efficient but intelligent.

GIS in Architecture, Engineering, and Construction

GIS offers comprehensive insights into existing infrastructure, topographical features, and environmental constraints, enabling planners and engineers to identify optimal locations for new projects and improve existing ones. Spatial analysis tools within GIS allow professionals to assess terrain, accessibility, population density, and environmental impacts, thereby supporting data-driven and informed decision-making. Tools such as ArcGIS Urban, ArcGIS Indoors, ArcGIS CityEngine, and ArcGIS Reality provide spatial intelligence at every level, from strategic planning to operational execution, ensuring that decisions are informed, collaborative, and grounded in real-world context.

GIS plays a transformative role in all stages of an AEC project, right from planning to maintenance.

Planning: In the planning phase, GIS aids site selection and feasibility analysis. By integrating demographic data, terrain, and land-use maps, planners can pinpoint optimal locations for highways, airports, and industrial corridors while minimizing environmental disruption.

GIS empowers stakeholders by providing a spatial perspective on complex datasets, facilitating evidence-based planning and policy formulation. Through scenario modelling and predictive analytics, planners can assess the potential outcomes of different development strategies, select cost-effective options, and promote sustainable growth. This proactive approach minimizes risks and ensures that infrastructure initiatives align with long-term development objectives.

Designing: During the design phase, GIS supports the visualization of engineering concepts in a spatial context. Integration with BIM brings even greater precision. By linking 3D building models with real-world coordinates, design teams gain insight into accessibility, utilities, and community impacts. Digital Twins take the precision to new levels.

ArcGIS is foundational for any digital twin. It connects different types of data and systems to create a single view that can be accessed throughout the complete project life cycle. It enhances data capture and integration, enables better real-time visualization, provides advanced analysis and automation for future predictions, and facilitates information sharing and collaboration.

Building: On-site construction benefits from real-time GIS dashboards and drone mapping. Supervisors can compare design models with as-built models, detect deviations early, and ensure safety compliance, thereby reducing rework and delays.

Operation and Maintenance: Following construction, GIS becomes a dynamic system for asset management. By

integrating spatial and asset data, organizations can monitor the condition, performance, and lifespan of infrastructure assets. This integration enables proactive maintenance, optimized resource allocation, and extended asset lifecycles. GIS-based asset management systems enhance operational efficiency, reduce costs, and support informed decision-making throughout an asset's life.

GIS for Roads, Highways, and Ports Management

GIS offers a comprehensive solution for the infrastructure sector by creating **a System of Record, a System of Engagement, and a System of Insight.** It builds a connected platform that integrates data across departments and external agencies. It brings together asset inventories, maintenance records, safety data, and environmental information into a single, unified environment. GIS supports both day-to-day operations and long-term planning by enabling the comparison of project scenarios, prioritizing needs, and optimizing investments based on measurable outcomes.

Roads and Highways

Accurate, up-to-date land information is foundational for efficient planning, land acquisition, environmental compliance, and sustainable construction. Land Information Systems (LIS) provide an integrated, authoritative view of land parcels, ownership, encumbrances, and terrain conditions. GIS adds powerful spatial analytics, visualization, and decision-support capabilities to a LIS. Together, they streamline corridor planning, reduce project delays, optimize alignment selection, and help mitigate risks related to land disputes or environmental sensitivity.

By enabling transparent data sharing among government agencies, developers, and communities, LIS and GIS play a transformative role in accelerating infrastructure delivery and ensuring that India's road and port networks are built smarter, faster, and more sustainably.

GIS aids in unifying existing Department of Transportation (DOT) systems through a centralized Linear Referencing System (LRS), enabling data fusion and sharing across business units. It helps in planning, managing, and maintaining roadway LRS networks, author maps that fuse data from different LRMs, and publish and share linear referenced data services.

GIS enables informed decision-making through accurate data analysis, improving efficiency in project planning and prioritization. GIS promotes cost-effective asset management by optimizing life-cycle costs and enabling proactive maintenance. It enhances coordination between agencies and stakeholders by serving as a shared information hub. Finally, GIS improves public engagement and transparency, allowing citizens to visualize how transportation investments support safety, mobility, and environmental sustainability. GIS has emerged as an essential technology for the future of roads and highways management. By integrating spatial data with performance metrics, it empowers transportation agencies to move from reactive maintenance to proactive, data-driven planning. Through better coordination, smarter investments, and clearer communication, GIS helps agencies achieve their strategic goals efficiently while meeting the growing demands of public accountability and sustainable infrastructure management.

GIS has emerged as an essential technology for the future of roads and highways management. By integrating spatial data with performance metrics, it empowers transportation agencies to move from reactive maintenance to proactive, data-driven planning. Through better coordination, smarter investments, and clearer communication, GIS helps agencies achieve their strategic goals efficiently while meeting the growing demands of public accountability and sustainable infrastructure management.

Railways

In the railway and public transport sectors, GIS facilitates route optimization, track maintenance, and service scheduling. It is an extremely powerful technology that can help shape various operational requirements and asset management of the Railways. The sector can use geo-enablement projects for asset management, decision-making and planning, disaster management and rescue operations, monitoring and alert systems, real-time tracking and prediction, or forecasts. Integration of GIS with ticketing and passenger information systems allows transit authorities to improve service reliability, enhance passenger experience, and boost ridership. Furthermore, GIS plays a critical role in designing multimodal transportation hubs that efficiently integrate multiple transit modes.

Airports and Seaports

GIS has an important role to play in all stages of port planning, including vessel & berth capacity, number of vessels, container capacity, port design and infrastructure expansion, bathymetric analysis and clearance, security operations, emergency response and management, and port operations and maintenance.

Asset Management

GIS streamlines the coordination and management of diverse facilities/assets, maximizing operational efficiency. It serves as a robust foundation for enhanced port facility management by integrating information for informed decision-making regarding limited port area allocations. A web-based GIS application or dashboard facilitates real-time monitoring of real estate leases and relevant leasehold details within organizational levels, facilitating better decision-making.

GIS maps utilities like water networks, gas pipelines, and cable networks, integrating them with on-site facility photos and asset databases. This setup enables comprehensive monitoring and visualization through GIS-based dashboards or web applications.

Port Operations Management

Efficient port operations demand precise coordination of activities like ship traffic control, berth scheduling, utility provisioning, and container management. Location-based information management solutions enhance efficiency through modeling, analysis, and visualization tools. GIS technology maps and displays vessel locations, aiding traffic control and safety management. Vessels can be color-coded by cargo type, with detailed berth information including vessel type, name, arrival times, and ownership. This data supports tariff calculations, billing, and reporting. Real-time integration with sensors and IoT devices enables predictive and proactive planning of port operations.

In the case of airports, GIS improves operational awareness by providing real-time dashboards that display gate status, aircraft positions, and resource availability. Operators can quickly detect conflicts, optimize gate assignments, and maintain smooth passenger and aircraft flows, even during disruptions. This spatially integrated view enhances decision-making, reduces delays, and boosts overall efficiency and revenue.

Risk Management

ArcGIS can help port operators navigate regulatory requirements and mitigate risks associated with environmental impact, safety hazards, and security threats. By integrating regulatory data layers and conducting spatial risk assessments, decision-makers can ensure compliance with regulations and implement appropriate risk mitigation measures. Location-based information management and visualization capabilities give you useful tools for environmental management. GIS technology can be used to create a comprehensive view of hazardous materials location and its storage and analyze the potential impact of chemical, oil, or gas spills in the marine environment. A 3D visualization of the port facilities or underwater features can also be created. With the help of bathymetric data, the channel depth can be determined for known areas, which will lead to proper dredging operations and underwater obstructions for safer navigation. Integrating sensor technology into port operations can indeed play a crucial role in monitoring and managing pollutants in the sea, as well as in maintaining the health of flora and fauna. Here's how sensor integration can contribute to this process for maintaining water quality, Marine life monitoring, Early Warning Systems, and more.

Smarter Capital Investment

GIS enables smarter capital investment by providing a comprehensive spatial view of airport assets, operations, and development needs. Integrated mapping of pavements, utilities, terminals, and airfield components helps identify asset conditions, maintenance histories, and life-cycle priorities so funds are allocated where they deliver the greatest value. GIS also supports data-driven justification for expansions by analyzing operational bottlenecks such as runway occupancy, taxiway conflicts, and gate congestion. Environmental and regulatory layers—noise, wildlife, flood risk—allow planners to select development sites that minimize impacts and costly delays. Scenario modeling helps compare growth options and align projects with demand forecasts and resilience goals, ensuring capital improvements are both cost-effective and strategically aligned.

Indoor Mapping of Airports

GIS-enabled indoor mapping improves airport operations and passenger experience through detailed digital maps of terminals, gates, retail areas, and operational spaces.

These maps support precise routing for travelers and staff, showing distances, travel times, and vertical navigation across multiple floors. Integrated sensor data enables real-time crowd monitoring, dynamic wayfinding, and congestion management. For staff, indoor GIS streamlines maintenance, inspections, and emergency response, turning complex indoor spaces into intuitive, navigable environments that boost efficiency and confidence.

Noise Analysis in Airports

GIS supports airport noise analysis by integrating flight paths, terrain, land use, and population data to map noise contours and assess community impacts. Analysts can compare noise exposure with residential zones, schools, and sensitive sites, and evaluate the effects of changes in runway use, schedules, or aircraft types. GIS helps prioritize mitigation strategies such as insulation programs or land-use changes and provides clear visualizations for stakeholder communication, making noise management more transparent and evidence-based.

Most ports have significant technology investments and management systems housing critical data. However, these data are often siloed within departments, hindering effective decision-making. GIS offers a solution by integrating existing data systems. With nearly all port data having a spatial component, GIS acts as a bridge between disparate datasets, enhancing data utilization. **The focus is not on developing new, complex systems but on maximizing the accessibility of existing data.** By creating open APIs that integrate data from various port management systems, including real-time updates, GIS enables centralized data access based on user credentials. This integration brings heightened control to a complex operational environment, fostering more informed decision-making.

Effective Planning and Management of Ports using ArcGIS

Adani Enterprises Limited is using a GIS-based web application as a centralized control 'Land Information System' that acts as a repository of land assets and resources. The Land & Estate department of the company has created a GIS-based system that facilitates master planning and management of multiple ports.

An infrastructural marvel, the mega port at Mundra is a major economic gateway that caters to the northern hinterland of India with multimodal connectivity. The department has incorporated a major project of Mundra Master Planning & and its Development using GIS systems.

GIS has played a crucial role in planning the development of a very important Port, an industrial Hub, and the supporting social and physical infrastructure.

The data was collated, processed, and developed using ArcGIS software, and the solution was deployed using the Portal for ArcGIS technology which helped the organization to analyze the current operation and development situation of the port, industrial hub, and social infrastructure and make decisions about the existing deficiency and expansion, needs of improvements and future development with their management support.

Integrating GIS, BIM, and Digital Twins for Resilient Infrastructure

The integration of GIS with Building Information Modelling (BIM) has emerged as a transformative approach in the infrastructure industry, bridging the gap between building design and spatial analysis to facilitate more informed decision-making, collaboration, and project outcomes. It involves converging building information with geographic data, creating a comprehensive and integrated digital twin of the built environment, encompassing both the indoor and outdoor aspects of infrastructure and building projects.

The integration also leads to substantial cost savings. By combining BIM with GIS, project teams can identify and address issues during the planning phase by creating detailed 3D representations of infrastructure projects. This proactive approach, supported by GIS, minimizes expensive rework, material wastage, and resource inefficiencies. Utilizing IoT sensors for monitoring equipment performance and maintenance, alongside GIS analysis, further contributes

to cost savings. The early detection of equipment issues, facilitated by GIS, enables preventive maintenance, eliminating the need for costly breakdown repairs. Additionally, optimizing resource allocation through real-time data, made possible by GIS, can lead to reductions in energy and resource costs, ultimately enhancing overall business profits.

