ASSOCIATION OF GEOSPATIAL INDUSTRIES

Role of Geospatial Technologies for **Urban Affairs in India**

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List of Abbreviations

AI	Artificial Intelligence
AIIB	Asian Infrastructure Investment Bank
AM/FM	Amplitude Modulation/Frequency Modulation
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
API	Application Programming Interface
BBMP	Bruhat Bengaluru Mahanagara Palike
BIM	Building Information Modelling
CAPEX	Capital Expenditures
CCP	Corporation of City of Panjim
CCTV	Closed Circuit Television
CSC-SAT	ClimateSmart Cities Self-Assessment Tool
CT	Community Toilet
CURE	Centre for Urban and Regional Excellence
DaaS	Data as a Service
DEM	Digital Elevation Model
DMRC	Delhi Metro Rail Corporation
EIB	European Investment Bank
EO	Earth Observation
ERP	Enterprise Resource Planning
ETA	Expected Time of Arrival
FDI	Foreign Direct Investment
GeoAI	Geospatial Artificial Intelligence
GHG	Greenhouse Gas
GIS	Geographic Information Systems
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMDA	Gururam Metropolitan Development Authority
GMIS	Geospatial Management Information System
GNSS	Global Navigation Satellite System
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HPEC	High Powered Expert Committee
HRIDAY	Heritage City Development Scheme
ICCC	Integrated Command and Control Centre
ICT	Information and Communication Technology
IoT	Internet of Things
ITS	Intelligent Transport System
JICA	Japan International Cooperation Agency
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
KSCL	Kanpur Smart Cities Limited
LDO	Land and Development Office
LiDAR	Light Detection And Ranging
LMIS	Land Management Information System
MC	Municipal Corporations
ML	Machine Learning
MLS	Mobile LiDAR Survey
MoHUA	Ministry of Housing and Urban Affairs
MoU	Memorandum of Understanding

MSW	Municipal Solid Waste
NCP	National Commission on Population
NEAT+	NEXUS Urban Risk Assessment Tool
NGO	Non Government Organization
NIC	National Informatics Centre
NLCPR	Non-Lapsable Central Pool of Resources
NRSC	National Remote Sensing Centre
NUDBI	National Urban Data Bank and Indicators
NUDM	National Urban Digital Mission
NUIS	National Urban Innovation Stock
OECD	Organization for Economic Cooperation and Development
OGC	Open Geospatial Consortium
OHOT	One Home One Toilet
OPEX	Operating Expenses
PaaS	Platform as a Service
PMAY	Pradhan Mantri Awas Yojana
PM-SVAMITVA	Pradhan Mantri Survey of villages and mapping with improvised technology in village areas
PT	Public Toilet
RADAR	Radio Detection and Ranging
RFID	Radio Frequency Identification
SA	Shelter Associates
SaaS	Software as a Service
SANMAN	Sanitation Manager
SBM	Swachh Bharat Mission
SCADA	Supervisory control and data acquisition
SCM	Smart Cities Mission
SCP	Smart City Proposal
SDA	Slum Dweller Associations
SDK	Software Development Kit
SLB	Service Level Benchmarks
SPV	Special Purpose Vehicle
SWEET	Solid Wast Emissions Estimation Tool
SWM	Solid Waste Management
TCPO	Town and Country Planning Organization
TCT	TERI Climate Tool
TERI	The Energy and Resources Institute
UA	Urban Agglomerations
UAV	Unmanned Aerial Vehicle
ULB	Urban Local Bodies
UN	United Nations
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
UT-DAT	Urban Transport Data Analysis Tool
WEAP	Water Evaluation and Planning System
WFS	Web Feature Service
WHO	World Health Organization
WMS	Web Map Service
XYZTA	Measurement of Geospatial data in term of Length, Breadth, Height, Time and Artificial Intelligence

EXECUTIVE **SUMMARY**

India's rapid urbanization might seem as an urgent challenge for policymakers, but it is also the reason behind the push for sustainable and efficient infrastructure development. Geospatial technologies have a pronounced role to play in this advancement, providing the right tools, platforms and technologies to achieve this vision.

The steady adoption of Geospatial technologies for smarter, data-driven urban planning & development in the country is seeing increasing support from various government, private and academic institutions in India. City planners are leveraging advanced digital mapping and location intelligence to build a solid foundation for planning, implementation and management. Real-time, accurate and precise Geospatial data is boosting instant decision-making for planned interventions.

For the Geospatial ecosystem, urban development is a key area of application. Land surveys, satellite and aerial imagery, drone surveys, and so on, are just some of the tools helping in spatial data production, analysis, updating, visualization and management for smart urban development.

This report by AGI India attempts to throw light on the state of urbanization in India, along with the evolving urban governance framework behind various national-level programmes and initiatives. Further, the report provides an overview of Geospatial technologies and their increasing relevance across verticals, highlighting interesting applications and potential capabilities for the urban development sector.

In response to the challenges that remain to be addressed, the report puts forth several recommendations, the crux being establishing a stronger relationship of central, state and local self-government institutions in the country with the Geospatial industry and other stakeholders in terms of collaboration over and adoption of Geospatial technology. The case studies and global initiatives included in the report highlight the application of Geospatial technologies in various contexts. Lastly, a list of openly available Geospatial and digital tools by global, national, and sub-national level organizations are available for reference in the annexure.

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NATIONAL INSTITUTE OF URBAN AFFAIRS

Hitesh Vaidya
Director

Message

Urbanization and economic growth are inextricably linked to each other. Economic growth often implies a paradigm progression from agrarian/rural to urban economy, with wider diversification of industries, sectors, and services. On the other hand, quality urban development has the potential to accelerate the economic growth of a nation, so long as conducive policies, sustainable practices, and effective infrastructure are in place.

