Power and Potential of Geospatial Infrastructure

Introduction

We are living in unprecedented times. Technology is rapidly transforming the world we live in. Influenced by economic and social considerations, the future of technology will depend on what it eventually means to citizens or customers in a defined framework and context influenced by expectations, circumstances, environment, and behavior.

Geospatial technology allows us to perceive what would otherwise remain invisible, unappreciated, or poorly understood. Through a common language of maps, GIS provides an incredibly powerful framework to communicate, analyze, share, and collaborate.

In today's world, the influence of geospatial technology permeates virtually every sphere of human activity. Its applications extend far beyond mapping, enabling us to solve complex problems, make informed decisions, predict outcomes, and unravel the intricacies of our environmental and social systems.

New age digital transformations are being shaped by a complex interplay of scientific and technological advancements that are driven by innovation on one side and the hyper-local consumer on the other. Artificial Intelligence, Cloud Computing, Internet of Things (IoT), Big Data Analytics, Augmented Reality/Virtual Reality, Blockchain and Quantum computing are some leading-edge technologies that have been able to mark their presence so far. One of the discernable features of these frontier technologies is their ability to either capture location or transform location rich data into spatial insights and contextualized intelligence.

Agnostic to industry sector, governments and businesses are increasingly embracing contextualized intelligence to improve governance and operational efficiencies. Cutting across the governance and business processes, geospatial technologies are aiding in improvement of asset management, operations management, network management, project management, resource management and disaster management. Behind the scenes, it is geospatial infrastructure that endows us with decision intelligence that is contextualized to events, subjects and/or processes.

A robust, scalable, and futuristic geospatial infrastructure will play a defining role in navigating the complexities of economy by fostering an inclusive, equitable and sustainable growth.

Changing Geospatial Landscape

In the past, GIS was confined to desktop computers, offering only a handful of features, and requiring specialized expertise to operate within office settings. In the present day, with versatile functionalities that are tailored and customized, GIS has become easily accessible from any location at any time, empowering individuals from all walks of life to utilize its capabilities.

Today, GIS serves a diverse community ranging from ordinary citizens to administrators, business leaders, scientists, social workers, and many others. It caters to the requirements of individuals, governments, businesses, entire enterprises, and civil society. With geospatial data becoming increasingly ubiquitous, contextualized geo-intelligence has taken a center-stage. Its economic value and benefits across the spectrum, sector-agnostically, are well acknowledged. Here are some ways in which the reach of geospatial technologies has grown:

- Increased Accessibility of Geospatial Data: The availability of geospatial data has greatly improved. Open data initiatives, online platforms, and mapping services have made geospatial data more accessible for a wide range of applications.
- 2. Advancements in Mobile Technology: With proliferation of smartphones and mobile devices, mobile apps and location-based services have empowered individuals to access geospatial information, and engage with location-specific content, contributing to the mainstream adoption of geospatial technology.
- 3. Integration with Everyday Applications: Geospatial technologies have been integrated into everyday applications and services like navigation apps, social media platforms and e-commerce services, making them more user-friendly and relevant to a broader audience.
- 4. Emergence of Web-Based Mapping Platforms: Web-based mapping platforms have democratized access to geospatial information and facilitated community-driven mapping initiatives.
- 5. Integration with Internet of Things (IoT): Geospatial technologies have converged with IoT devices, creating new opportunities for collecting and analyzing spatial data in real-time.
- 6. Advancements in Data Analytics: Big data analytics, machine learning, and artificial intelligence techniques are now being applied to geospatial data expanding capabilities in understanding complex spatial relationships., enabling deeper insights, pattern recognition, and predictive modeling.
- 7. Emergence of Cloud-GIS: Cloud computing for geospatial has volutionized the industry by offering scalability, cost efficiency,

collaboration, and enhanced processing power, enabling them to make informed decisions, streamline workflows, and unlock new insights and opportunities.

These advances have made geospatial technologies more accessible, user-friendly, and relevant in our daily lives, fostering their widespread adoption and impact.

Power of Geospatial Infrastructure

Infrastructure has played a pivotal role in connecting geographies and advancing economic progress from ancient times. The monumental change brought about by digital technologies in the last few decades is not just limited to the physical realm of infrastructure but has also ushered in a new way of understanding and solving problems. Often left out or passingly acknowledged "digital infrastructure" has become an indispensable necessity today.

By augmenting the digital framework behind the scenes, geospatial infrastructure enables contextualized interactions between the physical subjects and the people through technology and data. With sustainability as a new order of the world, geospatial infrastructure lets us tell stories about the world as it is today and the future, we want to see by providing a holistic view of the environment in which we are operating. This gains significance with the climate change and global warming concerns in the backdrop of unpredictable geopolitical and economic headwinds.