ArcGIS GeoBIM enables organizations to provide rich geospatial context to architecture, engineering, construction, and facility management projects. By bringing GIS and BIM data together, ArcGIS GeoBIM allows users to incorporate and use data from multiple systems, access project data from a common experience, explore GIS and BIM data side by side, collaborate and share information with stakeholders, and minimize costly data conversions. Using **AEC Project Delivery**, users can extend internal GIS content and context to resources outside of the organization. This allows them to collaborate and share information directly with stakeholders.

The concept of **Digital Twins** is evolving rapidly in infrastructure to create digital replicas of physical assets, systems, or processes, visualize, analyze, optimize, and simulate scenarios, improve decision-making, enhance operational efficiency, and drive innovation with sustainable & resilient solutions. **ArcGIS CityEngine** is an advanced 3D modeling software used for creating massive, interactive, and immersive urban environments based on real-world GIS data with the potential to showcase a fictional city of the past, present, or future.

The convergence of GIS, BIM, and Digital Twins is a transformative leap toward building intelligent infrastructure ecosystems. ArcGIS is foundational for any digital twin.

It connects different types of data and systems to create a single view that can be accessed throughout the complete project life cycle. It enhances data capture and integration, enables better real-time visualization, provides advanced analysis and automation for future predictions, and facilitates information sharing and collaboration.

AI in Infrastructure

Taking things to the next level, Artificial Intelligence is revolutionizing the infrastructure industry by enabling smarter, data-informed decision-making across the entire infrastructure lifecycle. By analyzing vast amounts of spatial, environmental, and operational data, AI algorithms can identify patterns, forecast outcomes, and predict potential issues before they occur. In the AEC context, this means anticipating construction delays, optimizing resource allocation, predicting equipment failures, and improving design efficiency.

When combined with GIS, predictive analytics enhances spatial understanding, allowing engineers and planners to visualize risk zones, forecast infrastructure performance, and model future urban growth scenarios.

For instance, AI can predict which areas are prone to flooding, structural deterioration, or energy inefficiency, enabling proactive maintenance and resilient design strategies. Ultimately, AI-driven predictive analytics transforms GIS and AEC workflows from reactive problem-solving to proactive planning—reducing costs, improving safety, and promoting sustainability in the built environment.

Conclusion

As the discussion unfolds, GIS is revolutionizing the way we plan, construct, and manage infrastructure. The geographic approach fosters understanding, promotes collaboration, and enables data-driven decision-making, inspiring us to take decisive action. Across sectors, from transportation and utilities to urban planning and disaster management, GIS is fostering efficiency, sustainability, and resilience. By leveraging the power of GIS, we are shaping the infrastructure of tomorrow, paving the way for a more sustainable future. As the infrastructure industry leverages the next generation of tech, GIS integrated with advanced technologies like AI, IoT, and Cloud Computing will be an integral component of the revolution, and we will continue to witness exciting developments in the realm of smart infrastructure.

JNPA Masters Smart Port Governance with ArcGIS

Client
Jawaharlal Nehru Port Authority

Industry
Government

Project
A unified GIS system to map, manage, and analyze the port and township infrastructure.

Organization Profile
The Jawaharlal Nehru Port Authority (JNPA), located at Navi Mumbai, is India's leading container port and a critical node in the country's maritime logistics network. Since its inception on May 26, 1989, JNPA has played a pivotal role in handling around 50% of the total containerized cargo across all major Indian ports. With direct connectivity to over 200 ports worldwide, it serves as a gateway for global trade and is ranked 26th among the top 100 container ports in the world. JNPA's journey from a bulk cargo terminal to a technologically advanced container port is a testament to its commitment to efficiency, innovation, and sustainability.

Website
www.jnport.gov.in

Project Summary

JNPA undertook a major digital transformation initiative to bring its electric meter infrastructure, land parcel records, lease allotments, and utility assets into a unified Geographic Information System (GIS) platform. Esri India partnered with JNPA to build a scalable geospatial framework that could map, manage, and analyze the port and township infrastructure more effectively. The initiative began with mapping electric meter boxes spread across the port and township areas and expanded to integrate land allotment data, utility networks, and field-based inspection tools—all within the ArcGIS Enterprise ecosystem.

Challenges

Before adopting GIS, JNPA faced multiple operational challenges:

a. No spatial visibility of electric meters and utility infrastructure across the township and port areas.

b. Fragmented data silos, with information stored in spreadsheets, physical documents, and isolated systems.

c. Manual verification of allotments and infrastructure leading to inefficient field operations and higher manpower costs.

d. Inability to correlate spatial assets with SAP-based lease data, limiting decision-making and reporting capabilities.

e. Delayed access to accurate data for inspections, maintenance, and planning due to a lack of real-time field reporting tools.

The Solution

Esri India proposed and implemented a comprehensive ArcGIS-based solution, fully integrated with JNPA's operational systems:

a. **Electric Meter Box Mapping:** Using ArcGIS Field Maps, field teams captured the geographic locations and attributes of electric meters across the port and township areas.

b. **Centralized Geospatial Database:** All spatial and non-spatial data were integrated into a secure ArcGIS Enterprise geodatabase hosted within JNPA's infrastructure.

Electric Meter Operations and Maintenance Dashboard

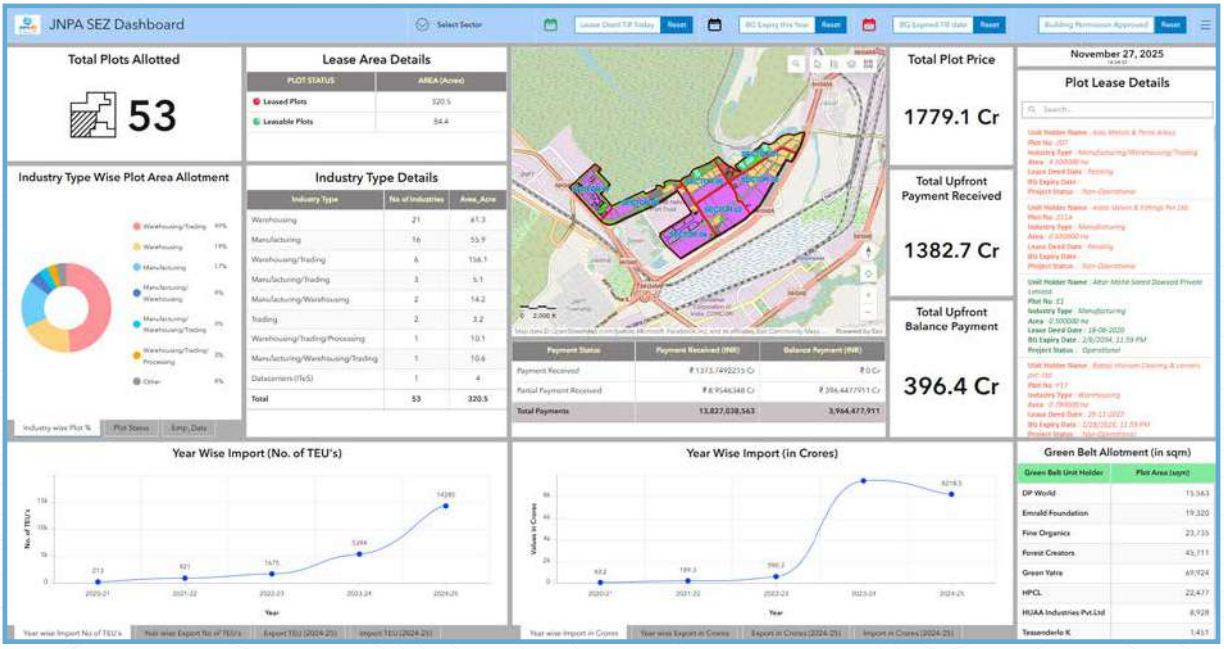
c. **Integration with SAP:** Allotment records from JNPA's SAP system were spatially linked to land parcels and buildings, enabling visual validation and real-time data correlation.

d. **Web and Mobile Applications:** Operational Dashboards and web apps were created using ArcGIS Dashboards and Experience Builder, providing interactive tools for various departments including Estate, Electrical, SEZ and Planning.

e. **Real-time Field Inspections:** With ArcGIS mobile tools, ground teams can now collect and validate data in the field, reducing turnaround time and increasing accuracy.

f. **Data Governance and Security:** Role-based access ensures that data is secure, validated, and accessible to authorized users only.

The solution created a live, unified geospatial platform enabling JNPA teams to view, analyse, and act on spatial information in real-time.



SEZ Lease Management Dashboard

Port Asset Management Dashboard

Port Operations Dashboard

Benefits

The deployment of Esri's GIS solution brought measurable and strategic advantages to JNPA:

a. 30% reduction in site verification time through mobile-enabled field inspections.

b. Seamless data correlation between SAP allotment records and spatial land parcels, improving accuracy in lease validation.

c. Up to 40% reduction in manual reporting efforts, due to automated dashboards and digital maps.

d. Improved infrastructure planning and resource allocation using spatial analytics.

Quarter Allotment

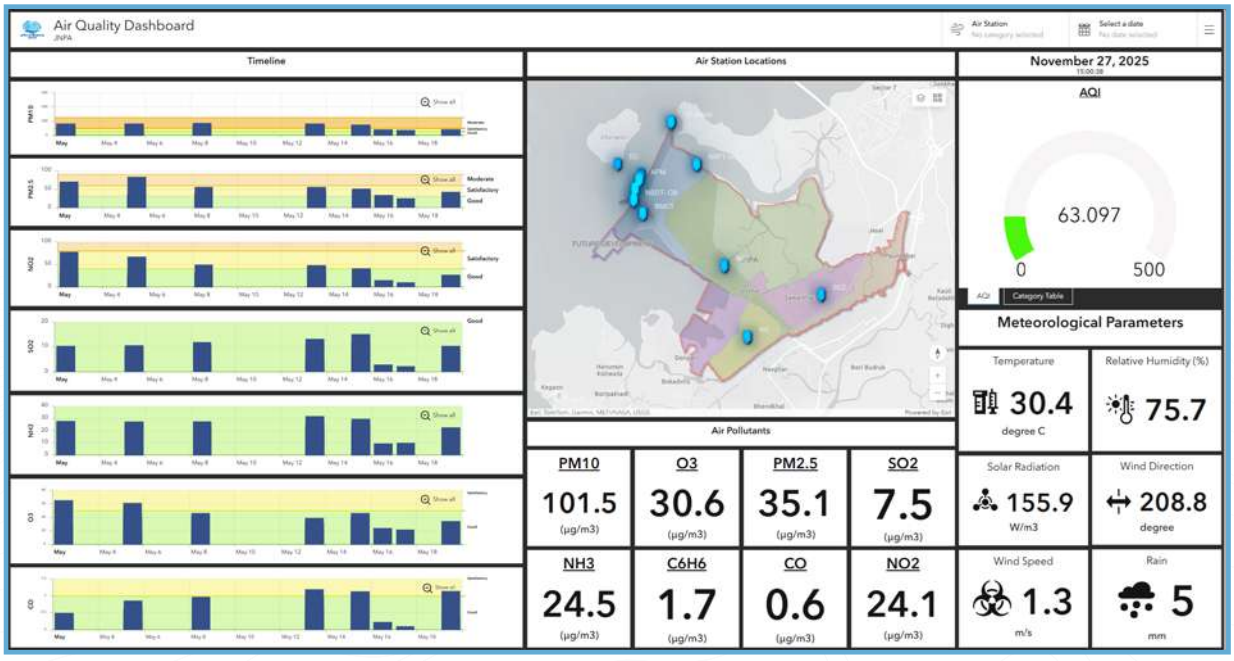
Daily Berthing Dashboard

e. Significant cost savings by reducing redundant field visits and enabling quicker, data-driven decisions.

f. High data accuracy, reducing inconsistencies in asset records and improving accountability across departments.

g. Better inter-departmental collaboration, as all users now refer to a common geospatial platform.

