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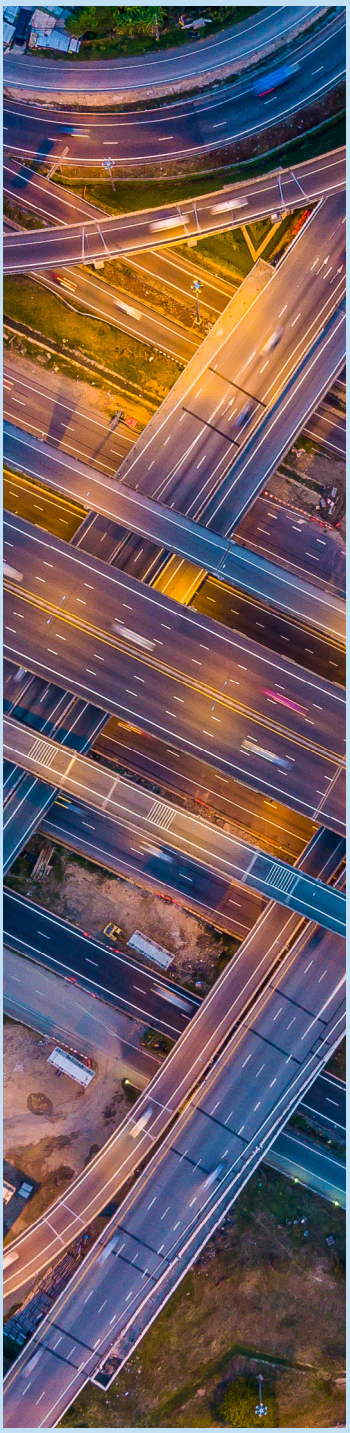

GEOSMART CITIES: BUILDING SPATIAL INFRASTRUCTURE FOR URBAN DEVELOPMENT

Abstract

With rapid urbanization across the globe, concept of smart city is scaling up for better economic growth and one such scenario is the Government of India's smart city initiative with its objective of enhancing living standards of citizens.

Implementing smart city concept is still a challenge and city planners are slowly advancing towards usage of digital technologies and location based applications as a means to evolve with a smart environment for citizens. This paper advocates faster, wider mapping mechanisms to build geospatial data, which will in turn enable faster and more efficient deployment of smart cities. It establishes the key developments on usage of geographical information systems (GIS) to build the components for smart cities.

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An urgent need for digital mapping technologies

Increased population and rapid urbanization have led to several city-specific challenges: congested modes of transport, unplanned settlements, rampant pollution and the consequent environmental degradation, strain on limited resources, and sanitation hazards. With the advent of smart city initiatives (for example, in India) city administrators are increasingly inclined towards using leading-edge technologies and mapping intelligence to develop a safe and smart atmosphere for citizens to thrive-in.

Mapping technologies linked with location intelligence can provide the necessary data for city administrators to plan, develop, and govern cities effectively. Maps were and are answerable to various questions that evolve from city governance and related policy making. Real-time information, the cutting-edge technology of today, provides valuable inputs for instant decision-making. In almost all areas of city administration namely traffic, public utilities, health, infrastructure, communities, and people, geospatial technology and its related components together can play a decisive role.

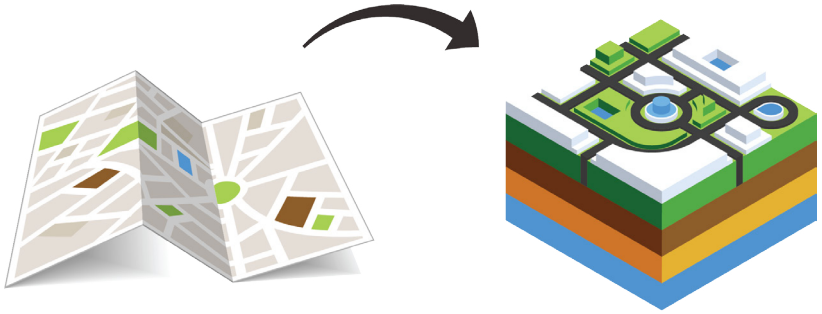
Location intelligence for smarter & stronger infrastructure

In today's digital world, the concept of location intelligence has been gaining relevance and the continuous evolution of geospatial technologies with its widespread usage through real-world applications has considerably effected every sphere of life. Digital innovations like machine learning, the internet of things (IoT), robotics & automation, and artificial intelligence (AI) are further broadening the geospatial industry's horizons, driving faster production, and helping target every vertical industry.

