Building Smarter Infrastructure with GIS

There is a dire need to strengthen India's infrastructure. As the world's second most populous country, India houses more than 1.4 billion people currently, and the numbers are continually growing. It is also one of the fastest-growing economies in the world, with an annual growth rate of 7.2%. Improved infrastructure is required not only to accommodate the rising population but also to keep pace with the rapid economic growth. The Indian government has estimated that the country needs to invest US$1.4 trillion in infrastructure by 2025 to achieve the $5 trillion economy vision. As per a report by KPMG, India is the fastest-growing construction market, currently clocking around 7-8% annual growth. By 2025, India is poised to overtake Japan.

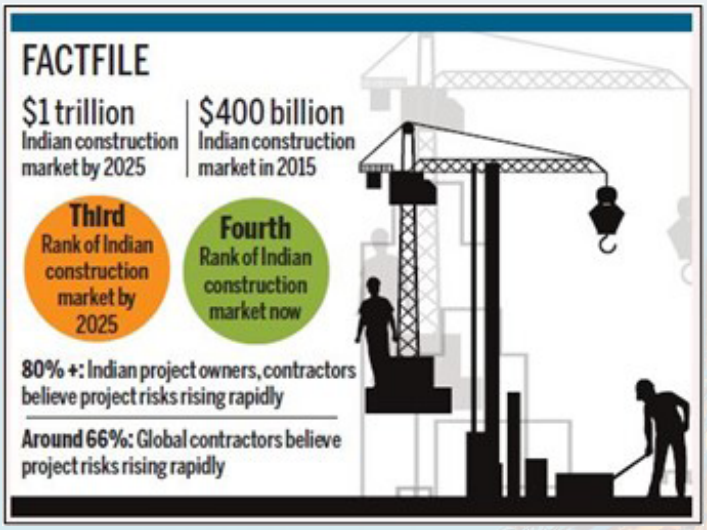
Rising Challenges

With the growing size and quantum of projects in AEC, the complexities and associated risks are also increasing. Infrastructure projects are not just capital intensive with 30% wastage, 40% rework, and significant schedule overruns, the industry also accounts for 39% of energy consumption and is responsible for 19% of GHG emissions.

Landscape, access, utilities, amenities, natural resources, and their impact on the local environment and ecology are integral aspects to consider. Moreover, as a disaster-prone nation, disaster risk to projects due to natural hazards is considerably high.

Additionally, factors like regulatory issues, weather conditions, unforeseen site conditions, or disputes often lead to project delays. These delays often lead to cost overruns and can strain relationships between stakeholders. Budget overruns are a significant concern in the AEC industry. Unforeseen expenses, changes in project scope, or inaccurate initial cost estimates can lead to financial challenges for contractors and developers. The industry also often faces shortages of skilled labor, including architects, engineers, and construction workers. This can lead to increased competition for talent and potential compromises in project quality. Also, with sustainable practices and green building standards becoming the need of the hour, higher upfront costs need to be considered. All these factors can have an impact on project delivery, profitability, and overall sustainability of infrastructure projects.

Addressing these challenges often involves a combination of industry collaboration, **technological innovation**, effective project management, and a proactive approach to risk management. By embracing digital transformation, the AEC industry stands to benefit in almost every aspect of the project lifecycle. From improved project management to enhanced collaboration and streamlined design and construction, the impact of digital transformation is far-reaching and transformative.