Encroachment Detection Dashboard



Air Quality Dashboard

> At JNPA, GIS has become a strategic enabler across all domains—ensuring precise encroachment monitoring, efficient asset and electrical infrastructure management, smart SEZ planning, and real-time environmental tracking. By integrating spatial intelligence into our operations, we've enhanced transparency, accelerated decision-making, and set new standards in smart port governance—positioning JNPA as a benchmark for operational excellence and sustainable growth.
>
> - **Shri Unmesh Sharad Wagh, Deputy Chairperson, JNPA**

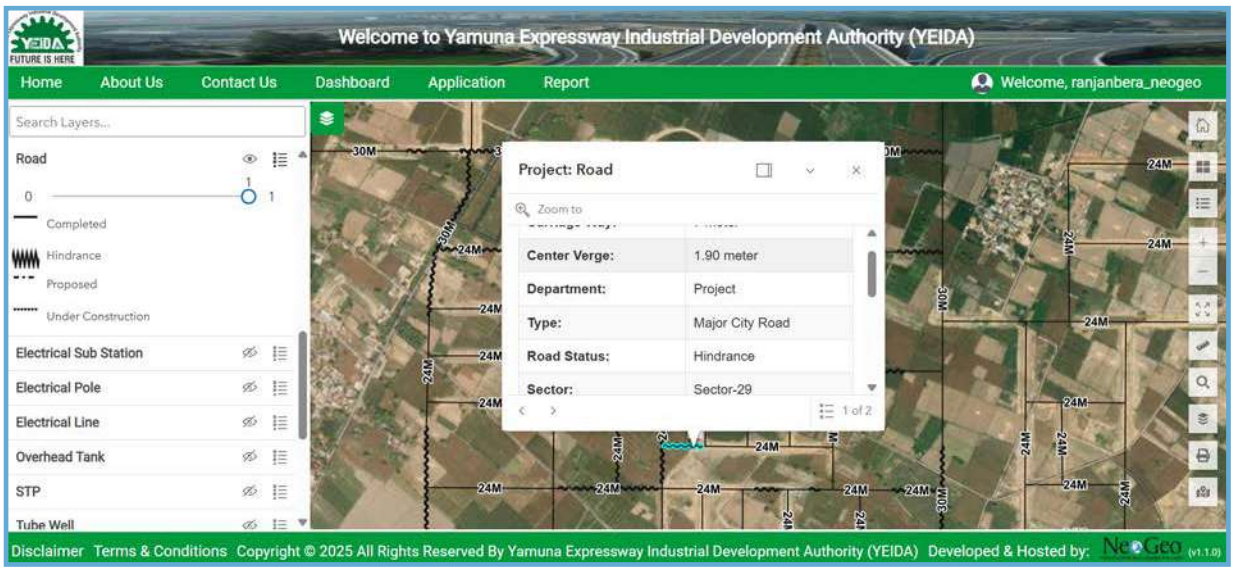
Esri India and NeoGeoInfo Technologies Collaborate to Create A Unified Digital Platform for YEIDA

Esri India and NeoGeoInfo Technologies collaborated to create **OneMap Geoportal**, which is the **Yamuna Expressway Industrial Development Authority's (YEIDA)** unified digital platform, used for managing, analyzing, and visualizing geospatial data. The portal brings together data from multiple departments into a single, intelligent, map-based system, enabling real-time decision-making, improved planning, and seamless coordination across government functions. **It serves as a foundation of smart governance.**

Objectives

The objectives of developing OneMap Geoportal for YEIDA were:

- Integrating all the GIS efforts undertaken by YEIDA and creating a single window GIS system. The system integrates master plans, zonal plans, land bank data, and cadastral data, all of which are available in various formats.
- Providing a common repository for satellite images and drone data, which different agencies are using from time to time.
- Creating user-based logins for different departments in GIS for Enterprise GIS use.
- Creating workflows for single-point GIS data collection and consolidation of the data from all departments in one place.
- Creating Decision Support Dashboards for executive decision making.
- Providing a GIS map-based interface to offer the details of all existing land allottees, a list of vacant plots, directions, measurement of plots, a list of landmarks, and details of YEIDA's urban services.



Asset Inventory: Information about Road Networks

Technologies Used

The YEIDA OneMap Geoportal is structured as a modular, scalable, and service-oriented architecture, integrating various GIS and non-GIS data sources into a unified digital platform. It is a hybrid GIS system operating in a local environment, securely connected to the ArcGIS Enterprise infrastructure.

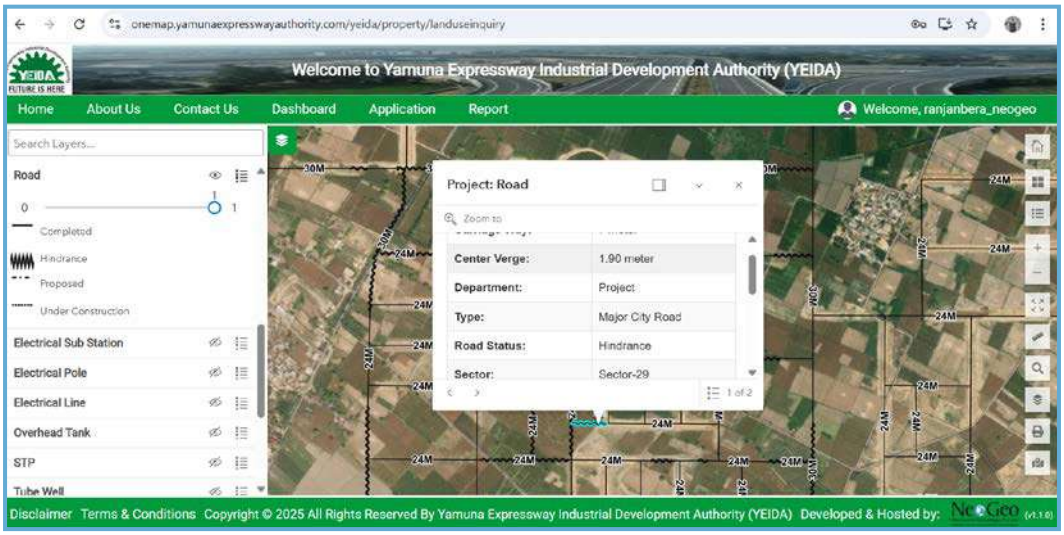
The technologies used are:

- Cloud-hosted Enterprise GIS (ArcGIS Enterprise 11.x, Portal, Relational Datastore).
- ArcGIS Pro for data management and advanced spatial analytics.
- High-resolution basemap creation and integration with existing cadastral and sector data.
- Web and mobile applications for departmental use and citizen engagement.
- Dashboards and analytics tools for real-time decision-making.
- APIs for integration with ERP, project monitoring, and external systems.

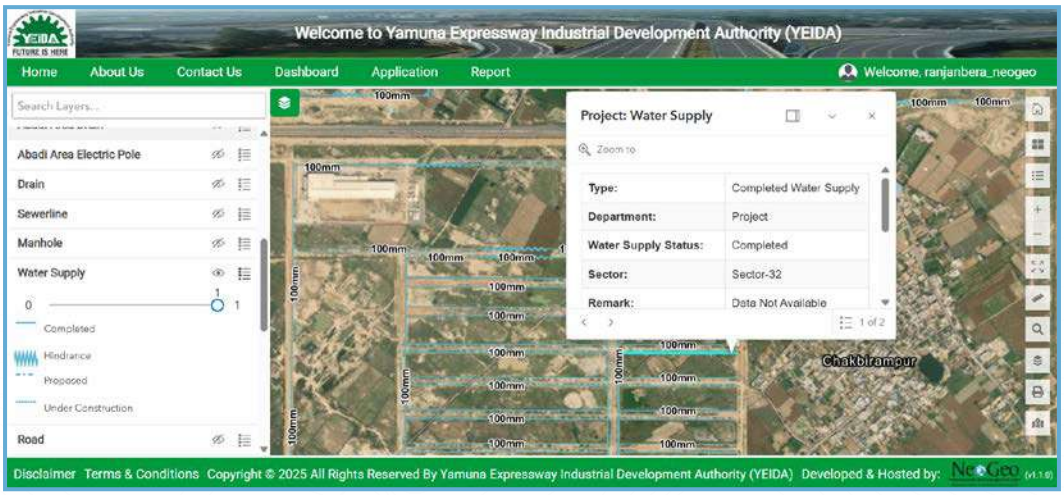
Key Features

The YEIDA One Map Geoportal facilitates:

- **Comprehensive Data Integration:** Infrastructure Mapping, Land Records, Asset Inventory, Urban Planning, Utility Networks, and more.
- **Monitoring & Analysis:** Encroachment Identification, Departmental Workflows, Collaboration Tools, Change Management, and more.
- **Citizen Engagement:** Data Transparency, Citizen Feedback Mechanisms, Grievance Management, and more.



Asset Inventory: Information about Sewer Line Networks



Asset Inventory: Information about Water Supply Networks

Change Detection: Agriculture Built-up

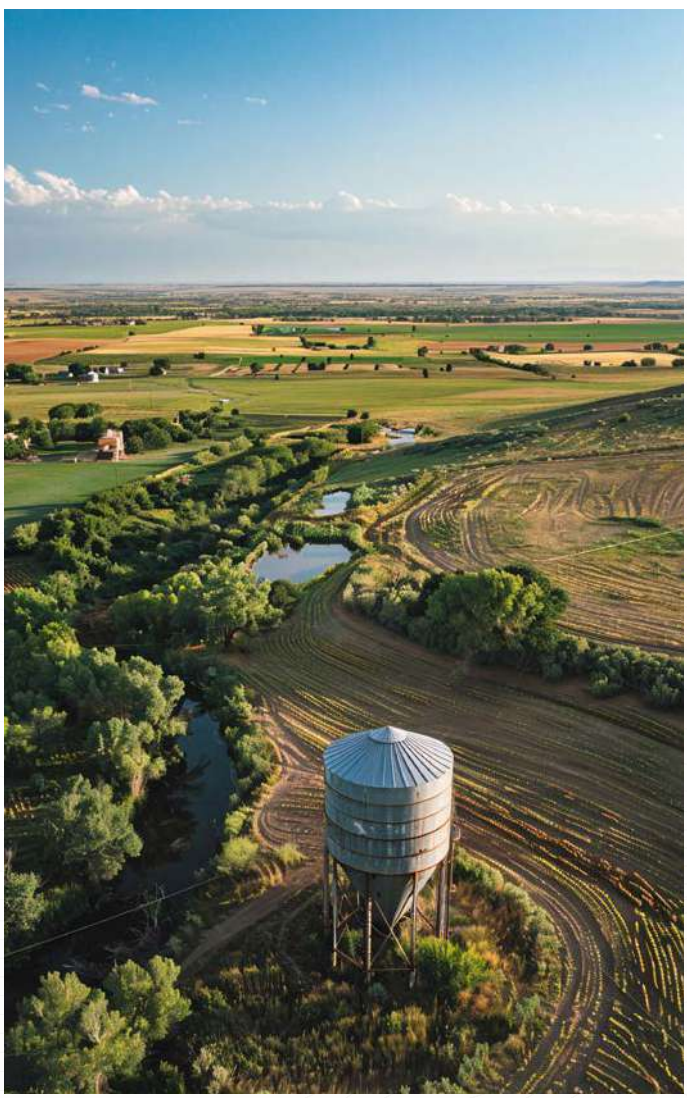
Change Detection: Deforestation

Benefits

With OneMap Geo Portal, YEIDA moves beyond static mapping, delivering intelligent, data-driven insights for smarter, faster, and more transparent e-governance. The YEIDA OneMap Geoportal provides a centralized, interactive platform for accessing and analysing spatial data related to land, infrastructure, and utilities within the region. It enhances transparency, supports informed decision-making, and streamlines planning and development processes for decision-makers, planners, and stakeholders.

Key benefits include:

- Identification of unauthorized land use
- Enhanced data-driven decision-making
- Driving long-term sustainable development
- Optimized delivery of citizen services
- Managing transition and transformation
- Transparent and open data access
- Strengthening departmental collaboration
- Centralized asset inventory management
- Reduced costs



Building Resilient Cities with GIS: Delhi Development Authority

Geographic Information Systems (GIS) play a vital role in modern city planning by providing powerful tools to collect, analyze, and visualize spatial data. Through GIS, planners can map and study various aspects of urban areas such as land use, transportation networks, population density, and environmental features. This spatial analysis helps in making informed decisions about where to build new infrastructure, how to manage resources efficiently, and how to plan for sustainable urban growth.