In simple terms, geospatial infrastructure is a layer that is integrated with the digital infrastructure to enable acquisition, processing, management and dissemination of spatial data and location information with high precision and accuracy. From a technological perspective, geospatial infrastructure is the foundation that supports the use and implementation of geospatial technologies, such as Geographic Information Systems (GIS), remote sensing, and Global Positioning Systems (GPS). Powered by hardware, connectivity, and software that bridge and facilitate interactions within and outside the ecosystems, value from everincreasing volumes of data has become a key enabler for integrated approaches and sustainable development. While being able to visualize and assess the subjects more holistically and accurately in real-time, location inclusive digital interventions have enabled cognizance to social and environmental issues that are intricately interleaved with economic and business activities. Armed with smart devices, location aware citizens and consumers are increasingly seeking hyper-localized intelligence that is personalized and prescriptive. After all the human brain is wired to model and create a spatial frame of the things around us and it is natural for humans to desire information that is contextual, accurate, and timely. And this would not have been possible without geospatial infrastructure.

Recent government initiatives like Digital India, PM Gati Shakti National Master Plan, National infrastructure Pipeline and National Logistics Policy echo an integrated approach and articulate their intent to leverage digital intelligence by strengthening the infrastructure (Physical and Digital). All these aspirational initiatives have one thing in common they are multi-sectorial and multi-disciplinary trying to solve complex socio-economic-environmental challenges by harnessing contextualized decision intelligence powered by the geospatial infrastructure.

Emphasizing geospatial as "common good" and location as a "common reference frame," National Geospatial Policy 2022 reaffirms the societal, economic, and environmental value of geospatial data to enable government systems and services, and sustainable national development initiatives, while elucidating the need and roadmap to strengthen the geospatial infrastructure in the country.

As a "System of Systems," geospatial infrastructure comprises of the systems, processes, and policies that are used to acquire, manage, distribute, and apply geospatial data. By providing accurate and timely geospatial data, geospatial infrastructure:

- 1. **Provides Valuable Insights:** Geospatial infrastructure helps organizations gain valuable insights about location-based data, allowing them to make informed decisions and optimize their operations.
- 2. Improves Efficiency: Geospatial infrastructure enables organizations to optimize their processes and operations, leading to increased efficiency and productivity.
- **3.** Facilitates Collaboration: Geospatial infrastructure enables collaboration across different industries and sectors, leading to the development of new partnerships and opportunities.
- Supports Innovation: Geospatial infrastructure provides a platform for innovation, allowing organizations to develop new products, services, and solutions that leverage location-based data.

These benefits are being further amplified by 4IR technologies (Industry Revolution 4.0) such as Cloud Computing, Geo-AI (Artificial Intelligence), Internet of Things (IoT), and Big Data Analytics. These technologies rely on geospatial infrastructure to hyper-localize outcomes, reduce turnaround times, and lower costs. There is a growing demand for a robust geospatial infrastructure as more organizations recognize its potential value and applications.

Components of Geospatial Infrastructure

Providing specialized capabilities to manage geospatial data, geospatial infrastructure acts as a backbone for all spatial operations including data acquisition, processing, integration, analytics, and dissemination. This infrastructure also facilitates management, sharing and collaboration of geospatial data, information, and knowledge. The components of geospatial infrastructure include elements that collectively enable the capture, management, analysis, and dissemination of geospatial data. Here are the key components:

- 1. Geospatial Data: This component forms the foundation of geospatial infrastructure. It includes satellite imagery, aerial photography, LiDAR (Light Detection and Ranging) data, digital elevation models, land cover datasets, and other spatially referenced information.
- 2. Geographic Information Systems (GIS): GIS software is a principal component of geospatial infrastructure. It allows for the collection, storage, analysis, and visualization of geospatial data. GIS enables users to create maps, perform spatial analysis, generate insights, and make informed decisions based on spatial relationships.
- **3. Global Positioning System (GPS):** GPS technology provides accurate positioning and navigation information by utilizing signals from a network of satellites. GPS is vital for capturing real-time location data, enabling precise mapping, surveying, asset tracking, and navigation in various applications.
- 4. **Remote Sensing:** Remote sensing involves gathering data about the Earth's surface from airborne or satellite sensors. It includes techniques such as capturing multispectral imagery, thermal imaging, and radar sensing.
- 5. Spatial Data Infrastructure (SDI): SDI is a framework that facilitates the sharing, discovery, access, and integration of geospatial data from multiple sources and organizations. SDIs provide standards, protocols, and tools for harmonizing geospatial data across different systems, ensuring interoperability, and facilitating efficient data exchange.
- 6. Geospatial Analysis Tools: These tools enable advanced spatial analysis and modeling, allowing users to extract valuable insights from geospatial data. They include algorithms for spatial statistics, spatial clustering, network analysis, terrain analysis, and other techniques that support decision-making processes.
- 7. Geospatial Applications: Geospatial infrastructure supports a wide range of applications across various sectors, including urban planning, transportation management, environmental

monitoring, disaster response, precision agriculture, natural resource management, and many others. These applications leverage the capabilities of geospatial data and tools to address specific needs and challenges.