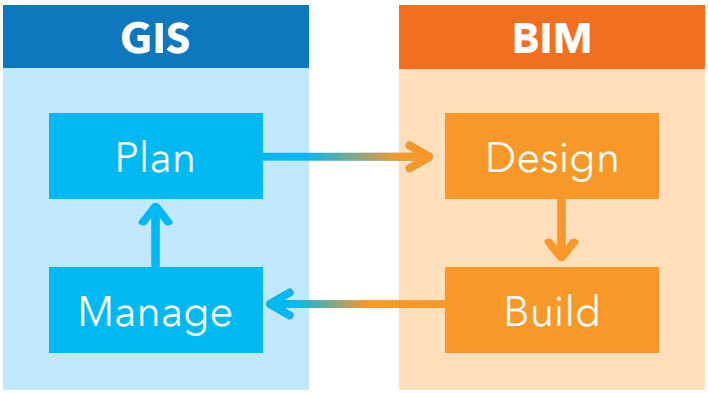
Source: Financial Express

Digital Transformation in AEC

Currently, every industry is going digital, benefiting immensely from digital innovations, and infrastructure is no exception. Digital transformation enables AEC companies to adopt sustainable practices and maximize resource efficiency. Digital tools also enable the implementation of lean construction principles, which aim to reduce waste and improve productivity. Through the use of digital workflows and automated processes, companies can streamline construction operations, minimize errors, and eliminate unnecessary rework.

According to the **Geospatial Market in the AEC Industry Report (2019)**, digitalization in building infrastructure helps to save 10%-20% in the entire construction workflow, whereas project time saving is 14%. In transport infrastructure, there is a cost-saving of 15%-23% in the design and engineering phase and 8% in the entire construction workflow, whereas time-saving is around 17%. In industrial infrastructure, the total cost saving is 8%-10% in the construction workflow, and project time saving is about 8%. Apart from these benefits, digitalization also improves collaboration, enhances clarity, and makes construction sites safer.

Today's smart infrastructure projects necessarily warrant the usage of advanced technologies such as Geographic Information Systems (GIS),



Building Information Modelling (BIM), Drones, Digital Twins, etc. **BIM** has gained significant prominence in AEC, enabling architects, engineers, and contractors to create digital representations of the physical and functional characteristics of a facility. The government's mandate for the adoption of BIM in public infrastructure projects and the increasing awareness and benefits of BIM among industry stakeholders have contributed to its widespread adoption in the Indian AEC industry.

GIS aids in spatial analysis, site selection, land management, infrastructure planning, and environmental assessment. Its capabilities to capture, store, analyze, and visualize spatial data facilitate informed decision-making, efficient resource allocation, and sustainable development in AEC projects.

Drones and remote sensing technologies are increasingly utilized in AEC projects for site surveying, aerial mapping, progress monitoring, inspection, and documentation. Drones enable stakeholders to capture high-resolution aerial imagery, generate 3D models, conduct site surveys, monitor construction progress, and improve safety and efficiency on construction sites. **Site Scan for ArcGIS** is a cloud-based drone mapping software designed to revolutionize imagery data collection, processing, and analysis for smaller sites.

VR and AR technologies are gaining prominence in AEC for design visualization, stakeholder engagement, virtual tours, simulation, training, and marketing purposes. VR and AR enable stakeholders to experience and interact with virtual models, walkthroughs, and simulations, facilitating better design understanding, decision-making, and collaboration.

The concept of **Digital Twins** is evolving rapidly in India across various sectors like AEC, manufacturing, and healthcare, enabling stakeholders 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. **ArcGIS Utility Network** provides a comprehensive framework of functionality for the modeling of utility systems such as electric, gas, water, stormwater, wastewater, and telecommunications. It allows users to build real-world behavior into the network features they model.