The smart cities initiative (especially in a country like India) is an evolving concept, with several other digital transformations such as smart utilities, smart infrastructure, and smart mobility that are underway, aligned to it. Against this backdrop, location-based intelligence is extremely essential to measure variations against the plan for long-term urban development.

Several map-based mechanisms can be considered to develop decision support models to manage a sustainable use of limited resources.

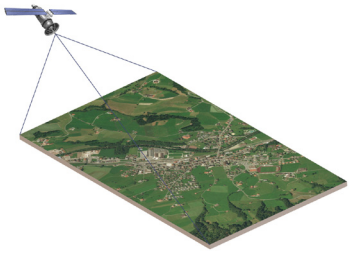
Data is the king in the geospatial space and its production is key. However, tremendous effort is required to produce the data needed to achieve the end goal of sustainable urban transformation leading to effective city governance. Regardless of any other development, geospatial data is the fuel and this fuel is still inadequate. Earlier, very little digital street and address data was available for enterprises, so their digital maps had to be created more-or-less from scratch. Due to this, GIS-based projects appeared expensive, with time-consuming tasks and a slower go-to-market strategy for any enterprise investing in building map intelligence.



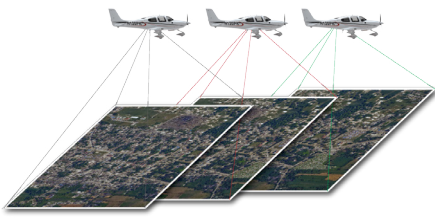
Developing interactive high precision smart maps – a quick tour

In recent times, the map building process has evolved dynamically with various technology firms been investing in developing in-house capabilities to work on digital map production. Map making process has seen various levels of evolution – from creation of static paper to active digital maps and further to production of intelligent maps through basic to complex-problem solving analysis on GIS platform.

Field based survey techniques been a time consuming process, is mostly used for special types of mapping viz. road constructions, land records, and so on. It's still widely used with the usage of GPS, electronic distance measurement (EDM) and other allied technologies.



Satellite imagery enables large scale mapping that is used for both surface and subsurface assets. It includes the satellite-based cartography of urban or rural environments, landform changes, coastal environments, and land degradation. It also enables topographic map updation, production of image maps, and agricultural monitoring.



At the same time, aerial photographs captured from air by a special camera fixed in aircraft with the camera axis vertical or nearly so, provides detailed images for agricultural mapping, mining exploration, topographical analysis, public utilities etc.

The next evolution of geospatial data creation is drone based mapping, whereby drones with high resolution cameras generates digital maps with more accurate and precise data unaffected by cloud coverage unlike aerial photographs.

In addition, GIS communities believe that better mapping can be obtained through drones than through on-the-ground survey tools.

However, the biggest technological revolution underway in the geospatial industry is the leveraging of artificial intelligence and deep learning algorithms. There is significant ongoing research on applying AI- and deep learning-based automation on spatial data. As one such case, it is being widely used in image processing techniques where computer models, trained through deep learning, identify and isolate individual objects in a landscape image. These objects are then further processed and classified using computer vision algorithms.

The popular concepts of crowdsourcing and volunteered geographic information, through empowering non-domain experts and the public to collect GIS data, have been useful in encouraging the involvement of the map users' community, and in bringing down the cost of mapping. Crowdsourced data collection is largely driven by the consumer market due to cellphone location-based services (LBS) applications.

Envisioning GeoSmart cities through the prism of digital mapping technologies

Urban ecosystem development is characterized by the growth of comprehensive infrastructure facilities providing levers for the smart management of city operations. Location intelligence is the key entity in measuring variations in urban architecture. In the modern era concept of smart cities, the core architecture of city operations revolves around the valuable information gleaned from smart maps. The real essence of smart maps includes a citizen-centric approach, real-time information, point-of-interest, location-based object monitoring, shortest possible routes and interaction with neighborhood objects.