As a combination of hardware, connectivity, and software, geospatial infrastructure serves as a framework that facilitates seamless interactions within and beyond ecosystems. All these work together harmoniously to unlock the potential of geospatial data, enabling informed decision-making, fostering collaboration, and promoting holistic and sustainable development practices. These key functional components are supported by:

- 1) Standards and Interoperability
- 2) Data Management and Storage
- 3) Data Processing and Analysis
- 4) Data Visualization and Dissemination
- 5) Policy and Governance
- 6) Capacity Building and Human Resources

Supporting the entire geo-data lifecycle and binding all the infrastructure components in a user-friendly environment, GIS software plays a key role in facilitating interactions between data, systems, processes, and users.

Integrating all the components of geospatial infrastructure, as a onestop destination, Esri India's "Indo ArcGIS" helps businesses to build their own geospatial infrastructure at a lower cost of ownership. Hosted on a secure MEITY approved cloud, Indo ArcGIS also provides an exhaustive repository of ready to use India data sets at no additional cost. Indo ArcGIS on Cloud supports organizations and industries of various scales, bringing together distributed information and making GIS accessible to a wide range of users. With its SDI framework, GIS platform for data ingestion, processing, integration, and dissemination, as well as advanced analysis tools and applications, ArcGIS System enables geospatial infrastructure with out-of-the-box technology and end-to-end workflows.

Potential of Geospatial Infrastructure

Using web-GIS technology, an integrated geospatial infrastructure connects various organizations across borders, sectors, and jurisdictions. As cloud computing gains popularity, GIS portals are becoming the focal point of geospatial infrastructure.



By efficiently organizing and providing access to content and capabilities, enabling users to utilize them anywhere and at any time, organizations and communities can lay the rules of engagement to manage spatial data cooperatively and improve engagements. Here are ways in which geospatial infrastructure is adding value to different sectorial applications:

- 1. Urban Planning and Development: Geospatial infrastructure supports urban planning by providing tools for mapping and analyzing land use, infrastructure networks, transportation systems, and population density. It assists in planning, design, 3D modelling, identifying areas for growth and development, and improving urban resilience and sustainability.
- 2. Smart Cities and Infrastructure Management: Geospatial infrastructure forms the backbone of smart city initiatives. It enables efficient management of utilities, infrastructure planning, asset management and GeoBIM. Geospatial data assists in optimizing energy consumption, improving waste management systems, enhancing public safety, and fostering citizen engagement.
- **3. Transportation and Logistics:** Geospatial infrastructure facilitates efficient transportation and logistics management. It aids in route optimization, fleet tracking, real-time traffic monitoring, and intelligent transportation systems. Geospatial data enables effective supply chain management, enhances delivery operations, and improves overall transportation efficiency.
- 4. Agriculture and Food Security: Geospatial infrastructure supports precision agriculture, crop monitoring, yield prediction, and soil analysis. It aids in optimizing resource allocation, irrigation management, and pest control. Geospatial data assists in enhancing agricultural productivity, ensuring food security, and promoting sustainable farming practices.

- 5. Public Health and Epidemiology: Geospatial infrastructure aids in public health and epidemiological studies. It enables disease mapping, surveillance, and analysis of health-related data to understand patterns, track the spread of diseases, and inform public health interventions. Geospatial data assists in resource allocation, healthcare planning, and disease prevention strategies.
- 6. Disaster Management and Emergency Response: Geospatial infrastructure plays a critical role in disaster management and emergency response. It supports hazard mapping, risk assessment, early warning systems, and post-disaster recovery efforts. Geospatial data helps identify vulnerable areas, coordinate emergency response activities, and assess damages for effective relief operations.
- 7. Natural Resource Management: Geospatial infrastructure assists in the sustainable management of natural resources. It helps monitor forests, track changes in land cover and land use, manage water resources, and mitigate the impact of natural disasters. Geospatial data enables informed decision-making in conservation, agriculture, forestry, and environmental management.
- 8. Environmental Monitoring and Conservation: Geospatial infrastructure contributes to environmental monitoring and conservation efforts. It facilitates monitoring of biodiversity, habitat mapping, climate change analysis, and ecosystem management. Geospatial data helps identify ecological hotspots, monitor pollution levels, and support conservation planning and decision-making.
- **9. Prescriptive Personalized Services:** Geospatial infrastructure enables commercial industry to provide prescriptive personalized services to their customers. With consumer behavior being reshaped towards instantly gratifying personalized experiences, prescriptive hyper localization of geospatial data helps in improving user experience for shopping, travelling, gaming, and navigating with virtual walkthroughs and immersive experiences.