GIS in Plan, Design, Build, and Operate

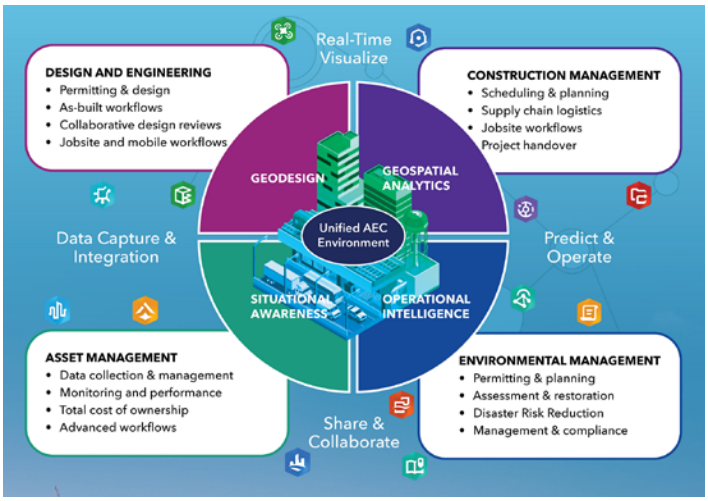
Modern infrastructure projects are very complex, span over multiple years, and require very careful planning and execution. Very often this means access to large amounts of data in real time. Unfortunately, in the absence of an effective information management system, a huge amount of time is spent on locating and validating the data. This not only leads to poor communication but also cost overruns. Effective data and communication management is, thus, very important for not only saving on the direct costs of the projects but also for ensuring statutory compliances (e.g. environmental), timely completion, and avoiding associated penalties and levies. Engineering information systems benefit a lot by using GIS, and today, many projects leverage GIS over the whole lifecycle — planning, survey, construction, operations, and maintenance. ArcGIS Urban facilitates the application of GIS technology to urban planning, helping users to streamline plan creation, analyze the impact of plans, visualize current projects, and facilitate public engagement.

GIS plays a crucial role in assisting project teams in site selection and evaluation based on geographical, resource, and environmental factors. It enables building professionals to visualize the landscape, strategically plan structure placements, and harmonize the built environment with nature. This location-based approach proves valuable in planning roadways, railways, and pipeline routes, allowing planners to assess terrain and environmental variables along proposed routes for optimal and environmentally conscious decisions.

For instance, when creating new roads, GIS aids in identifying ideal terrain, flood plains, traffic conditions, weather patterns, and environmentally sensitive locations, influencing construction and mitigation strategies. The integration of context-aware capabilities with IoT sensors, 2D drawings, 3D models, and construction machinery data facilitates real-time geospatial analysis on construction sites. This integration allows for the continuous monitoring and optimization of construction operations, enhancing efficiency, safety, and resource management. ArcGIS GeoPlanner is a web-based planning tool that empowers users to rapidly design city, regional, and landscape-scale scenarios in a collaborative, iterative environment.

Geo-enabling the AEC value chain provides builders with better control over their outcomes while ensuring the right balance between social, economic, and environmental aspects. Esri's ArcGIS portfolio

supports the end-to-end AEC value chain. Recognizing the gravity of the emerging situation and technological heterogeneity in the AEC industry, Esri solutions are conceptualized and developed embracing Findable, Accessible, Interoperable, and Reusable (FAIR) principles. Supported by intelligent mapping and data capture tools for Geodesign, intuitive visualization for enhanced situational awareness, advanced geospatial analytics for operational intelligence that is actionable, and multi-mode dissemination for sharing and collaboration among stakeholders, ArcGIS AEC solutions foster transparency, efficiency, and cost optimization across the value chain.



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.

Bringing GIS and BIM Together

As digital interventions make their way into the AEC sector, activities can no longer be carried out in isolation. Being myopic to the construction sites alone is no longer tenable. The need for contextual understanding to demystify the interdependencies and linkages in the infrastructure environs is greater than ever.

BIM and GIS technologies have traditionally operated in silos, with BIM focusing on detailed building design, construction, and facility management, while GIS focuses on spatial analysis, mapping, and geographic data management. Integrating GIS with BIM facilitates better contextualization of the infrastructure and its surroundings. The integration has emerged as a transformative approach in the AEC 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.

BIM-GIS integration fosters collaborative workflows and processes in the lifecycle of projects. Integrated workflows enable stakeholders to share, access, analyze, visualize, and collaborate on building information, geographic data, design models, spatial analysis, and project documentation in real-time, enhancing communication, coordination, integration, and collaboration.

> "The amalgamation of BIM and GIS transforms traditional decision-making with an enhanced collaborative approach for the industry by providing a unified platform to access, share, analyze, visualize, and collaborate on building information, geographic data, design models, spatial analysis, and project documentation."