GIS also supports disaster management by identifying flood-prone or earthquake-sensitive zones, allowing for better risk assessment and mitigation strategies. Moreover, it enables planners to simulate different development scenarios, evaluate their impacts, and communicate plans effectively through visual maps and models.

Through an interaction with **Mr. Durganand Minz, Dy. Director/ GIS In-Charge, Delhi Development Authority (DDA)**, we explore how GIS enhances the accuracy, efficiency, and transparency of city planning, leading to smarter, more sustainable, and well-organized urban development.

How important is it to use technology in city planning?

Earlier, we used to work with paper maps, but now, with the help of technologies like ArcGIS, a lot of things can be done in city planning. Earlier, the master plans were drafted manually, but we are now using software. When you have to plan a city, you have to think about so many aspects, like population, land cover, transportation, housing, public spaces, etc. While planning a city, you have to forecast how your city will be in the coming 25 years. Technology can help us forecast things in the right way and plan accordingly.

Nowadays, the Government of India has mandated the use of spatial analysis in the development of city plans. In most development authorities, municipal corporations, and urban organizations, the role of planners has been highly effective. If we do not educate our planners in digital spatial planning tools like ArcGIS Enterprise or various modules of ArcGIS, we will not be able to effectively deliver the city or any locality.

Please tell us about your experience working with ArcGIS.

When I joined DDA in 2007, I took on the challenge of handling the city development aspect using ArcGIS. Moving on from ArcGIS Desktop to Indo ArcGIS, we are now using ArcGIS Enterprise for the whole organization. Using ArcGIS, we believe that we will be able to deliver more positive outcomes in the future.

How can the use of AI aid in making city planning, including infrastructure development, better?

AI plays a major role in making decisions from the right perspectives. It offers numerous tools that can be utilized for city planning. AI can predict where and when floods are likely to happen. This helps city planners take action early, such as improving drainage systems or avoiding construction in high-risk areas. On the land use side, AI can look at population trends, transportation networks, and environmental factors to suggest the best ways to use the available space. It can help determine where to build housing, parks, or roads while ensuring the city grows sustainably. AI gives planners powerful insights so cities can be safer, more efficient, and better prepared for future challenges.

The integration of GIS and AI transforms city planning and drives sustainable urban development. By combining GIS's spatial data analysis capabilities with AI's predictive and decision-making power, planners can better understand complex urban systems and make more informed, data-driven choices. Together, GIS and AI enable cities to plan more intelligently, minimize environmental impact, and create resilient, sustainable communities that balance development with ecological preservation.

ArcGIS - The Backbone of Digital Twins

Digital twins create a representation of both natural and built environments, allowing stakeholders to monitor current performance while also exploring and predicting future outcomes. The advantages of digital twins significantly increase when GIS data is incorporated. This integration enhances visualization and analytical capabilities, enabling users to gain valuable insights into various scenarios and their potential impacts. Improved access to data facilitates faster decision-making and boosts workflow efficiency.

Digital Twin Life Cycle

An integrated digital twin enabled through a modern GIS is not one single solution or product—rather, it is an ecosystem of capabilities and applications being bought together by GIS to support holistic and collaborative approaches. It is not one digital twin but rather many digital twins that are integrated and interconnected.

Below are the four elements for managing the information lifecycle for a digital twin:

Data capture and integration are foundational to a digital twin. Organizations need comprehensive, end-to-end data management. They need to capture the data, model it, integrate it, and then manage it and its associated attributes and behaviors throughout its lifecycle.

Real-time and visualizations bring the data to life, taking information and creating a better understanding of what is happening now. Sensor technology enables real-time situational awareness combined with advanced visualization capabilities to virtually represent how the physical components are operating in the real world.

Analyze and predict to move decision-making beyond just understanding the current operational state. Organizations must understand the past and view predictions of the future. They need to simulate and forecast expected outcomes as well as automate the decision-making process.

Sharing and collaboration are enabled via desktop and mobile devices for both internal and external stakeholders. Digital twins are about collaboration, sharing information, and getting it to those who need it, when they need it.

Esri's ArcGIS enhances data capture and integration, enables better real-time visualization, provides advanced analysis and automation of future predictions, and allows for information sharing and collaboration.

The Five Levels of Digital Twins

Digital twins can be classified into five levels of sophistication, ranging from basic data integration to fully autonomous operation.

Level 1: Descriptive Twin

The descriptive twin serves as a live, editable representation of design and construction data, providing a visual replica of a built asset. Users can choose the information to include and the data to extract, effectively creating a virtual model of physical assets or networks.

Level 2: Informative Twin

Building on the descriptive twin, the informative twin incorporates operational and sensory data. It aggregates and verifies data from various sources, ensuring that systems work together seamlessly and in real-time.

Level 3: Predictive Twin

At this level, the predictive twin leverages operational data to generate insights and forecast outcomes, enhancing decision-making capabilities.

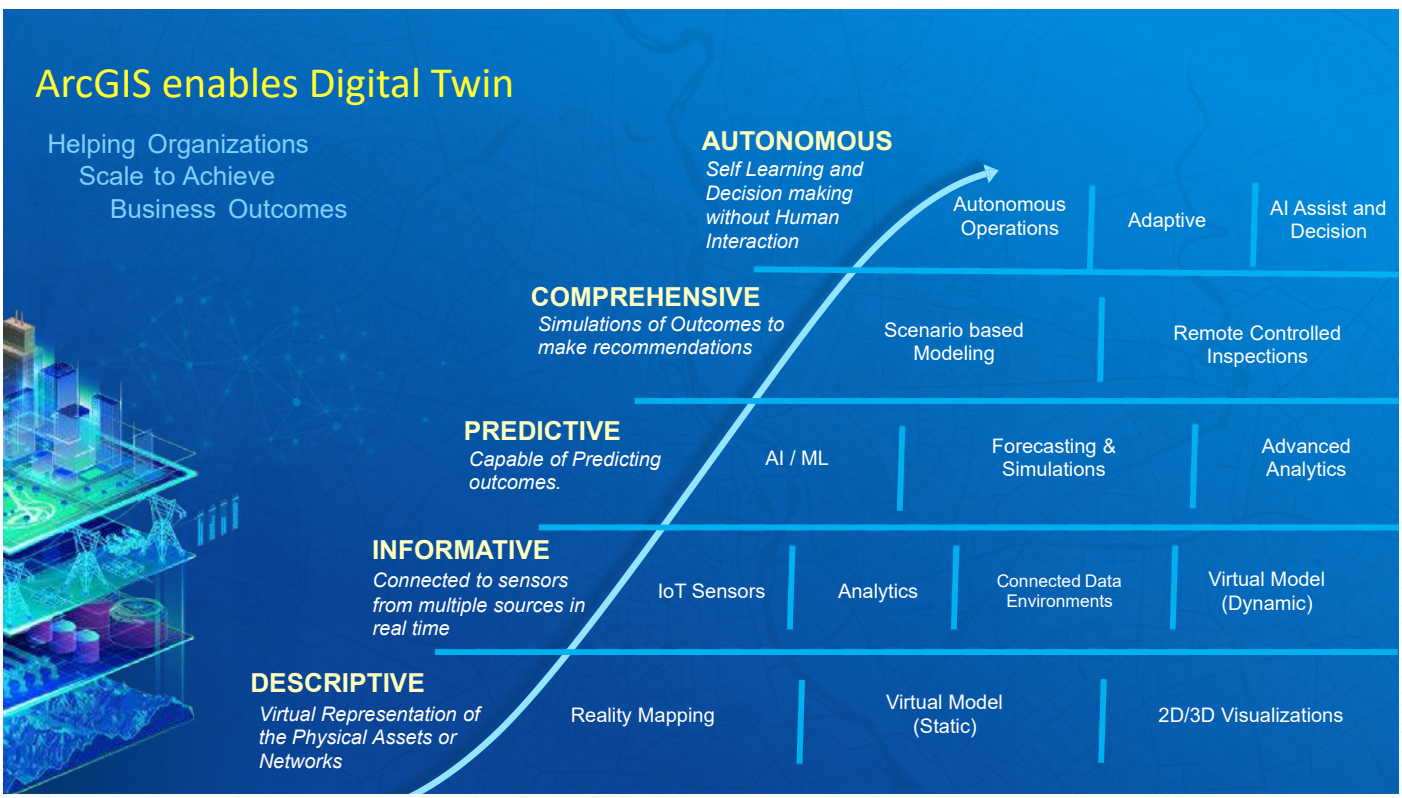
Level 4: Comprehensive Twin

The comprehensive twin takes it a step further by simulating future scenarios and exploring "what-if" questions. It provides outcome simulations that inform recommendations.

Level 5: Autonomous Twin

The most advanced level, the autonomous twin, can learn and act independently on behalf of users. It features self-learning capabilities and can make decisions without human intervention.

ArcGIS uniquely integrates many types of digital models and provides end-to-end capabilities to support a digital twin. It serves as the foundation for digital twins.



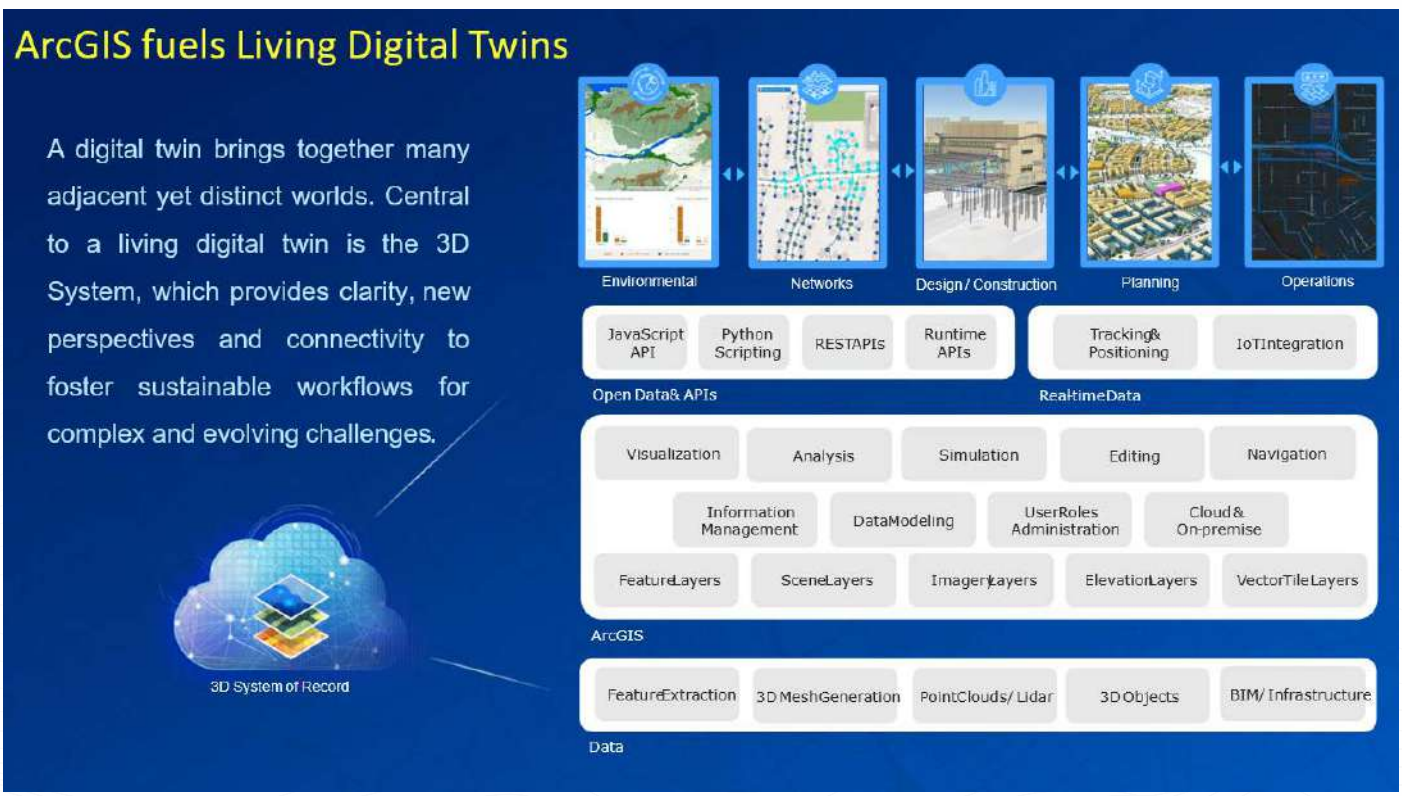
ArcGIS Fuels Living Digital Twins

A digital twin brings together many adjacent yet distinct worlds. Central to a living digital twin is the 3D System, which provides clarity, new perspectives, and connectivity to foster sustainable workflows for complex and evolving challenges. What makes ArcGIS unique is that it integrates and connects all these different types of information models and digital twins. ArcGIS allows users to go beyond using very detailed building information models of structure interiors, to see the buildings' relationships to networks and see all this in context next to the larger city views.