As India's leading national think tank on urban planning and development, the National Institute of Urban Affairs (NIUA) is committed to the generation and dissemination of cutting-edge research in the urban sector and provide innovative solutions to address the challenges of a fast-urbanizing India. NIUA seeks to pave the way for more inclusive and sustainable cities of the future, and Geospatial technology is at the crux of such a reimagining. Cities are the engine of economic growth, and this idea is engraved in NIUA's upcoming endeavours. NIUA is now moving from the static data to more spatial data by undertaking geo spatial analysis.

Geospatial technologies are being extensively used in the sector for planning, managing and maintaining urban infrastructure, delivering citizen-centric services, and streamlining e-Governance workflows for decades now. While the Geospatial Management Information System (GMIS) includes data of all 100 Smart Cities to monitor their progress and predict key milestones, the AMRUT Mission outlines the creation of a comprehensive urban database rooted in Geospatial data collection & analysis.

On the other hand, the Swachh Bharat Mission is using Geospatial technology to verify construction of household toilets through geo-tagged, self-attested photographs. The scheme on Urban Infrastructure Development in Satellite Towns and Seven Megacities stresses on the development of city development plans integrated with 'mother cities', and optimizing land use, road networks, infrastructure distribution, employment generation, and more. State-of-the-art next-generation digital infrastructure projects such as the National Urban Digital Mission and India Urban Observatory are being built on the pillars of Geospatial insights, intelligence, and collaborative workflows.

I commend the Association of Geospatial Industries (AGI) for conceiving this all-inclusive Report on Geospatial Technologies for Urban Affairs in India and throwing light on its past, present, and potential applications for the growing needs of Indian cities.

I extend my best wishes and support to all Government authorities – Central, State, and Local – along with the Geospatial industry at large, who must together unblock existing roadblocks to realise the technology's full potential and ensure sustainable economic growth in the near future.

New Delhi
25th July, 2022

(Hitesh Vaidya)
Director (NIUA)

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FOREWORD

A major driver of socioeconomic growth, urbanization is an inevitable phenomenon in this twenty-first century for a developing country like India, which is still transitioning from its predominantly rural to a thriving urban society. The need of the hour, however, is to involve all stakeholders in an inclusive, insightful development process through the adoption of spatial planning tools.

The share of urban population in the country has reached one-thirds of the total population, while the coming decade will see an even bigger shift from rural settlements to ever-expanding urban centres. Such a vast scale of urbanization brings its own challenges, which must be addressed through the creation and maintenance of world-class urban systems by Central, State and Local Self-Governments.

As providers of Geospatial content, services, solutions and platforms, the Geospatial industry holds immense potential in terms of supporting such initiatives through accurate data, robust platforms, advanced tools and unprecedented technologies. The establishment and maintenance of a responsible, sustainable urban machinery on the pillars of technological prowess can ensure quantitative and qualitative improvement for India's urban centres.

Through this report, AGI India attempts to highlight the role and relevance of Geospatial technologies in various national projects and programmes in India, besides discussing further avenues of exploration to realize the twin goals of sustainability and efficiency in urban development.

Pramod Kaushik
President
Association of Geospatial Industries

CHAPTER 1

OVERVIEW OF URBANIZATION IN INDIA

What is Urbanization?

Urbanization refers to the process by which cities grow, characterised by the shifting and settling of an increasing number of people in urban areas. It leads to visible physical growth in the size and complexity of urban areas, or cities. Increased avenues for education, entertainment and livelihoods in better-equipped urban areas have been drawing more and more people out from their rural roots.

The world is presently undergoing the largest wave of urban growth in history. More than half of the world's population now lives in towns and cities, and the number is set to cross the 5 billion-mark by 2030. Africa and Asia pose as two major hubs of this imminent wave, and some of the biggest social, economic and environmental transformations are being anticipated in these regions in the near future.

Figure 1: Share of people living in urban areas, 2020

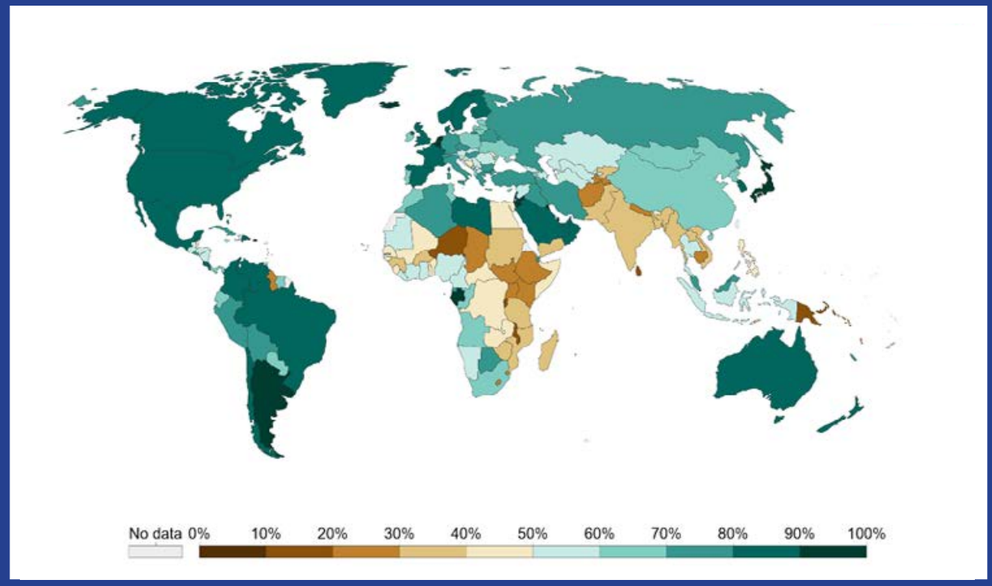


Illustration Source: Our World in Data

Understanding urbanization and cities is key to their efficient management and to prepare for the inevitable challenges that they pose. Responsible city planning, with its focus on insights and data, can bring equality, accessibility and efficiency to the urban space.