This integration leads to optimized planning and design enhancing project feasibility, sustainability, resilience, functionality, aesthetics, and value.

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-

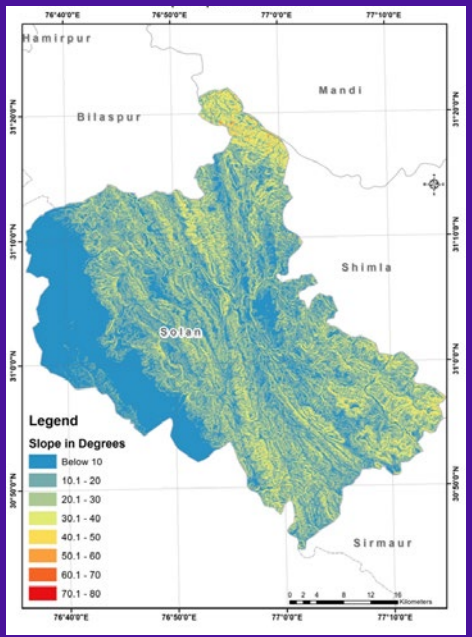
time data, made possible by GIS, can lead to reductions in energy and resource costs, ultimately enhancing overall business profits.

Esri's 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.

GIS takes BIM to new levels by providing real-time data about an asset's existing environment. Integration of BIM and GIS leads to the creation of a robust model where geographic and infrastructural design information is put together. This information helps designers and engineers to explore and evaluate the design and construction more effectively. An information-rich model can also be used to improvise all the assets within a larger area for operations and maintenance. The benefits of this integration are manifold.

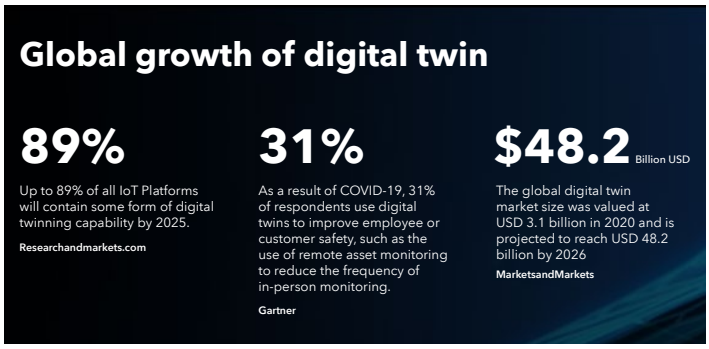
Solar Power Plant Sites Identification using ArcGIS

AGiSAC carried out a study to identify suitable plots of land for PV plant installation. Disparate datasets such as imagery, DEM, land use, settlement clusters, and locations of existing infrastructure such as roads and electricity sub-stations were used in ArcGIS Pro spatial overlay analysis to find suitable sites along with solar power potential calculated in MW.



Digital Twins in AEC

A technology that's increasingly enabling the AEC sector to perform better is "Digital Twin Technology".



Digital twins are virtual representations of the real world including physical objects, processes, relationships, and behaviors. For the AEC industry, a digital twin is in the form of a built asset. Take, for example, an office building and its digital twin. At the end of design and construction, there is an exact, digital replica of the entire building, from the roof to the HVAC system and MEP. The actual, physical building is mirrored as a "twin" in a digital, dynamic format. Unlike a digital model or a simulation, a digital twin isn't static. Just as the final, completed office building changes with use, so does the digital twin. It is responsive and continues to evolve as more data is supplied to it, such as data from artificial intelligence (AI), sensors, or the Internet of Things. That means it can also simulate and predict informed decisions based on real-world conditions of the building.

Digital twin isn't a "one and done" exercise, and there are different levels of use. A digital twin for one project may be more simplistic with editable data, while another may be a fully mature use with enhanced simulations. But the core benefits remain the same. From the beginning of a project throughout the entire life cycle of an asset, a digital twin continues to live, grow, and provide new insights for better ROI, energy savings, maintenance, and performance. This is the basis of a digital twin. A digital twin for AEC is a dynamic, up-to-date replica of a physical asset or set of assets—whether it's a building, a campus, a city, or a railway—that brings together design, construction, and operational data.