These are just a few examples of the wide-ranging sectorial applications of geospatial infrastructure. As technology continues to advance, its potential applications are expanding across various sectors, driving innovation, and enabling smarter, more sustainable approaches to societal challenges.

Emerging Trends in Geospatial Infrastructure

Geospatial infrastructure is the driving force behind modern Geographic Information Systems (GIS). It assumes responsibility for essential elements like security, privacy, accessibility, identity management, collaborative spaces, and content negotiation. By leveraging open standards, APIs, licenses, and marketplaces, geospatial infrastructure guarantees smooth integration and connectivity between organizations, surpassing geographical boundaries, legal jurisdictions, and industry sectors. This integrated approach facilitates effective sharing and collaboration, empowering organizations to swiftly connect and cooperate in their geospatial pursuits.

Some notable trends that are emerging and are expected to make a profound impact in the near future include:

- 1. Cloud-Based Geospatial Services: Cloud computing continues to play a significant role in geospatial infrastructure. Cloud-GIS offers scalability, flexibility, and cost-effectiveness. It enables ondemand access to geospatial tools, data storage, processing power, and collaborative capabilities, making it easier for organizations to leverage geospatial infrastructure without heavy upfront investments.
- 2. Real-Time Geospatial Data: The demand for real-time geospatial data is increasing rapidly. Advancements in sensor technologies, IoT, and satellite imagery enable the collection of up-to-date, high-resolution spatial data. Real-time data allows for more accurate and timely decision-making in areas such as transportation management, disaster response, and urban planning.
- 3. Artificial Intelligence (AI) and Machine Learning (ML): AI and ML technologies are being increasingly integrated into geospatial infrastructure. These technologies can automate data analysis, pattern recognition, and predictive modeling, leading to improved spatial analysis and decision support systems. AI and ML algorithms can process large volumes of geospatial data, extract meaningful insights, and enable advanced geospatial applications.
- 4. **3D** Geospatial Visualization: 3D geospatial visualization is becoming more prevalent in various applications, such as urban planning, architecture, and virtual reality. Technologies like LiDAR, photogrammetry, and 3D modeling enable the creation of detailed, immersive representations of the physical world referred to as metaverse by some. 3D visualization enhances spatial understanding and supports more accurate spatial analysis and simulation.
- 5. Geospatial Integration with Internet of Things (IoT): The integration of geospatial infrastructure with IoT devices and networks is expanding. IoT sensors embedded in infrastructure, vehicles, and environmental systems generate vast amounts of spatially referenced data. By combining geospatial and IoT technologies, organizations can gain deeper insights into spatial patterns, monitor assets in real-time, and optimize resource management.
- 6. Open Data and Open Standards: Open data initiatives and open standards continue to gain momentum in the geospatial domain. Governments, organizations, and communities are embracing open data principles, making geospatial datasets and tools more accessible to the public. Interoperability through open standards

allows for seamless data exchange and integration between different systems, enabling collaboration and innovation.

7. Spatial Data Privacy and Security: As the amount of geospatial data grows, ensuring privacy and security becomes paramount. Protecting sensitive location information, adhering to data protection regulations, and implementing robust security measures are critical considerations for geospatial infrastructure. Techniques like differential privacy, data anonymization, and secure data sharing protocols are emerging to address privacy concerns.

These emerging trends demonstrate the evolving nature of geospatial infrastructure and its increasing importance in various sectors. Keeping abreast of these trends is critical for us to harness the full potential of geospatial data and technology to drive innovation and informed decision-making.

In Closing

India is emerging as a prominent player in the global economy. The role of infrastructure in driving economic growth cannot be overstated. Investing in high-quality infrastructure is essential for accelerating and sustaining economic progress over the long term. Geography and spatial thinking are essential for successful and all-inclusive growth. Empirical evidence suggests contextual intelligence has become a valuable tool for promoting economic growth and development.

Over the past two decades, the reach of geospatial technologies has expanded multifold, transforming various aspects of our lives. The recognition of GIS as a valuable decision-making tool has led to its integration into various sectors, extending their reach and impact. Geospatial infrastructure becomes a critical component of modern society.

Providing valuable insights, improving efficiency, facilitating collaboration, and supporting innovation in various sectors, geospatial infrastructure is reshaping the way governments, businesses and communities collaborate and interact with spatial data. Harnessing the potential of geospatial infrastructure will be critical for a sustainable, inclusive, and equitable growth.

As National Geospatial Policy 2022 sets the stage for a strong geospatial infrastructure, enabled ecosystems and ease of doing business, it is incumbent on us to take these efforts forward at a faster pace. While we invest in geospatial infrastructure, we should not lose sight of the importance of capacity and expertise.