Figure 2: Key urbanization statistics, World Urbanization Prospects 2018, United Nations

700 MN INCREASE IN URBAN POPULATION BY 2030

57% OF GLOBAL POPULATION LIVES IN TOWN/CITIES

39 MN POPULATION OF DELHI BY 2030, LARGEST GLOBALLY

Geospatial data and technologies have an important role to play in this quest for responsible, well-informed urban development. Satellite images, combined with advanced Geographic Information System (GIS) analytic tools, navigation and positioning systems, sensors, aerial and LiDAR surveys can be used along with ICT and BIM technologies in zoning, urban planning, infrastructure and utility management, among other areas. With smart city planning hinged on accurate and up-to-date data from multiple sources, urban development stakeholders must now focus on developing robust applications for collection, storage, maintenance and updating of geospatial data.

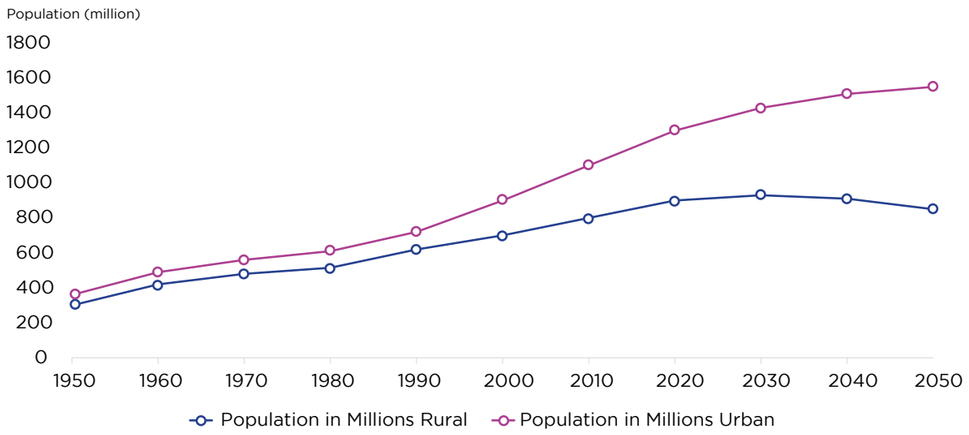
Urbanization in India

URBAN SETTLEMENTS, OR CITIES, HAVE CONTRIBUTED TO 60% OF INDIA'S GDP IN 2011

Of the total Indian population of 1210.2 million as on March 1, 2011, about 377.1 million, or one-thirds reside in urban areas.

The next decade and a half will see a massive shift of another 200 million people from rural settlements to the country's ever-expanding urban centres. This sharp trend is an inevitable product of economic change, as it is everywhere else in the world.

Figure 3: Urban and Rural Population in India; A Comparison



Source: Urbanisation and Urban Development in India, Urbanet

Undeniably, the productivity of Indian cities and towns depend on the creation and maintenance of world-class urban systems, which in turn depend on the efficiency of urban infrastructure and services.

NATIONAL COMMISSION ON POPULATION (NCP) IN INDIA PREDICTS THAT ABOUT 38.6% INDIANS WILL LIVE IN URBAN AREAS IN THE NEXT 15 YEARS, THAT IS, BY 2036.

The High-Powered Expert Committee (HPEC), appointed by the Ministry of Urban Development, stated in its 2011 report that ₹ 39 Billion (₹ 39.2 lakh crore at 2009-2010 prices) must be invested in urban infrastructure over the next 20 years in order to bridge the huge gap between demand and supply. In this light, the last decade has seen huge impetus to investments for infrastructure development, which has also shaped widespread adoption of advanced technologies.

Geospatial technologies and data have emerged as particularly significant, with recent programmes like the Smart Cities Mission, AMRUT and Metro Railway projects having adopted Geospatial components of spatial modelling, GIS-based centralised city information systems, aerial and LiDAR surveys, satellite imagery, and so on, for nationwide program implementation and monitoring .

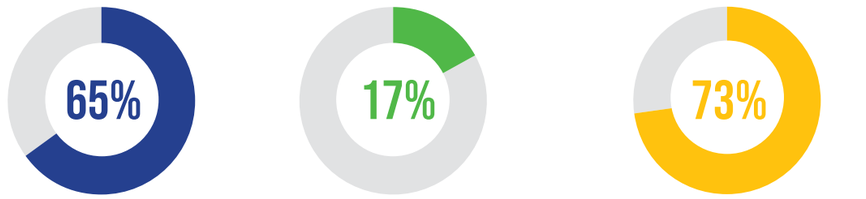
Figure 4: Various Stakeholders of Urban Development

Source: Author

Key Issues for Urban Governance in India

The rapid pace of urbanization in India has been an instrument of socioeconomic, political and cultural progress, but has also thrown in multiple challenges. These include heavy pressure on public utilities, poverty, unemployment, underemployment, social evils, and more.

Figure 5: Statistics reflecting the problems of urban development in India



No Master Plan
65% of urban settlements lack a master plan, leading to pollution, piecemeal interventions & urban sprawl

Slum Habitats
17% of the total urban population of the country lives in slums, under extremely poor living conditions

Population Share
The contribution of urban growth to the total population by 2036 is estimated to be at around 73%.

Data Source: Reforms in Urban Planning Capacity in India, NITI Aayog, 2021; Illustration Source: Author

According to NITI Aayog's September 2021 Report titled "Reforms in Urban Planning Capacity in India", no Indian city features among the top 50 cities in global rankings. "A significant portion of urbanization in the country is unacknowledged and unaddressed," the report highlights, reinforcing the importance of data-driven insights for master planning, without which urban areas are facing "piecemeal interventions, haphazard constructions, urban sprawl, and environmental pollution", among other concerns.

Data fragmentation, along with inadequate involvement of start-ups, technology developers and industry experts at the grassroots level is to blame. Obsolete and arbitrarily updated development control regulations, with no empirical evidence or data-driven decision support systems augment the challenge. Added to these factors is the deficit of human resource capacity at the lowest rungs of urban governance, where the actual fieldwork is to take place. To understand the key issues of urban development in India, we have categorized them under the following major heads.