Geospatial digital twins, developed with ArcGIS, can be accessed on mobile devices, web browsers, or through advanced desktop applications from Esri and its partners. Additionally, GIS data drives numerous simulations that reflect real-world dynamics and behaviors. For straightforward analyses, such as assessing shadow impacts on proposed structures, 3D GIS offers intuitive, interactive experiences directly in web browsers. For more intricate analyses, advanced geoprocessing workflows can simulate changes in extensive utility networks, displaying results in user-friendly dashboards.

For decades, ArcGIS has been essential in helping clients to model, analyze, and monitor their assets and systems. Emerging technologies like game engines and real-time data feeds introduce exciting opportunities for creating more interactive experiences, allowing users to explore and analyze their assets and surroundings.

Esri is making substantial investments in reality capture, building information modeling (BIM) integration, building systems integration, and the analysis of Internet of Things (IoT) data. These advancements will play a crucial role in developing the next generation of digital twins with ArcGIS.



Conclusion

The emergence of Industry 4.0 and IoT has accelerated the adoption of the digital twin technology across industries. Currently, the digital twin technology meets the requirements of various users in government as well as private sectors like telecommunications, utilities, etc. Players in the automotive, aerospace, and defense industries appear to be more advanced in their use of digital twins today, while logistics, infrastructure, and energy players are gearing up to follow suit soon. Organizations across verticals are increasingly exploring ways to deploy digital twins in a variety of ways, including in operations, city planning, smart infrastructure, and much more.

GIS technology has a very important role in advancing the idea of creating digital twins for the infrastructure sector in the country. Any digital twin of a fixed asset or real-world system benefits directly from including GIS data about the asset or system and its geographic context. Not only can GIS be used to create digital twins of natural and built environments, but it also can be used to integrate many different digital representations of the real world.

ArcGIS is foundational for any digital twin. It connects different types of data and systems to create a single view that can be accessed throughout the complete project life cycle. ArcGIS enhances data capture and integration, enables better real-time visualization, provides advanced analysis and automation of future predictions, and allows for information sharing and collaboration. There is an array of GIS products that may be utilized for Digital Twin, including ArcGIS Enterprise for integrating drone and LIDAR outputs, GeoBIM, Indoors, UNM and Geoevent Server, and ArcGIS Urban.

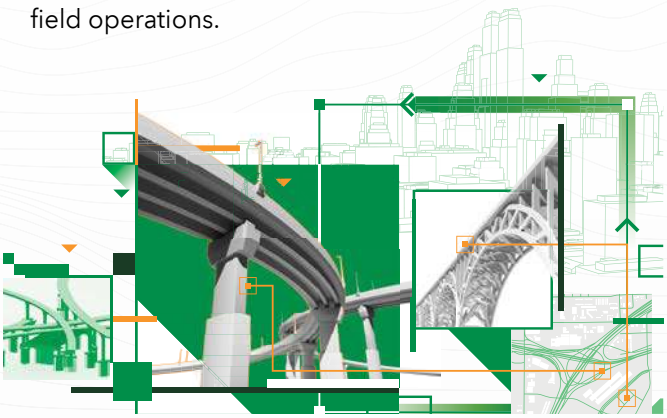
ArcGIS GeoBIM

Connecting projects in context

ArcGIS GeoBIM is a solution for exploring building information modeling (BIM) models, engineering documents, and project management issues in a geographic context to analyze risks, costs, and timelines. ArcGIS GeoBIM allows you to integrate and visualize GIS data with engineering documents to make coordinated decisions across project teams.

With ArcGIS GeoBIM, you can do the following:

- Manage data by automatically georeferencing BIM documents, issues, and projects into hosted feature layers.
- Link Autodesk BIM 360 or Autodesk Construction Cloud data to features in ArcGIS web maps and web scenes to help you find detailed BIM and engineering information after locating it in a geographic context.
- Create apps using configurable templates that you can use to query, visualize, locate, and view the location of engineering documents, issues, and projects and to view complete, up-to-date engineering details for one or more projects.
- Collaborate on design coordination, planning across time, and issue management.
- Visualize geographic features and BIM objects side by side to show relative context of the projects.
- Manage issues with dashboards to visualize risk, safety, and performance of issues in one or more BIM projects.
- Integrate ArcGIS GeoBIM with ArcGIS Field Maps for field operations.



The ArcGIS GeoBIM user experience consists of two components: the ArcGIS GeoBIM Project Manager and one or more ArcGIS GeoBIM apps.

ArcGIS GeoBIM Project Manager

The ArcGIS GeoBIM Project Manager allows you to create ArcGIS GeoBIM apps. This is the page that appears after you click the project on the landing page. **There are five components (pages) that you need to create a project in the Project Manager: the Accounts page, the Tools page, the Links page, the Apps page, and the Maps page.**

Tools page

The Tools page has been designed to provide a schematic interaction with the synchronization operations that can be performed by selecting the needed process and choosing the appropriate settings for it. You can get the latest feedback on the operations by refreshing and checking the layers added to the page table.

The panel on the left side allows you to select what tools to run, to apply custom properties for each tool or to perform special GIS analysis for the synchronized data. Each tool card has a settings icon on the lower-right side that will open custom properties and settings that you can apply to the tool.

The Locate Engineering Documents tool allows you to locate CAD and BIM documents on a map and create polygons that show the extent of these models. This tool also allows you to perform and apply an outlier analysis to the synchronized documents. Given the tool complexity and the possibility of having the documents in BIM 360 or Autodesk Construction

Cloud with an incorrectly defined WKID, an invalid one or none, this GIS analysis provides a better understanding of the data by flagging the outliers in the map.

The Locate Issues tool allows you to locate design, engineering, and construction issues on a map based on engineering document locations and project addresses. Similar to the Locate Engineering Documents tool, the settings button allows you to use the project address to force synchronization and to add a default WKID to be used inside the tool.

The Create BIM Project Boundaries tool allows you to create BIM project boundaries on a map based on document and issue locations. This tool requires engineering documents data to be already available, so even if this tool is run in isolation, the engineering documents are synchronized or updated as a prerequisite. Synchronizing the Issues data is optional for this tool to run but recommended and preferred because the output will supply a general view of the geographical context of the entire BIM project and the number of engineering documents and issues belonging to it. The settings button for this tool allows you to select one or more output shapes for the boundary of the BIM project.

Links page

The Links page allows you to add data (web map or web scene) and link BIM 360 or Autodesk Construction Cloud projects to layers and features in the map. The Links page can be accessed by all users but can only be modified by a user with an ArcGIS Online Creator account.

Apps page

The Apps page displays and stores all the apps that you create. Creators can view, edit, and delete apps on this page. ArcGIS GeoBIM has two types of apps: the viewer app and the issues dashboard app.

Maps page

The Maps page displays and stores all web maps associated with an ArcGIS GeoBIM project. After you configure and save an app using the App Editor, the web maps selected for the app are displayed on the Maps page. The Maps page is used to enable ArcGIS Field Maps integration in the ArcGIS GeoBIM project.

ArcGIS GeoBIM app

The ArcGIS GeoBIM app connects web maps, web scenes, and georeferenced BIM 360 project data. **The ArcGIS GeoBIM app consists of these elements: the Map widget, the Link Explorer, the Table widget, the Elevation Profile widget, the Editor, and the Details group.**

The **Map widget** is located at the top of the project. It is where your project's web map or web scene appears.

The **Link Explorer** is located in the Explorer group, and it allows you to link more documents to the features in the Map widget.

The **Table widget** is located in the Explorer group. The Table widget has these elements: the Documents table, Issues table, Schedules table, Notes tables (Location, Line and Area notes) and BIM Projects table. The Documents table contains the list of documents (models) in the web map or web scene.

The **Elevation profile widget** is located in the Explorer group. The Elevation Profile widget generates and displays an elevation profile for any line in a web map or web scene.

The **Editor** is located in the Explorer group. The Editor is used to add custom Note features or edit the geometries of features within the project layers of an ArcGIS GeoBIM app.

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ArcGIS Indoors

Beyond the Blueprint

ArcGIS Indoors enables your organization to build an indoor Geographic Information System (GIS) and put the power of indoor mapping, wayfinding, and space management software into everyone's hands. With three license levels available, ArcGIS Indoors Pro, Indoors Maps, and Indoors Spaces, your organization can consolidate your asset and space information into a single place, the indoor map, and provide easily accessible web and mobile apps, for location discovery, wayfinding, room reservations, and space planning. It allows organizations to create and curate indoor maps by using data from sources like BIM, CAD, and other formats. It provides tools to maintain up-to-date floor plans and manage indoor data hierarchically.

How to maximize your ArcGIS Indoors experience:

1. It is necessary to ensure that the quality of your input CAD drawings (DWG, RVT, IFC) is good. Ensure that the layers are clean, and key features like walls, doors, rooms, and assets are distinct. A consistent and standardized naming convention makes geoprocessing much smoother.

2. ArcGIS Indoors uses a specific geodatabase schema. Use the Create Indoor Dataset tool in ArcGIS Pro to generate an empty geodatabase with the schema to help visualize the structure.

3. Use the Populate Indoors Database to refine your data.

4. Simplify the floor plan by filtering or removing any text or overlap in the data during the import or initial processing steps.

5. Ensure your Units (rooms, offices) and Details (assets, equipment) have accurate centroid locations, especially for irregular-shaped rooms.

6. Use ArcGIS Pro's network dataset tools to identify and fix disconnected edges or nodes.

7. Always use the latest version of the add-in, as Esri frequently updates it with new features and bug fixes.

8. Publish your Indoors data as tiled map services (vector tiles for base maps, cached image services for large imagery) to improve loading times.

9. Limit the number of layers visible at different zoom levels to keep the map clean and fast.

10. Define custom categories and think about what users will search for and navigate to.

11. A visually appealing and accurate indoor base map is crucial. Ensure floor plan symbology is easy to understand. Use distinct colors for different types of rooms or zones.

12. Customize the web viewer's look to match the organization's branding and utilize QR codes at key locations (e.g., building entrances, asset tags) that link directly to the Indoors app and zoom to that location.

13. Test data accuracy, routing, search functionality, and performance on various devices and browsers.

ArcGIS Urban

Urban planners engage at many levels of an infrastructure project: from detailed site plans to long-term strategies. The latest ArcGIS Urban release has something to offer for planners at every level.

- Do you use ArcGIS Urban primarily for site plan management? You can now upload and accurately position 2D site plan blueprints directly in your project scenarios. This helps you bring proposals efficiently into spatial context.

- Do you need a way to keep stakeholders focused on what is most relevant? You can now set which project scenario is visible by default in the overview and plans, helping to highlight active proposals and ensuring stakeholders see the latest information.

- Are you working on long-range planning itself? Then you'll appreciate that metrics can now be copied between plans and urban models, and that your spatial analyses can now be saved and managed in the new analysis mode in the plan editor.

Unlock the full value of site blueprints

Reviewing site plan proposals based on 2D blueprints is a reality for many urban planners. These static documents provide a wealth of information about a proposed development, including building dimensions, parking spaces, and green area arrangements. But applying that information while working in 3D is often clunky and disjointed.

With this release, you can now upload images of 2D site plans directly into your project scenarios, position them accurately on the map, and place the proposal in its real-world context.