The smart city concept and its development in India through the usage of mapping technology is helping to accomplish the vision of a smart urban community. For example, Surat has water quality monitoring system, Bangalore has a GIS system to standardize the administration of property tax, and Kanpur has an online GIS-based property tax management system to generate better revenues for civic facility investments. Below are elucidated a few such other mapping services for sustainable development of a city's infrastructure.

1. **Detailed urban base mapping and interactive visualization of surface features:**

- Satellite Imagery and GIS analysis can assist to develop intelligent maps depicting residential, commercial, administrative, and institutional zones on a regional scale.
- Urban planners can view, understand and analyze Surficial features in 3D-Urban map environment. Aerial/ Satellite photography (nadir and oblique), True ortho-photos and LIDAR data are primary sources for creating 3D-perspective and map terrain models

2. **Connecting neighborhoods - corridor mapping for transport/utility/ mobility management:**

- Alignment planning and land feasibility studies can help define land availability based on land use studies, ROW mapping, and topography.
- Base map, LIDAR, and aerial data will provide inputs for proximity analysis for road and pavement extensions, new railway alignments, and utility assets establishments.
- Base map with image data classification for land use impression can help generate updated digital parcel map and forest cover map to build confidence and define corridors for infrastructure growth & development.

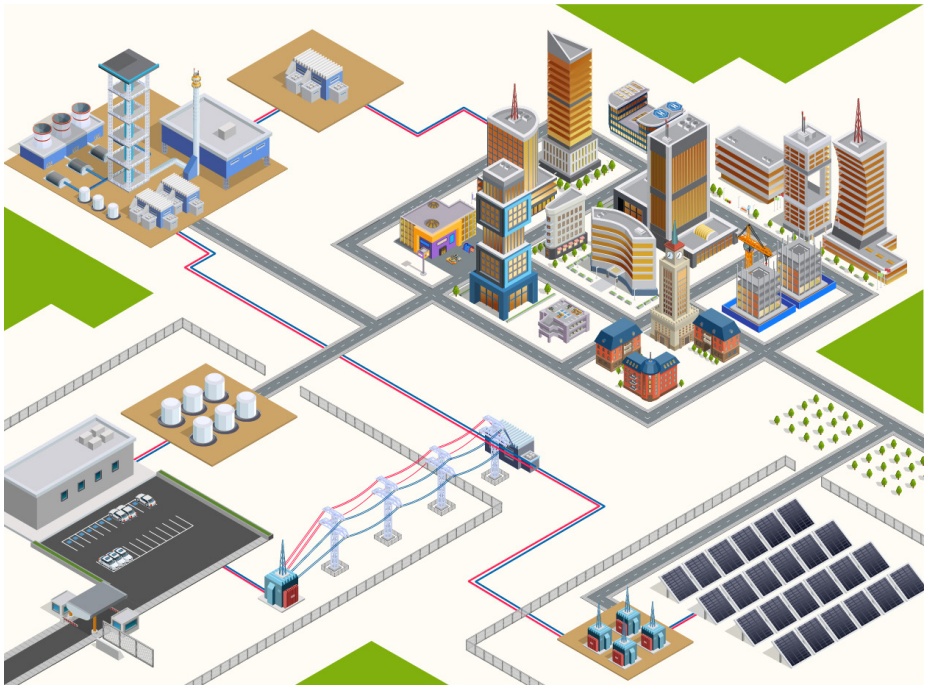


Fig: Sample ROW map representation that provides inputs on all real property assets along the highway ROW

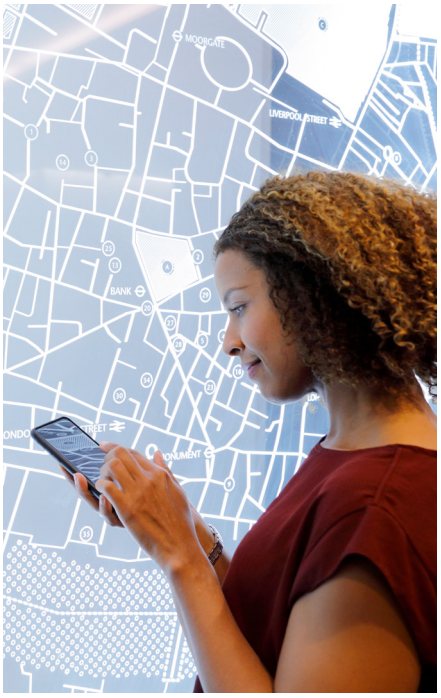
3. **Site suitability analysis for building waste disposal sites:**