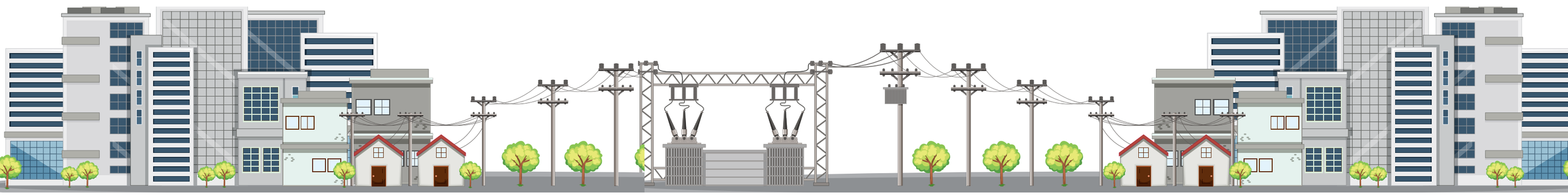
City Planning

Figure 6: Needs of the Hour for Efficient City Planning

Source: Author

Key Issues for City Planning in India

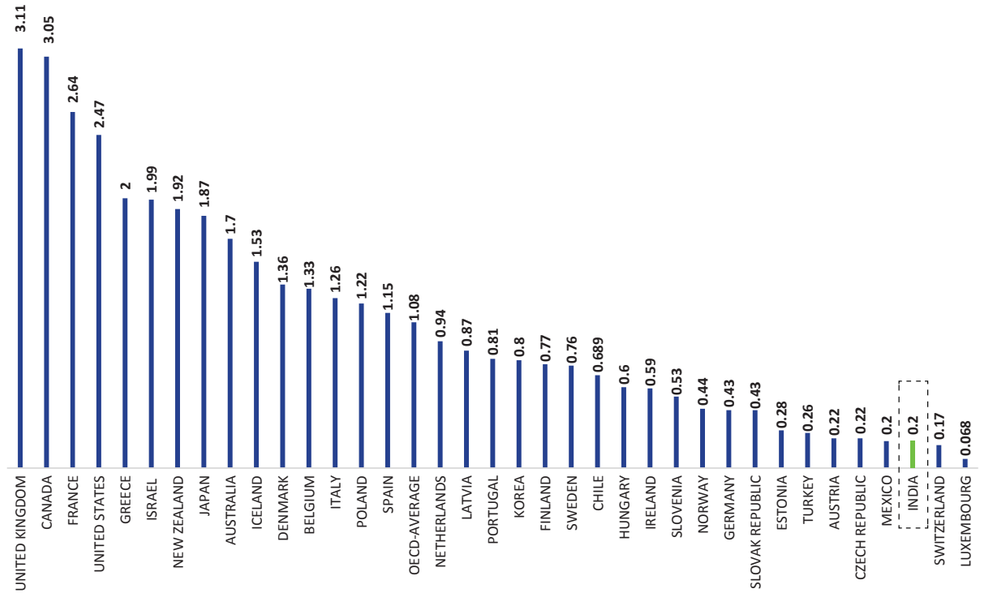
- Lack of use of modern survey technology in planning- satellite images, LiDAR, Drones, GPRs
- Lack of integration of physical, social and economic data of cities
- Little to no transparency in data collection methods
- Absence of integrated platforms for citizen participation and community input
- No common pools for stakeholders to share knowledge resources
- Lack of comprehensive spatial development strategies
- Inadequate mechanisms for storing and handling large volumes of data



Property Taxation/ Land Management

A pertinent issue authorities find themselves grappling with in the urban sector is that of property taxation management, resulting in huge loss of revenue among other problems.

Figure 7: OECD Country-Level Property Tax Revenues, compared to India



Source: World Bank Open Knowledge, Governance Global Practice Discussion Paper

Key Issues for Property Taxation/ Land Management

- Lack of regular updates on land regulations and policies
- Lack of regular updates or monitoring of taxable property
- Inadequate data support for validating property assessment
- Complex and expensive methods of property evaluation
- Lack of up-to-date maps for existing/ modified/ new properties
- Low efficiency in collection of property taxes.
- Continued use of obsolete/inadequate mapping techniques
- Gaps in linkage of spatial information to regulations
- Errors, manipulation, tampering and deviations due to manual processes
- Lack of a uniform procedure of taxation
- Maintenance of property records on papers stored in-premise

Urban Mobility

- Absence of strategic urban mobility planning
- Unprecedented escalation in the number of personal vehicles
- Lack of investment and attention to eco-friendly motorised public transport
- Lack of attention to infrastructure for pedestrians and bicyclists
- Lack of service improvements, capacity building, institutional strengthening, and awareness among citizens for public transport
- Lack of scientific surveys of traffic through Cameras or other sensor based technologies.
- Absence of optimization of public transport in terms of crew, route, frequency.
- Fragmented mobility ecosystems dividing public and private stakeholders
- Absence of municipal intervention in urban mobility planning
- Outdated technologies for the manufacturing, operations and safety of intermediate public transport (taxis, auto-rickshaws)

Climate Risk and Disaster Management

- Extreme weather events increasing at an alarming pace
- New developments ignoring spatial, geoclimatic and physical contexts
- Lack of collaboration between public and private sector
- Lack of detailed knowledge about extreme weather events among various stakeholders
- Absence of integrated databases on past disasters and present/projected data
- Absence of platforms for community participation for mitigation and response efforts
- Lack of robust data sharing systems for real-time information relay

Utilities – Water, Telecom, Electricity, Gas

- Poor quality of utilities due to inefficient assessment mechanisms
- Limited spectrum availability leading to exorbitant costs
- Tremendous pressure on civic infrastructure systems
- Poor fixed line penetration in telecom network and low broadband penetration
- Information gaps on unserved households for robust planning
- Lack of sufficient participation from the private sector
- Highly fragmented and scattered data across organizations, departments and groups
- Absence of well-developed data repositories that are updated from bottom up