This is especially useful when 3D building models aren't available yet, but you still need to assess the visual and spatial impact of a development. Using the uploaded image as a base, you can easily sketch out a simple, low-level of detail building, giving a clear and immediate sense of scale, massing, and fit within the surroundings. What's more, if you receive a revised version of the blueprint, uploading it won't disrupt your work. The new version will line up with the original, so there's no need to reposition.

View project scenarios in context

Beyond simply viewing 3D volumes on a map, planners also need to know how a proposal interacts with existing buildings, infrastructure, and nearby developments, whether already built, in progress, or part of long-term planning efforts.

With ArcGIS Urban's July 2025 release, you can now choose which project scenario is shown in the overview. The configured project scenario is also visible in the plan editor if the project is within the plan's study area.This helps reveal important relationships early and supports a more integrated, future-aware planning process.

Copy and paste metrics

The metrics in ArcGIS Urban allow you to analyze the impact of developments in quantitative terms. Since the December 2024 release, configuring sophisticated metric calculations has been easier than ever. But there was one piece missing: Reusing your carefully configured metrics in a different context wasn't straightforward. That changes with this release.

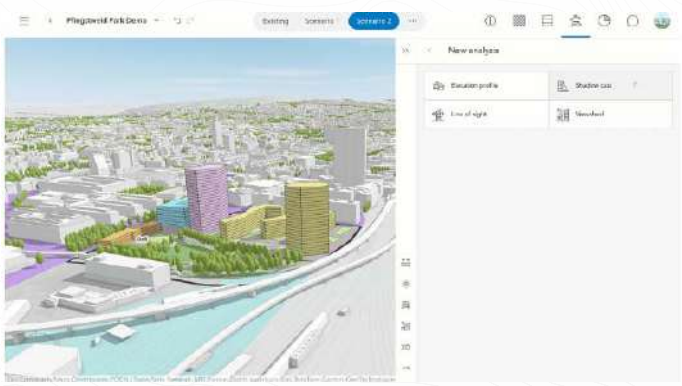
Whether you created metrics in a plan and want to use them across your entire urban model, or you've set up dedicated metrics in a plan to calculate the construction costs and want to use them in a new plan, you can now copy and paste metrics across plans and even between urban models. This allows you to create metrics once and reuse them multiple times.

When pasting metrics, a dialog helps you map the space-use types used in the copied metrics calculation to the space-use types in the target plan or urban model. This ensures that the space-use type parameters used for the calculation get associated correctly in the target plan or urban model.

Reveal spatial insights

Understanding the impact of a proposed development isn't just about metrics. It's also about how it fits into its spatial context: Does a proposed building cast shadows onto neighboring spaces? Does it interfere with protected view corridors? Can someone on a future balcony see the nearby water body they were promised?

With this release, a dedicated analysis mode in the plan editor has been introduced to help answer those questions. The new mode consolidates familiar tools, like shadow cast, elevation profile, line of sight, and viewshed, into one convenient location. You can now save and manage your analyses with a persisted list. This makes it easy to revisit, refine, and share them with collaborators directly within the plan.



What else is new?

Discussions

Collaboration is at the heart of urban planning, bringing together planners, architects, developers, and other stakeholders. To support this, the July 2025 release introduces a redesigned experience for discussions with a new concept called channels. Channels let you manage who can join each discussion, making it easier to have focused conversations with the intended audience at each planning stage.

Urban API updates

In this release, the Urban API also allows you to programmatically define which project scenario should be displayed in the overview. In addition, when creating a shadow cast analysis, there is a new input field that allows you to configure the time interval for individual discrete shadows displayed as context.

School of Planning and Architecture, Delhi: Fostering Sustainable Design Thinking through GIS-integrated Education

Integrating GIS education into architecture and planning programs is essential for preparing students to address complex spatial challenges in contemporary built environments. Through an interaction with **Dr. Prafulla Parlewar, Head and Professor of the Department of Urban Planning at the School of Planning and Architecture (SPA), New Delhi**, let's explore how GIS education enables future architects and planners to make more informed and data-driven decisions.

How is SPA Delhi currently integrating GIS and geospatial technologies into its teaching, research, and capacity-building initiatives?

At the School of Planning and Architecture (SPA), Delhi, we have made it a priority to integrate GIS and geospatial technologies into the core of our academic framework. The integration of these tools within the curriculum across our various departments is a key focus for us. Students gain practical experience in our studios and various established centres, including the Centre for Analysis and Systems Studies (CASS), which encompasses the Centre for Remote Sensing and the Centre for Excellence in Urban Planning and Design. They work with industry-standard software such as ArcGIS.

In the realm of research, it is evident that both faculty members and scholars are leveraging these technologies to a significant extent. They utilize them for modeling intricate urban and regional challenges, as well as for conducting thorough data analysis. This work frequently involves the integration of AI and machine learning, resulting in innovative applications across various domains such as deep learning, digital twins, and advanced simulations. We conduct regular capacity-building workshops aimed at our students, faculty, and external professionals to ensure they remain informed about the latest advancements in the field.

How important is industry collaboration, like with Esri India, for strengthening the professional readiness of students?

We aim to establish a collaborative environment that benefits both the industry and our students. This involves providing the industry with a steady flow of talent while offering our students a practical platform to apply and refine their skills in real-world scenarios. This exposure allows our students to cultivate skills that extend beyond mere technical proficiency. They demonstrate a unique ability to think strategically. Graduates from SPA Delhi emerge not merely as analysts, but as future leaders and urban strategists. They are equipped to take charge in any setting, tackle challenges that others might consider insurmountable, and spearhead the integration of technology within the country's most prominent organizations.

How do you see the role of architecture and planning education contributing to sustainable infrastructure development in India?

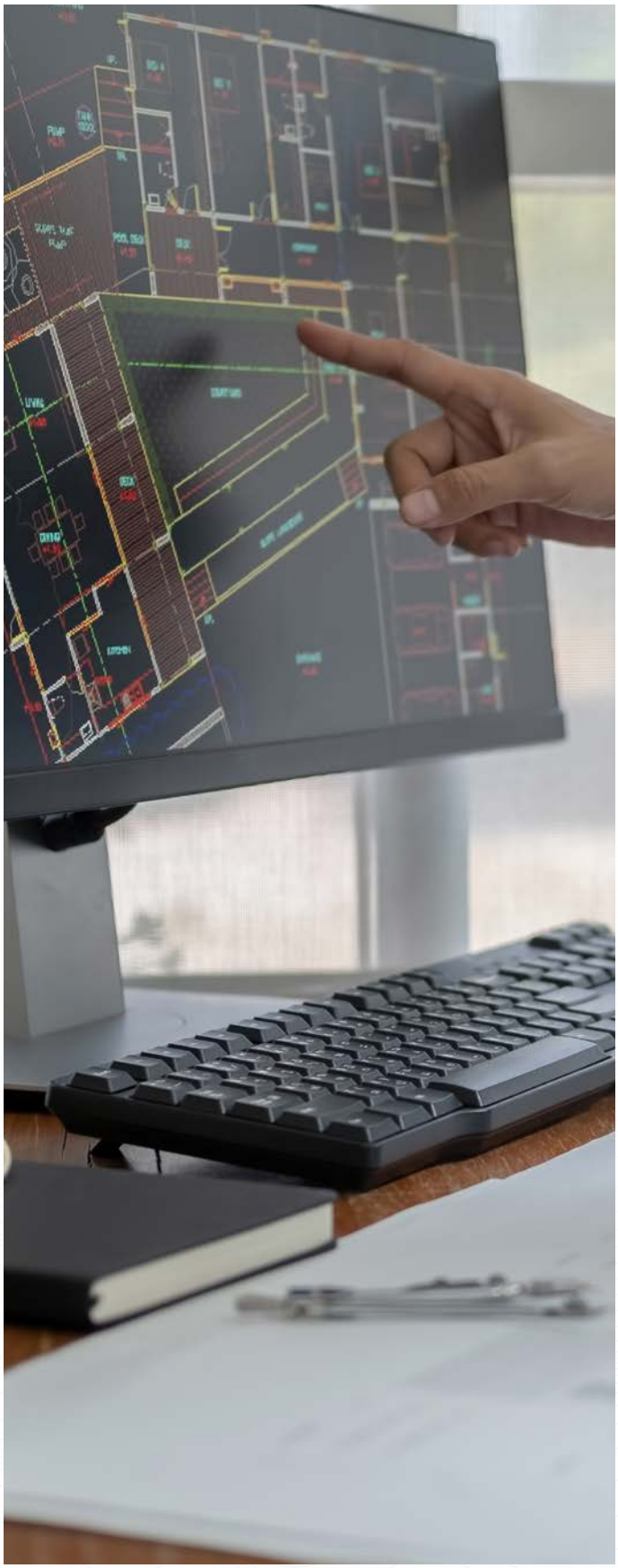
Our institute views its role as crucial in fostering a sustainable future for cities in India. We take this responsibility very seriously and are committed to executing it with the utmost effectiveness. We are deeply committed to addressing

critical urban challenges, such as unplanned growth and environmental stress, through our educational philosophy. Our focus extends beyond merely producing architects and planners; we are dedicated to nurturing the visionaries who will address and resolve India's most urgent urban challenges. Our curriculum aims to develop professionals who adopt a holistic approach, seamlessly integrating infrastructure development while tackling challenges related to environmental, social, and economic factors. Our objective is to cultivate a generation equipped to design and oversee the sustainable, equitable, and resilient cities of the future. Our alumni have not only entered the field but are also at the forefront, occupying significant roles in both government and industry and actively shaping the future of urban development in India.

How do you envision GIS and technologies like AI shaping the future of urban design?

The integration of GIS, AI, and a focus on human-centric design, in my view, clearly shapes the future of urbanism. This convergence presents exciting opportunities for creating more efficient and livable urban environments. We are on the brink of a transformative phase in data-driven planning. AI-powered analytics will significantly improve our comprehension of urban dynamics. For many years, the approach to planning has relied on inflexible and unchanging blueprints, which tend to lose their relevance quite rapidly. Our institute is at the forefront of transforming the traditional model into something more innovative and relevant. In our studios and research, we approach the city as a dynamic and adaptive system rather than a static entity to be illustrated.

In today's evolving landscape, we see a significant need for a new type of professional, one who embodies the qualities of both a planner and a technologist. Our focus is on developing a hybrid professional who possesses a strong command of both Python and machine learning algorithms, alongside a profound understanding of planning theory and public policy. Our curriculum is designed to equip students with the skills to build predictive models for urban growth, utilize AI to optimize infrastructure, and apply generative design not only for aesthetic purposes but also for addressing complex social challenges. These individuals go beyond merely utilizing technology; they are the visionaries shaping the future of planning tools.



AI-ENABLED URBAN INFRASTRUCTURE MANAGEMENT

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Abstract

The rapid growth of urban population globally has intensified the demand for highly efficient, disaster risk resilient as well as cost-effective infrastructure (transportation systems, water supply, sewerage, drainage, solid waste management, power supply). The failure of urban planning in India lies in the lack of democratic participation, our cities developing at a faster rate than calculated by planners as well as a top-down approach for planning.

This research examines the combined use of GIS with Artificial Intelligence and the Internet of Things as refined products of Big Data, in revolutionizing urban infrastructure monitoring and management, resulting in the sustainable, resilient, cost-effective and efficient infrastructure that is required for present and future generations, in essence transitioning from reactive to proactive planning.

The research will delve into first understanding the status quo of existing physical infrastructure – transportation network, water supply, sewerage, drainage, solid waste management and power supply – in terms of quantitative and quantified qualitative data, as well as data from primary and secondary surveys, interviews, policy analysis and digital twin modelling.

Key applications such as intelligent traffic management, predictive maintenance of critical assets, and optimized resource allocation are examined in detail. While highlighting the significant benefits, the thesis also addresses the inherent challenges, including concerns related to data privacy, algorithmic bias, implementation costs, and the need for robust technical infrastructure. The analysis concludes by identifying critical research gaps and outlining future directions, emphasizing the necessity for a balanced, ethical, and human-centric approach to developing truly smart, resilient, and sustainable urban environments.