- Site evaluation for landfill zones can be properly demarcated through GIS studies and multi-criteria decision analysis to ensure environmental sustainability and public health Protection.
- Local transfer stations, transportation distances, topography, hydrology of the area, and recycling centers will be part of overlay analysis to define confidence zones.
- Areas pertaining to drainage channels, human settlements, cultural heritage sites, or medical and educational institutions can be excluded through spatial analysis.

Fig: Sample waste disposal sites (confidence zones) identified from GIS-based Overlay Analysis

4. **GIS based property tax mapping and management for development of civic amenities and city municipalities:**

- City operations development in most of the urban local bodies depends on the revenue generated from property tax.
- GIS system can help mapping of land parcels and further assist in monitoring property owners complying respective tax payments.
- GIS based system would work on a dynamic, and robust framework pertaining to key parameters related to spatial property database extracted from various map sources i.e. satellite data base maps, field inspection data, and ownership details. It would provide an interactive decision support system for tax assessment of property based on the property category or other such criteria. Examples of categories include residential, commercial, industrial, institutional, vacant plot, or mixed type, and other property criteria could include area, usage, locality, or other characteristics.
- There have been several initiatives by State & central government institutions of India that has provided comprehensive GIS mapping of all land properties with unique property identifiers along with their corresponding tax payment details that has helped in monitoring duplicate land ownership and generating revenue for the respective government since all the properties are spatially located & recorded.



5. **Land use mapping and change detection analysis for urban local bodies:**

- A city becomes smarter if we can define the location of each object on its landscape, its current condition, and further monitor any improvements.
- Image data interpretation can help simulate and set a pattern to detect changes of objects on the earth surface over a time period. Thereby, changes in urban structure can be predicted over a specific, requisite timeframe.
- Land use studies for an urban area can be carried out through classifying image data into a set of clustered pixels and passing it through pattern recognition and predictive analysis.
- With GIS generated intelligent maps and the evolution of machine learning techniques, various associated algorithms can be developed to generate decision-making outputs.
- In the recent blow to the scenic state of Kerala through its worst flooding ever, aerial images have provided a good use case for detecting and depicting changes in infrastructure, standing crops, and tourism facilities, using pre-flood and post-flood image data.