Sanitation and Sewerage

- Limited data available or processed on wastewater collection
- Lack of real-time information updates leading to dearth of preventive maintenance or even damage repair
- Lack of awareness among households about faecal sludge management
- No maps or spatial data available for sewage systems in cities. Non availability of gradient maps

Solid Waste Management

- Lack of proper facilities to ensure safe and timely transportation of solid waste
- Inadequate monitoring systems to keep track of garbage transportation
- Waste dumping and open burning still prevalent and not being tracked down
- Lack of training and environmental awareness on solid waste management, coupled with low availability of qualified waste management professionals
- Unclear regulations and enforcements hindering innovations in the segment as well as attraction of investments for adequate funding
- Lack of real-time information on quantities, characterization, waste management and treatment options of the solid wastes for various stakeholders

CHAPTER 2

LEVERAGING GEOSPATIAL TECHNOLOGIES FOR URBAN AFFAIRS

Overview of Geospatial Technologies

Geospatial technologies and data are not new for the urban sector. For decades, central and state ministries as well as ULBs have been using Geospatial technologies for planning, managing, and maintaining city infrastructure and delivering citizen-centric services. Now, with advancements in data capture methods, availability of miniaturized high-performing sensors, improved connectivity, and computing power, supported by liberal policies, integration of various forms of data has become easier. This is helping expand the value and impact of Geospatial technologies application in the urban landscape.

Geospatial Technologies is an umbrella term that represents a variety of tools and technologies used to capture, store, process, share, disseminate and analyse information about the Earth's environment and objects on and below the surface. Today, Geospatial data can be measured in 5 dimensions, including Length, Breadth, Height, Time, and Artificial Intelligence (XYZTA).

With the addition of AI capabilities, Geospatial technologies can help in diagnosing problems based on the spatial dimension more easily and effectively. It thus helps city administrators in evidence-based planning and addressing issues more effectively. Geospatial technologies hold the potential to provide a one-stop interface between the Government and the citizens, ensuring seamless and integrated access to various governance functions and services.

Geospatial Technologies

EARTH OBSERVATION

Definitions: Technologies that capture information about Earth's surface through various sensors mounted on satellites or airborne vehicles, including aeroplanes, drones etc.

Urban Sector Applications: Identifying change in land use patterns, disaster risk management, monitoring urban green cover

SURVEYING

Definitions: Technologies used to make relatively large-scale, accurate measurements of the Earth's surfaces, including the determination of the measurement data, reduction and interpretation of the data to usable form, and, conversely, the establishment of relative position and size according to given measurement requirements. These include LiDAR, RADAR, GPR etc.

Urban Sector Applications: Cadastral mapping, property taxation, 3D city models

GLOBAL NAVIGATION SATELLITE SYSTEM & POSITIONING

Definitions: GNSS provides precise position or geographic location of people, equipment or things that are attached to device that includes a GNSS chip. Data about the location is gathered from a system of navigation satellites that cover the entire globe. The US GNSS – GPS is the most popular. GNSS chips are fitted in IoT sensors and Survey equipment too.

Urban Sector Applications: Identifying spots of utility leakage, traffic monitoring and control

GIS OR SPATIAL ANALYTICS

Definitions: A Geographic Information System (GIS) is a conceptualized framework that provides the ability to capture and analyse spatial and non-spatial data. GIS helps integrate different data layers for enabling spatial-based decision making.

Urban Sector Applications: Site selection, Predicting & managing disasters, Integrated Command and Control Centres

Facilitators

IoT Sensors – Sensors of all kinds are fitted with GNSS chips providing precise timing and location information. They are being used for assessing water levels, checking levels of pollution, analysing garbage density and many other urban functions.

Cloud Computing - Cloud computing technology uses the internet for storing and managing data on remote servers, and then access data via the internet. A Geospatial cloud platform can provide software-as-a-service (SaaS)-based with functions like analytics and visualization capabilities and applications. Geospatial datasets and maps can also be provided over Cloud platform to users that can be immediately employed in their applications. Also cloud platforms can be used to deliver dynamic dashboards during emergencies like Covid.

Big Data Analytics - Big data analytics is the use of advanced analytic techniques against very large, diverse big data sets that include structured, semi-structured and unstructured data, from different sources, and in different sizes from terabytes to zettabytes. Geospatial data is a typical example of Big Data sourced from a variety of sources used to develop analytics about our world.

AI/ML - Artificial intelligence (AI) is the ability of a computer to simulate human intelligence and perform tasks commonly associated with human beings. A subset of AI is Machine Learning (ML) that refers to the concept that computer programs can automatically learn from and adapt to new data without being assisted by humans. The scientific field of Geospatial Artificial Intelligence (GeoAI) combines innovations in spatial science and AI/ML, data mining, and high-performance computing to glean meaningful information from spatial big data.

Integrated Command and Control Centres

City administrations are moving towards integration of real-time data from IoT sensors, crowdsourced data, data from social media platforms, drones, roads and traffic sensors, smart grids, as well as information from various line departments into an Integrated Command and Control Centre (ICCC) that can operate & manage multiple city service operations including real-time monitoring & improvement of service delivery.

INDIA HAS 88 OPERATIONAL ICCCS, INCLUDING AGRA, SURAT, JABALPUR, VARANASI, BENGALURU. REMAINING 29 SMART CITIES ARE FOLLOWING SUIT

Source: MoHUA

Digital Twin

CITIES CAN EXPECT TO SAVE $280 BILLION BY 2030 WITH THE DEPLOYMENT AND USE OF DIGITAL TWINS.

Source: ABI Research

Digital Twin is a virtual representation of the real world, including physical objects, processes, relationships, and behaviours. Geospatial technology is a prerequisite for building a Digital Twin ecosystem through connection of different types of data and systems to create a single view that can be updated, changed, and accessed on a real-time basis on a cloud platform that can provide data access and delivery. Digital twins can allow the simulation of plans before implementing them and expose problems before they become a reality. Hence, they can prove to be extremely useful for city administrators for monitoring and managing energy consumption, waste management, security monitoring, mobility improvements, and infrastructure management.