With advancements in 3D modeling and simulations, Digital Twins are increasingly assuming greater significance in the AEC workflows. The proliferation of IoT sensors and devices is providing accurate insights for enhanced location awareness and response. Smart applications streaming real-time insights into ArcGIS enable seamless monitoring and administration of the construction processes, facility management, and environmental monitoring.

Interconnecting GIS and Digital Twins

A digital twin benefits directly from the integration with GIS technology. GIS adds spatial context around the asset, connecting the information model to other models and its surroundings. AEC firms are increasingly leveraging the idea of integrating GIS and digital twins for abstracting and modeling everything to enhance business processes, mitigate risk, optimize operational efficiencies, and boost decision-making.

> “Digital twins are abstracting and modeling everything. They offer a means to improve business processes, reduce risk, optimize operational efficiencies, and enhance decision-making with automation to predict future outcomes. ArcGIS technology is the foundation for digital twins.”

Opportunely, there is an array of GIS products that are being utilized for digital twin deployment, including **ArcGIS Urban, ArcGIS Indoors, ArcGIS CityEngine, ArcGIS Velocity, and ArcGIS Reality.**

The convergence of GIS technology, IoT, and BIM is creating interactive 3D visualizations, which are redefining the digital twin as well as the value it brings to organizations. A digital twin is not a single product or solution—it is a complex network of technologies and systems. It must work in harmony to achieve the desired transformational outcomes and return on investment that organizations desire. As digital twin adoption increases, the possibilities and applications of digital twins continue to evolve and create value in almost every industry and organization.

The evolution of GIS technology and the deployment of IoT sensors have resulted in unprecedented amounts of data, which can now be processed, analyzed, and visualized in innovative ways. As IoT and GIS adoption increases and their applications mature, the future is becoming increasingly intelligent and automated. GIS and IoT technologies are connecting systems and data in new ways, enabling the transformation of many organizational workflows. The innovation and integration of these technologies are creating a modern digital nervous system and enabling real-time integrated digital twins.

In Closing

Gauging the vital role, the infrastructure industry has to play in India’s growth story, the Indian Government is greatly emphasizing the enhancement of this sector. Infrastructure is a key focus area for India in the next 25 years as the country aims to emerge as a developed nation by 2047. Enabling steps like the Smart City Mission, National Infrastructure Pipeline, and Gati Shakti, are booster programs for the infrastructure industry. The time is very conducive for the growth of the AEC industry, provided they undergo digital transformation at a faster pace. Technologies such as BIM, GIS, and Digital Twins have the potential to enable the AEC industry to achieve smarter outcomes and help build a resilient and sustainable India. The convergence of these technologies is redefining the possibilities of how they may be used to model, manage, and simulate single facilities, entire cities, and even large natural systems.

As climate change clouds uncertainties on the future, building climate-resilient infrastructure becomes inevitable for sustained economic growth. With the influence of technological advancements on one side and climate change events on the other, it is important that we can assess, visualize, quantify, predict, and prepare for the change in our infrastructure ecosystems in advance and adapt with time. This is the only way we will be able to manage the uncertainties before the pressures build up.

There is no doubt that contextualized geo-intelligence delivered by modern GIS is the foundation for infrastructure that is intelligent, data-centric, and dynamic. Decision-makers are already taking a geographic approach, and infrastructure systems are being integrated with geospatial technology including GeoBIM, digital twins, sensors, and advanced spatial analytics. Accordingly, we are now creating ‘smart infrastructure.’ Through smart infrastructure, we are forging an ecosystem that bridges the gap between the physical realm and the digital domain. As the AEC industry leverages the next generation of tech — GIS integrated with advanced technologies like AI, IoT, Cloud Computing will be an integral component of the revolution, and we will continue to witness exciting developments in the realm of smart infrastructure.