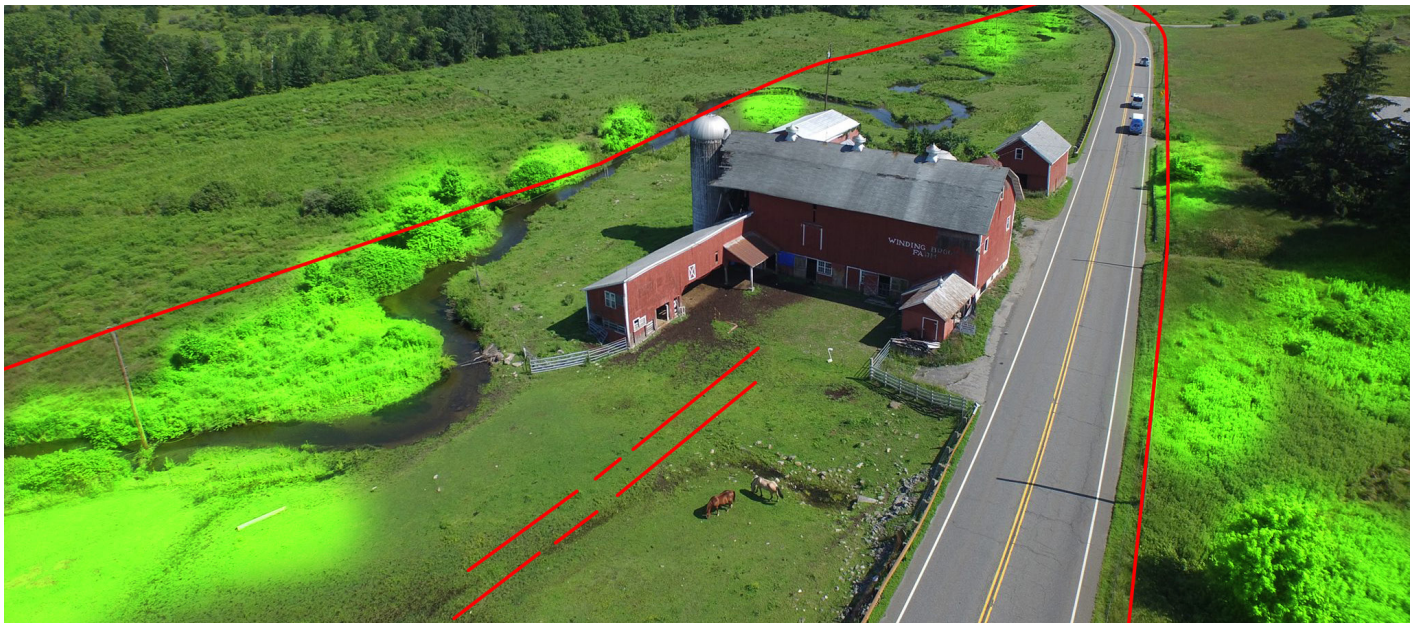


Fig: Monitoring changes in land use & vegetation cover using GIS-based change detection analysis

6. **Asset management, network mapping, and utility alignment planning:**

- GIS mapping can be carried out for underground or surface utilities and their related networks to depict assets on a map environment for key decision makers.
- High resolution mapping or 3D-models of asset schematics can enable accurate asset re-positioning. Map assets can be visualized, stored, analyzed, interpreted, and understood to reveal relationships and patterns.
- GIS can help visualize, plan, document, build, and maintain network infrastructure for public utilities.
- Map-based outputs using land parcel data will decipher zones for establishment of utility alignment.
- Machine learning techniques for the utilities market can be utilized along with voluminous geospatial historical databases to interpret patterns to deduce utilities' (water pipeline, electric transmission lines, etc.) health and possible gaps in their networking systems.
- GIS has always been used to detect potential pipeline leakages, power thefts, and so on and these can be mapped using data mining methods as well.

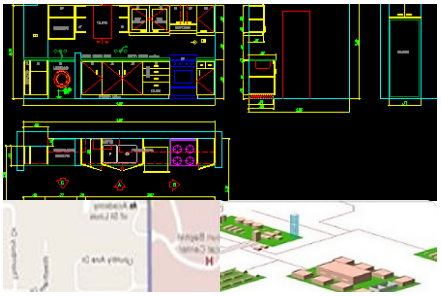
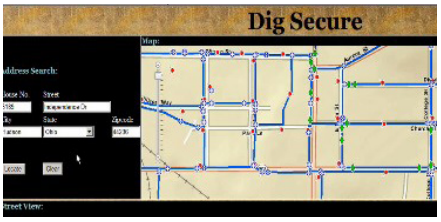


Figure: Sample representation on Public Utility Network & alignment layout on a GIS platform



The way forward

Location technologies and smart maps can greatly enable effective city operations that comply with land and other governmental regulations. Through real-time data, asset mapping, asset management, and continuous monitoring of intelligent transportation and mobility services, urban areas will become increasingly smart, safe, and sustainable. All the related stakeholders i.e. city authorities, city planners, engineers, and the general public will be aided with a decision-support system towards improving a city and helping it achieve its ultimate vision of becoming a truly smart city.

Author

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Sudeep has over 11 years of work experience in GIS, Image Processing and data management. He has delivered solutions for various industrial segments relating to Mineral & Mining, Agriculture & forestry, Land Administration & Property Tax, Disaster Management, Urban Infrastructure, Utilities. Over the years he has served large corporates, e-governance sector, large utilities, public institutions for India and overseas locations. He has worked as domain consultant for reputed e-governance projects funded by International funding agencies. Immensely involved in project management, & operation activities on large geospatial engagements, has functioned as techno-commercial personal and Solution design professional.
In his current role at Infosys BPM, he is part of Solution design team responsible for pre-sales activities, developing GIS solutions for key industrial verticals, focuses on growth of GIS data services in new segments/ geographies.

Sudeep holds a post-graduation degree in Applied Geology from College of Engineering, Anna University, Chennai and has also done his Master of Business Administration.

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