IT Infrastructure

At the heart of leveraging Geospatial technologies for urban affairs lies digital transformation of the ULBs or city administration, thus unlocking agility, boosting operational efficiency, and enhancing innovation potential for users. Hence, the need for the right compute resource is critical. The core drivers of choosing the right digitalization model are:

Performance
respond quickly to data integration

Reliability
maintain performance, reliability and serviceability as systems grow in size and complexity

Analysis
derive greater value from the datasets.

At the same time, having the right processing power, storage power and cyber security provisions are key considerations for leveraging the power of Geospatial technologies for urban administration.

Cloud infrastructure provides access to on-demand Cloud facilities without the hassles of managing the underlying infrastructure and dealing with the related investment and maintenance costs.

Potential Application of Geospatial Technologies in Urban Sector

Urbanization comes with its own set of challenges. For better management, city administrators need to see the world (or their jurisdiction) as a single ecosystem and Geospatial Technologies can help them in doing so. Taking an ecosystem approach to look at the interplay between various subsystems like social, economic and environmental helps city administrators make data-informed actionable decisions. Some of the key ways that Geospatial technologies help local governments are enumerated below.

City Planning

City or Urban Planning is the designing and planning city infrastructure and layout in a way that lends to improved mobility, better environmental monitoring, accessibility to key resources like offices, hospitals, schools, parks, recreation etc. City planners need to manage changes in urban sprawl due to population growth, for which they need a variety of information like environmental data, socioeconomic data, land use maps and plans and planning applications. Geospatial technologies can help in city planning by providing a tool for database creation, spatial analysis and modelling and visualisation.

Tools

1. Modernizing & Visualization
2. Spatial Analysis
3. Database Creation

Applications

1. Demand Assessment for services
2. Gap Identification in services and infrastructure and to pllan accordingly
3. Creating alternate plans
4. Evaluation of planned development

GIS enhances data capture and integration, improves real-time visualization, provides advanced analysis and automation of future predictions, and allows for information sharing and collaboration. Thus, it can help in monitoring land use change and serve as a single window to access historic data and data from various sections/departments. By overlaying existing land development on land suitability maps, city planners can identify areas of conflict between the environment and potential development. It can also provide connectivity measurement, such as how easy it is to walk or bike in a city. Geospatial technologies can further help in impact assessment of urban development on the environment and assist in the evaluation of planned development.

Property Taxation

For city administrators, the main source of revenue comes in the form of property tax. Property taxes are geographically tied to the city jurisdiction, providing a steady and assured source of revenue, besides power and autonomy to the administration, allowing them to spend it as per their own volition.

Tools

1. Satellite Imagery
2. Field Surveys
3. GNSS Technology
4. Drone Survey

Applications

1. Preparation of property parcel maps / building foot prints
2. Tax assessments
3. Tapping Tax Evaders
4. Understanding Population Density Distribution

In order to assess the optimal amount of property taxation, local bodies need to have current, updated and accurate cadastral data. This is how Geospatial technologies get tied to property taxation and city governance, since preparation of precise and accurate cadastral maps require the use of high-resolution satellite imageries, survey and GNSS technologies. Further, GIS technology can provide an analytical tool to city administrators to establish a property and tax management system that layers records of property with property tax jurisdictions of commercial, residential, and industrial units. This enables them to tap tax evaders, understand population density distribution, plan better citizen services using property tax information.

The ongoing Government of India scheme – PM-SVAMITVA is a case in point, which is utilising maps created by drone surveys of village abadi (populated) areas for preparing accurate maps and generating property cards for village homeowners. These cards can be used as collaterals and provides them ownership rights.

Urban Mobility

One of the key tasks at the hands of ULBs and city administrators is to provide convenient and economical mobility options to its citizens that are inclusive, environment friendly and sustainable. Geospatial technologies play a crucial role in achieving these objectives, while making it convenient for administrators to monitor urban mobility systems. These technologies are used for large scale spatio-temporal analyses of mobility patterns, thus helping citizens make appropriate mobility decisions. With the integration of sensors, IoT devices, AI and ML having become popular today, tasks such as behavioural predictions, real-time scenario evaluation and projections analysis has become extremely easy.

GNSS chips fitted in multi-modal transportation systems allows assimilation of real-time data about the location, speed, and direction of public transportation. Integrating information from such sources onto one GIS platform or providing it through APIs and SDKs can help build an intelligent urban mobility solution that can guide people in planning their movement from point A to point B, after enabling them to consider all options for completing the journey, including walking, taking a bus/metro/rickshaw or walking another stretch of the road etc. It can also help in route planning based on latest information on roadblocks, enroute construction/digging, traffic congestions etc.

Tools

1. Spatio-Temporal Analysis
2. Behavioural Predictions
3. Real-Time Scenario Evaluation
4. Projections Analysis

Applications

1. Mobility Decisions by Citizens
2. Transportation Route Development
3. Optimal Resource Utilization

Spatial analysis also allows city administrators to plan for developing new transportation routes based on key variables like demographic distribution, city layouts, environmental and geological considerations etc. This leads to optimal utilisation of resources while yielding fruitful results.

Further, real-time parking information can also be fed into the integrated system to provide citizens information on the number of parking slots available and their location. All such data can be made available on a citizen centric app or through other means of communication that can allow people to plan their movement better, while saving time and resources.

Climate Risk & Disaster Management

Geospatial technologies have a key role to play in all stages of Disaster Management Operations, i.e., prevention, preparedness, mitigation, response, and recovery. Municipal authorities establish disaster management plans, create early warning systems, emergency response mechanisms, capacity building, disaster, climate change mitigation strategies, evacuation plans, early system recovery and coordination of government agencies. City administrators can apply Geospatial technologies for climate risk and disaster management in the following ways.