Introduction

As the world grapples with the complex challenges posed by urbanization, climate change, and resource depletion, the imperative for sustainable infrastructure development has never been more pressing. In this context, the integration of Artificial Intelligence (AI) technologies offers unprecedented opportunities to revolutionize the planning, design, construction, and management of infrastructure systems The challenges of rapid urbanization in India are multifaceted as well as interconnected, causing a domino effect on the urban services and utility networks, thus necessitating the demand for highly efficient, multi-hazard resilient, cost-effective infrastructure. (Balasubramanian, S., 2024).

In the context of India, the failure of traditional urban planning often stems from a lack of democratic participation and a prevalent top-down approach, resulting in cities developing at a pace and in patterns that outstrip conventional planning capabilities (Ananya Roy, 2009). This leads to critical issues such as economic disparities, social inequality and exclusion, environmental degradation, overcrowding, housing shortages, and an overwhelming strain on existing infrastructure.

This paper examines the transformative potential of integrating Artificial Intelligence (AI), Geographic Information Systems (GIS), and the Internet of Things (IoT) – collectively, refined products of Big Data – to revolutionize urban infrastructure monitoring and management.

AI-enabled urban infrastructure monitoring uses AI technologies like machine learning and computer vision to design, manage, and optimize city systems, thus integrating diverse data from traffic, waste, energy, water, and safety networks (Setyadi and Jaya, 2025). In addition, AI-driven predictive analytics models have enabled early warning systems for earthquakes, floods and wildfires, facilitating proactive disaster preparedness and risk mitigation. (Bajwa, 2025). Integrating these with an AI-enabled monitoring system promises to transition urban planning from reactive problem-solving to proactive, preventative strategies, fostering truly sustainable, resilient, cost-effective, and efficient infrastructure required for present and future generations (Rad, A. M. et. al., 2025).

The research outlines the effective integration of Geo-Informatics with AI and IoT technologies, explores key methodologies for developing predictive infrastructure models, and investigates their contribution to multi-hazard resilience. It also critically addresses the ethical considerations associated with deploying AI for urban infrastructure, including data privacy, algorithmic bias, and equitable access to benefits.

Literature Review

The integration of geospatial analytics and Internet of Things (IoT)-based sensor networks has transformed hazard detection, risk assessment, and disaster preparedness across multiple domains (Park et al., 2023). Studies have shown that AI-enhanced seismic monitoring systems, when integrated with GIS-based hazard modelling, improve the precision of earthquake prediction and post-event damage assessment (Malik et al., 2023). Artificial Intelligence (AI) is therefore becoming increasingly indispensable in infrastructure development and management, revolutionizing traditional approaches and enhancing efficiency, sustainability, and resilience.

Thus, Artificial Intelligence is pivotal for Predictive Maintenance, Asset Performance Monitoring, Demand Management and Optimization, and Infrastructure Resilience and Risk Management (Balasubramanian, 2024).

Several studies have examined AI applications in various emergency response domains, including natural disaster management, traffic incident detection, healthcare emergency response, industrial hazard prevention, and cybersecurity (Jiang et al., 2020).

AI Technique	Description	Key Applications in Urban Infrastructure Monitoring
Machine Learning	Algorithms learn from data to identify patterns and make predictions.	Predictive maintenance (roads, bridges), traffic management, energy optimization, waste management, public safety, urban planning, environmental monitoring.

Deep Learning	Uses neural networks with multiple layers to learn complex patterns from large datasets.	Structural health monitoring (crack detection, rebar exposure, welding defects), advanced image-based surveillance, complex pattern recognition in traffic data.
Computer Vision	Enables computers to "see" and interpret visual data from images and videos.	Infrastructure inspection (damage detection), public safety/surveillance (anomaly detection, facial recognition), traffic flow analysis.
Natural Language Processing	Allows computers to understand, interpret, and generate human language.	Citizen engagement (chatbots for queries), analysis of public records/ reports (less direct monitoring).
Predictive Analytics	Uses statistical algorithms and machine learning to forecast future outcomes based on historical data.	Predicting infrastructure failures, forecasting traffic congestion, anticipating resource demands (energy, water, waste), proactive health crisis intervention.

Table 1: Prevalent Models and Applications in Urban Infrastructure Monitoring

ML Type	**How it Works**	**Prevalent Models (Examples)**	**Smart City Sub-Areas of Application**
Supervised Learning	Trained on labeled datasets with input-output pairs to learn patterns.	Neural Networks, Support Vector Machines (SVM), Naive Bayes, Long Short-Term Memory (LSTM), ResNet, XAI.	Transportation, Health, Environmental, Governance, Agriculture, Energy, Waste Management, Security, Water Management, Homes, Smart Grid.
Unsupervised Learning	Explores unlabeled data to discover hidden connections or patterns without explicit instructions.	Fuzzy Logic, K-Means, Clustering algorithms.	Grouping similar data points for pattern recognition (e.g., urban clusters), dimensionality reduction.
Reinforcement Learning	Agents learn to make decisions by interacting with an environment and receiving feedback (rewards/penalties).	Ant Colony Optimization, Particle Swarm Optimization, Artificial Bee Colony.	Sequential decision-making tasks like optimizing traffic flow, robotics, autonomous systems, game playing.

Table 2: Prevalent Machine Learning models and Applicability

Infrastructure Domain	Key Sensor Technologies (Examples)	Contribution/Monitored Aspect
Traffic Management	GPS, Cameras, LiDAR, Inductive Loop Detectors, Optical/Laser Sensors	Real-time traffic flow, congestion, vehicle speed, pedestrian safety, alternative routes.
Structural Health Monitoring	LiDAR, General Structural Health Sensors (vibration, strain, acoustic), Ultrasonic Sensors	Structural integrity (cracks, material weaknesses, rebar exposure, welding defects), vibrations, predictive maintenance needs.
Water Management	Water Quality Sensors (pH, turbidity, chlorine), Flow Sensors, Leak Detection Sensors	Water quality, distribution efficiency, leak detection, contaminant identification, sustainable water use.
Waste Management	Ultrasonic Sensors, RFID Readers (in smart bins)	Bin fill levels, optimized collection routes, waste volume, recycling processes.
Energy Management	Energy Consumption Sensors, Smart Grid Sensors	Energy distribution, supply-demand balancing, consumption patterns, integration of renewable sources, energy loss.
Environmental Monitoring	CO2, Humidity, Temperature, O3, PM2.5, NO2, SO2, TVOC/VOC Sensors, Microphones/Sonometer, Soil Sensors (light, temp, moisture), LiDAR (drones)	Air quality, noise levels, soil health, deforestation, water pollution, urban heat islands.
Public Safety	IoT-enabled Cameras, Anomaly Detection Sensors, Acoustic Sensors	Suspicious activities, crime hotspots, accident detection, fire detection, emergency response coordination.
Smart Parking	Ferromagnetic Detection, Radar Sensing, Ultrasonic Sensors	Real-time parking availability, guiding drivers to open spots, reducing search time and congestion.

Table 3: Sensor Technologies across Infrastructure Domains

Hazard Type	UDT Application
Floods	Real-time flood prediction models, simulation of inundation scenarios, early warning systems, optimization of stormwater management infrastructure (BGGI).
Extreme Heat/Urban Heat Islands	Modeling temperature variations, simulating impact of green spaces and reflective materials, optimizing urban layouts.
Earthquakes/Structural Failures	Real-time structural health monitoring, predictive analytics for infrastructure integrity, simulation of seismic impacts.
Pollution (Air/Water)	Real-time air and water quality monitoring, predictive analytics for pollution hotspots, simulation of mitigation strategies.
Disaster Response & Recovery	Real-time situational awareness, optimized resource allocation for emergency services, post-disaster damage assessment.

Table 4: Existing Urban Digital Twin Applications for Multi-Hazard Resilience in Indian Cities.

Thus, while the individual applications of GIS, AI, and IoT are well-documented, as per Tables 1,2,3 and 4, their need for a seamless integration into a comprehensive framework for sustainable infrastructure development and management is becoming increasingly apparent (Balasubramanian, 2024), which is the primary objective of this paper.

Proposed Integrated Framework for Urban Infrastructure Management

Our proposed framework offers a robust and adaptive approach to urban infrastructure management, synergistically combining GIS, AI, and IoT within a comprehensive digital twin environment. This multi-layered system is designed to facilitate real-time data collection, intelligent processing, sophisticated spatial visualization, and highly informed, proactive decision-making.

AI-Enabled Data Processing and Predictive Analytics

Raw, heterogeneous IoT data undergoes rigorous processing, including cleaning, normalization, and integration. Subsequently, advanced AI algorithms are applied to derive actionable intelligence.

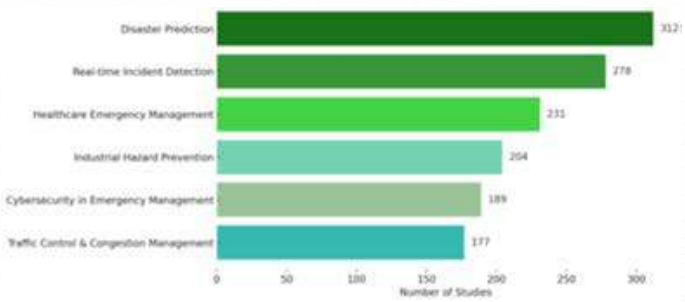

Figure 1: AI Applications in Emergency Management (Source: Bajwa, A., 2025)

Geospatial analytics and IoT-based networks for hazard detection for Spatial Intelligence and Visualization

GIS serves as the principal spatial intelligence platform, providing the critical geographical context for all data and AI-derived insights including:

1. Preparation and maintenance of georeferenced inventory of all urban infrastructure assets.

2. Performing complex spatial analyses, identifying critical infrastructure vulnerabilities, optimizing service routes, analysing urban growth patterns and assessing the spatial impact of various interventions.

The apex of the proposed integrated framework is therefore the creation of a comprehensive Urban Digital Twin (UDT). This dynamic, virtual replica of the physical city enables advanced simulation, detailed analysis, and ultimately, proactive urban planning:

1. **Scenario Simulation:** The digital twin allows for simulating the impact of proposed infrastructure projects (e.g., new road networks, water pipelines), policy changes (e.g., revised zoning regulations), or disaster scenarios (e.g., flood inundation, seismic tremors). This facilitates risk assessment and optimization before physical implementation.

2. **Performance Optimization:** Different operational strategies (e.g., optimized traffic light sequences, smart grid energy distribution, disaster response protocols) can be tested and refined in the virtual environment.

3. **Training and Capacity Building:** The digital twin provides a realistic and safe platform for training urban planners, engineers, emergency services, and maintenance crews.

4. **Enhanced Stakeholder Engagement:** Complex urban data and proposed interventions can be visualized in an easily understandable format, fostering greater public consultation, democratic participation, and transparency in urban planning, directly addressing a core identified challenge in Indian urban development.

Application

The integrated AI-GIS-IoT framework yields a multitude of practical applications and tangible benefits, driving significant improvements across urban infrastructure sectors:

1. **Optimized Location-Allocation and Predictive Maintenance of Critical Assets:** Leveraging AI, the

framework forms a matrix of choices for optimized location and route allocation for various utility-type services and predicts failures in infrastructure components before they occur, enabling proactive planning, minimizing costly downtimes, extending asset lifespans, and ensuring continuous service delivery.

2. **Multi-Hazard Resilience:** Crucially, the framework enhances urban resilience against various hazards – Cyclones, Flash Floods and Urban Flooding, Earthquakes and Wildfires, by integrating real-time environmental data with geospatial analysis to support cyclone prediction, flood inundation modelling, seismic risk assessment, and rapid damage assessment post-event. This capability is particularly vital for vulnerable areas, including coastal regions or those susceptible to fluvial and cyclonic events in the global South.

3. **Blue-Green-Grey Infrastructure Integration for Urban Resilience and Sustainability:** The framework supports the planning and monitoring of integrated 'Blue-Green Grey Infrastructure', enabling optimized land use compatibility and environmental management.