Tools

1. Digital Elevation Models
2. Large Scale Topographical Maps
3. Real-Time GIS Visualization

Applications

1. Disaster Risk Assessment
2. Evacuation Route Analysis
3. Warning & Communications
4. Sustainable Recovery Planning

Prevention and Preparedness – Large scale topographical maps and Digital Elevation Models can be used by city administrators to assess the terrain and slope of the area. Along with that, high resolution cadastral maps can add another layer of critical information for understanding population spread, location of hospitals and other emergency facilities, routing for emergency and dividing the urban area into risk zones. Additional data related to air temperature, rain discharge, humidity, pressure, wind speed, and high-water level can be used for making environmental sensitivity index and vulnerability maps.

Mitigation and Response – Using high resolution satellite imagery and other remotely sensed and in-situ data, timely interventions can be mitigated to avert large scale damage. GIS provides real-time visualization of spatial risks and resources and analyzes evacuation routes to safe area.

Through Integrated Command and Control Centres (ICCCs), city administrators can monitor and mitigate disaster risks and create appropriate interventions. They can also use social media and other broadcast systems to communicate about disasters, alerts and preparatory interventions.

Recovery – Recovery phase deals with rebuilding of life and resources post disaster. Again, use of Geospatial data such as base map, topographic map and Digital Elevation Model (DEM) in reconstruction and rehabilitation processes after disaster is very critical as it will provide information for design and sustainable planning.

Lack of information in the event of a disaster leads to slow access, ineffective and negligent post-disaster recovery. ULBs can plan a collaborative approach, involving various agencies in the planning process, through integration, information dissemination and environmental space interactions within the city.

COVID Response

The case of the Novel Corona Virus pandemic as an unparalleled emergency and disaster management incident warrants a special mention here. Geospatial technologies helped local governments to better understand the spread, manage the outbreak, ensure location-based containments and lockdowns and eventually monitor and roll out vaccination plans.

Tools

1. Spatial Analytics
2. Predictive Analysis

Applications

1. Contact Tracing
2. Monitoring Isolation & Quarantine
3. Rolling Out Vaccination Plans

Using smart devices, like smartphones, that are pre-fitted with GNSS chips, governments could undertake contact tracing of individuals and obtain a verifiable record of their movement and those they had been in close physical contact with. Once a tracked individual tests positive for COVID-19, tracing technology helps governments to determine who all might have been infected by analysing their recent interaction history. Then these contacts are alerted for testing or to go for self-quarantine.

> **"50 CITIES THAT USED ICCC AS WAR ROOMS FOR COVID RESPONSE, INCLUDING MANAGING MIGRANT MOVEMENT, BED AVAILABILITY ETC. FARED MUCH BETTER THAN THOSE THAT DID NOT USE THE TECHNOLOGY. THE EFFECTS WERE MORE VISIBLE DURING THE SECOND WAVE."**
>
> **Kunal Kumar**
> Joint Secretary, Smart Cities,
> MoHUA at Esri India User Meet

Geospatial technology helped local governments use spatial analytics in the form of dashboards that can provide historic and near real-time information on the disease spread. These GIS-based COVID-Tracker dashboards show various key parameters like coronavirus hotspots, disease heat map, and provide information on the number of positive, negative cases, patients recovered, daily case count, trends, age groups affected, etc. to help in data-driven decision making. Predictive analysis of likely hotspots based on data analytics can also be done.

Local bodies have converted their Integrated Command and Control Centres (ICCCs) to COVID-19 war rooms by integrating various technologies like CCTV monitoring, GIS mapping, real-time dashboard and analytics, helping in tracking, testing, monitoring, isolating, quarantining and treating the patients at the earliest, thereby helping minimise the spread of the virus.

Utilities – Water, Telecom, Electricity, Gas

Tools

1. High-Resolution Satellite Imagery
2. Drone-Based Mapping
3. LiDAR
4. Ground Penetrating Radar

Applications

1. Network Tracing
2. Asset Lifecycle Management
3. Realtime Operations of utility
4. Leakage analysis

Another important responsibility of city administration is to ensure uninterrupted supply of utilities like water, telecom, electricity, gas etc. Even though AM/FM (Automated Mapping/ Facilities Management) GIS systems have allowed utility providers to digitize, manage and analyse their utility network data, the improvements in data capture methods, such as high resolution satellite imagery, drone-based mapping, LiDAR, Ground Penetrating Radar, smart sensors, even crowdsourced smartphone locations & social media posts, enhanced GIS integration with Supervisory Control and Data Acquisition System (SCADA) and Enterprise Resources Planning (ERP) systems have greatly improved the management and operation of assets and utilities.

Further Big Data Analytics and Cloud computing arraying all these diverse sources are providing useful data and predictive capabilities to city administrators. For utilities, the cloud can be used to develop proprietary software using PaaS (Platform-as-a-service), for leveraging available solutions under SaaS (Software-as-a-service) or for aggregating data from different sources like Geospatial, IoT sensors, customers, clients, transactions, volunteered data, data from social media under DaaS (Data-as-a-service), and so on.

Sanitation and Sewerage

For the purposes of sanitation and sewerage management, Geospatial technologies offer several benefits. They can be used to measure access to water and sanitation facilities within the city jurisdiction, for mapping settlements lacking household sanitation, to study the existing drainage networks, and as a smart planning tool to devise effective strategies. Further, using cloud solutions, GIS-based platforms can be accessed and analysed anytime, anywhere, regardless of the location or device. This facilitates data representation and helps to identify gaps in delivery of sanitation services.

Tools

1. Waste Water Data models for capturing Asset data and operations data
2. Mobile GIS Tools for Asset Information capture
3. Tools for elevation analysis, Asset life cycle
4. Network tracing tools

Applications

1. Analysing Distribution & Access
2. Identifying Leaks & Damages
3. Sewerage Network Tracing
4. Asset Lifecycle management
5. Tracking Repairs & Upgrades

By layering information on several features, like sewer access locations, gutter lines, garbage bins, roads, water stand posts, taps, and community toilet blocks, along with household-level data, GIS systems can run complex queries to check whether all houses on the map are numbered, measuring proximity to water supply and drainage, identifying the occupancy of the structures, identifying the location of waste collection etc.