Challenges and Considerations

While the transformative potential of an AI-GIS-IoT integrated framework is immense, its successful implementation is contingent upon addressing several critical challenges:

- Data-Related Challenges: Quality, Availability and Integration
- Data Privacy and Security (Balasubramanian, 2024; Khan et. al., 2021)
- Algorithmic Bias and Equitable Access (Khan et. al., 2021)
- Technical Infrastructure and Interoperability (Islam, 2024; Bajwa, A. 2025)
- Time and Data Constraints
- Ethical, Governance and Societal Concerns
- Environmental Footprint and Energy Consumption in using AI

Conclusion

The integration of Artificial Intelligence, GIS, and the Internet of Things offers an indispensable paradigm shift for urban infrastructure management, moving from reactive responses to proactive, predictive, and multi-hazard resilient strategies, resulting in crucial efficiency gains, cost savings and enhanced safety. This framework not only addresses the pressing challenges of rapid urbanization, including economic disparities, environmental degradation, and strained infrastructure, but also quantifies the substantial losses incurred by traditional approaches in India, making a compelling case for immediate adoption. By enabling intelligent traffic management, predictive maintenance, optimized resource allocation, and the strategic integration of 'Blue-Green Grey Infrastructure', this approach promises to yield significant cost reductions, time savings, enhanced quality control, improved risk management, and substantial energy savings. The ability to monitor vulnerable areas and contribute to cyclone prediction and damage mitigation further underscores its critical relevance for global urban resilience.

The contribution of this paper lies in presenting a comprehensive, integrated framework that goes beyond theoretical concepts to highlight tangible applications and outcomes, while also providing a balanced perspective on the associated challenges. It underscores how sophisticated digital twins, powered by AI and enriched with real-time GIS data, can transform urban planning and governance into an ethical, human-centric, and truly sustainable endeavour.

Figure 2: Outcome Mapping for AI-Enabled Urban Infrastructure Management - Expected Outcomes

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Transforming Major Infrastructure and Tunneling Projects with ArcGIS

November 06, 2025 | Esri AEC

ACCIONA Construction Australia is a Tier 1 infrastructure and tunneling contractor, recognized for delivering some of the most technically complex and environmentally sustainable engineering projects across Australia, spanning transport infrastructure, renewable energy, and water solutions.

ACCIONA Australia is at the forefront of Sydney's most ambitious infrastructure expansion, delivering multibillion-dollar projects such as Sydney Metro West – Central Tunnelling Package, the Western Harbour Tunnel, and the WestConnex M4-M5 Link Tunnels. These projects span some of the most densely populated urban corridors in the country and demand unprecedented precision, coordination, and innovation.

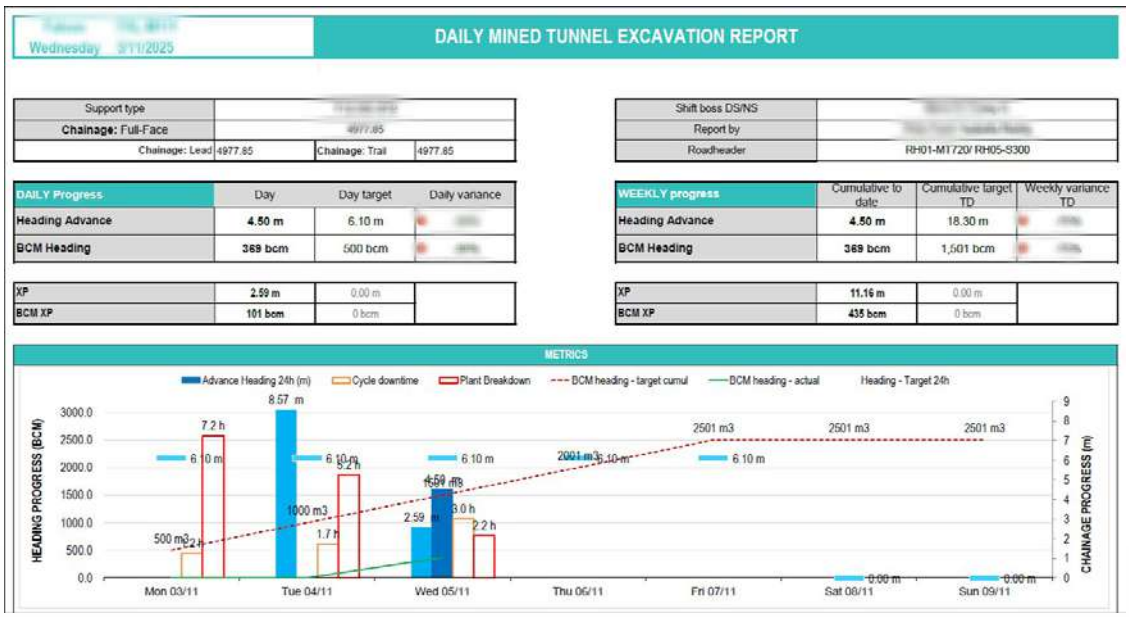
To meet these demands, ACCIONA required a centralized, intelligent, and interoperable data environment capable of integrating vast amounts of geospatial and engineering data. This environment needed to serve a wide range of stakeholders—from field engineers to design consultants to project managers—while bridging the gap between design, construction, and operations.

Challenge

Despite operating in a digitally advanced environment, ACCIONA faced fragmented data workflows that hindered efficiency and increased project risk. Tunneling progress was historically tracked in static PDF shift reports, which lacked spatial context and made it difficult for nontechnical stakeholders to interpret performance. Property condition surveys were stored in sprawling Excel spreadsheets with no geographic visualization, complicating prioritization and follow-up. Environmental monitoring processes were inconsistent, and incidents such as unauthorized water

discharges highlighted the urgent need for standardized digital compliance tools.

These disconnected systems created version control issues, coordination gaps, and delays in decision-making. They also made it harder to optimize resources, track progress against plans, and meet growing demands for transparency, sustainability, and efficiency.



Daily PDF report

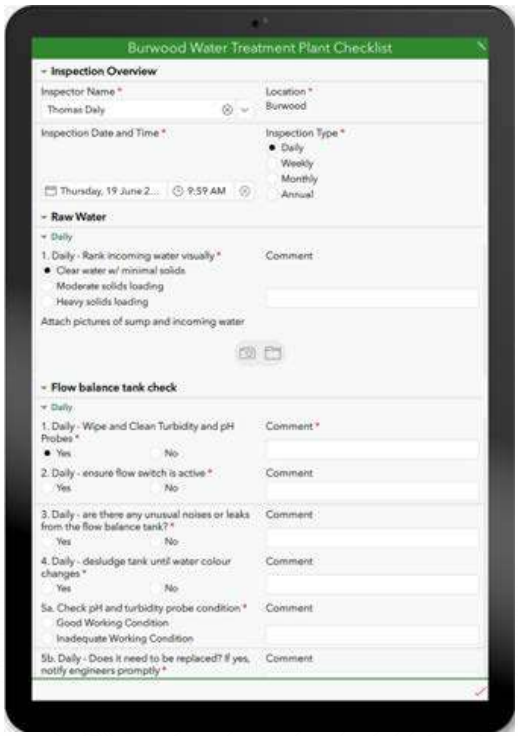
Solution

ACCIONA implemented a comprehensive ArcGIS infrastructure across its tunneling and infrastructure portfolio, making GIS a foundational element of its common data environment. This transformation was not simply a digitization of existing workflows but a complete rethinking of how projects were delivered.

Property condition survey and damage claim tracking dashboard

For tunnel excavation tracking, ACCIONA replaced static shift reports with a time-enabled dashboard built using ArcGIS linear referencing. This allowed excavation progress to be visualized in real time, showing tunneling machine performance, geotechnical conditions, and rate of advance in an intuitive and actionable format. Property condition surveys were migrated from spreadsheets into a centralized and interactive map-driven tracker, enabling teams to visualize inspection status for properties within 50 meters of tunnel alignment, identify trends, and coordinate follow-up actions more effectively.

Environmental accountability was strengthened through the deployment of ArcGIS Survey123, which standardized quality inspections, asset inspections, field checklists, and commissioning processes.

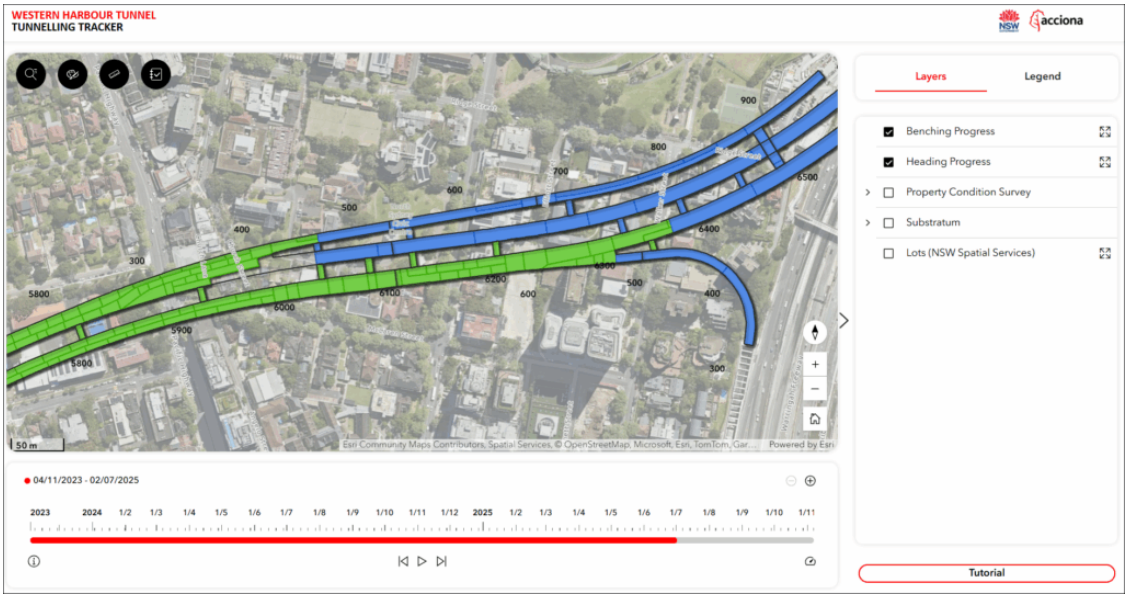


Standardised Survey123 form checklists

This improved compliance, enhanced data accuracy, and enabled proactive monitoring to prevent future incidents. By embedding ArcGIS into its workflows, ACCIONA empowered engineers, planners, and managers with live, geospatially contextualized project information. Collaboration was enhanced through map-based dashboards, mobile field access, and seamless data sharing between contractors, consultants, and clients. Environmental and community datasets were incorporated earlier in the design process, supporting sustainability and resilience planning from the outset.

Results

The integration of ArcGIS into ACCIONA's operations has delivered significant and measurable benefits. Planning efficiency has improved through faster route and alignment analysis based on real-time spatial constraints. Coordination across teams became more effective, reducing rework and miscommunication. Decision-making was enhanced, with leadership able to act on actionable insights grounded in location intelligence. Sustainability outcomes improved as environmental datasets were integrated earlier in the design process, leading to better results for both construction and community impact.



Monitoring tunnel excavation

Excavation tracking, site coordination, and data transparency have all advanced considerably. Stakeholder communication is now supported by accessible, real-time dashboards, while mobile field teams operate with tools that reduce errors, improve efficiency, and ensure compliance. Most importantly, GIS has evolved from a support function into a core pillar of project delivery, influencing everything from tunneling operations to environmental management and long-term asset planning.

By making GIS a strategic pillar of project delivery, ACCIONA has set a new benchmark for efficiency, transparency, and innovation in the global AEC industry. The integration of ArcGIS into its common data environment has unified data, streamlined collaboration, and ensured that every stakeholder operates from a single source of truth. This transformation has accelerated project timelines, reduced operational risks, and improved community and environmental outcomes–proving that spatial awareness, when turned into strategic insight, can redefine what is possible in modern infrastructure delivery.

> *We didn't just solve a data problem, we changed how we build. GIS is now embedded in our workflows, from design to tunnel construction to environmental monitoring to stakeholder engagement.*
>
> **Vincent Ochiel**, NSW GIS Manager
> ACCIONA Construction

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