Physical surveys done through sensor-fitted drones can enable wastewater managers to spot the occurrences and location of leaks. City administrators can use historical GIS data to prioritize on-going system maintenance, which can help engineers make more cost-effective decisions when dealing with troublesome leaks and when implementing repairs and upgrades.

Hydraulic modelling consists of a mathematical model used to calculate the hydraulic qualities (flow) of water to and from a sewer system. Integration of GIS has allowed wastewater utilities to keep up with system attributes such as pipelines, valves and storage tanks. GIS databases can be used for recording pipeline installation dates and for verifying diameter, along with identifying future changes to system workflows in the network, which could be caused by additional demand. This information is then plugged into the hydraulic model to give engineers a comprehensive view of how changes in the network can affect the amount of flow (hydraulics) from a wastewater plant and throughout a sewer system.

GIS can also be used to identify type, age and condition of sewer and wastewater infrastructure and can provide a graphic interface of the qualities to managers and engineers. These applications can be used to track repairs and upgrades, along with the installation of new infrastructure, and this information can be recorded and stored in a GIS database for easy retrieval at the touch of a button.

Solid Waste Management

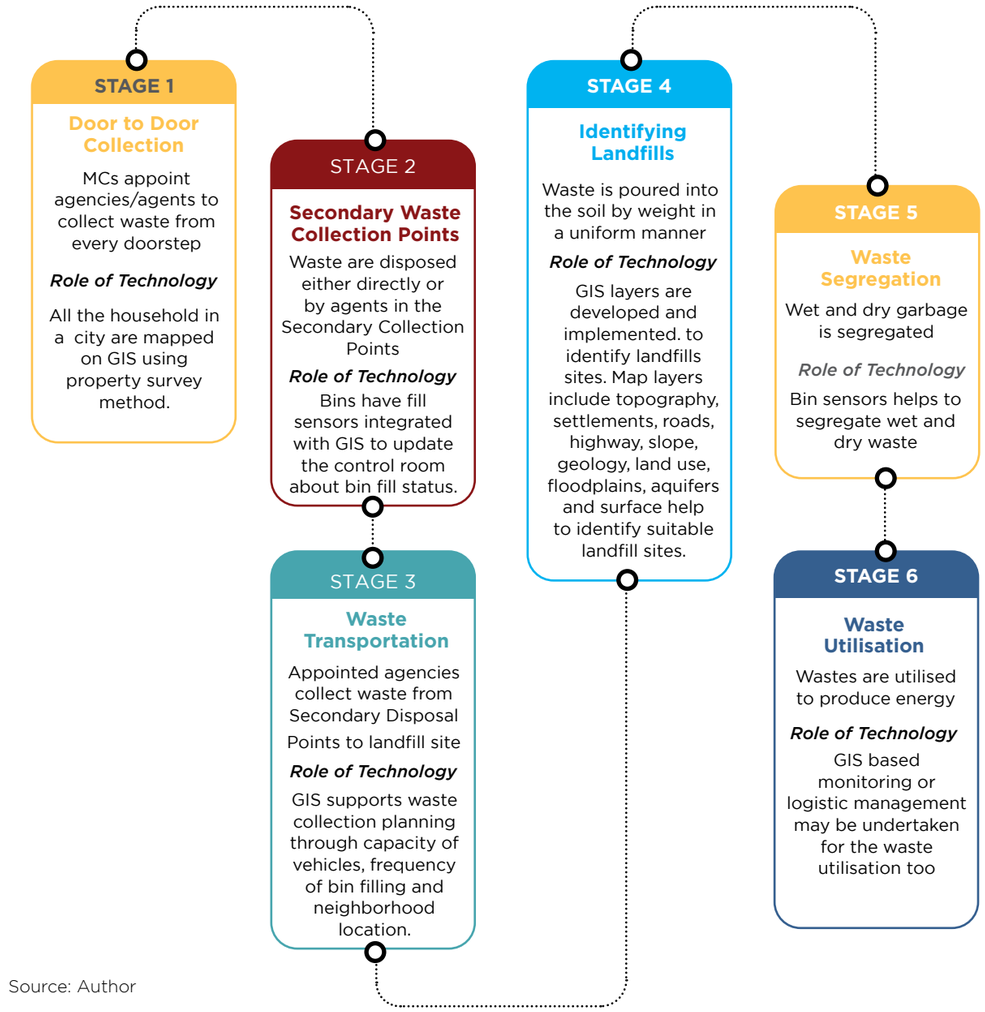
Solid Waste Management is the process of collecting and disposing of solid waste materials that comes from residential, commercial, industrial, and institutional activities, consisting of both hazardous and non-hazardous components like product packaging, waste cloth, glass and bottles paints, batteries, industrial waste etc. Thus, it becomes crucial to handle such waste properly and responsibly for better environment and public health.

Municipal authorities are responsible for devising rules for waste management and developing infrastructure for collection, storage, segregation, transportation, processing, and disposal of solid waste. This requires establishment of integrated Municipal Solid Waste (MSW) management systems coupled with new age technologies like Geographic Information System (GIS), Internet of Things (IoT), and sensors to help decision makers reach their final goal in keeping cities clean.

Geospatial technologies play a role in the six-staged SWM cycle.

1. **Door-to-door collection** - Households are mapped on GIS based platform using property survey method and connected to a control room via Radio-Frequency Identification (RFID) or mobile app to monitor the status of waste collection.
2. **Secondary Waste Collection Points** - Wastes are disposed to a Secondary Collection Point, where GIS along with IoT and sensors helps develop an optimal routing system for better collection of waste. GIS data helps pinpoint the location of bins. These bins are sensor-enabled and indicate when they fill up, transmitting the information immediately to Integrated Command-and-Control Centres. This complete process reduces distance and time for the collection vehicle fleet to reach designated locations. GIS also helps in reallocation of waste bins and complete redesigning of the collection sectors.
3. **Waste Transportation** - In this stage, GIS supports in defining the route of the vehicle based on capacity of vehicles, the frequency of filling of community bins/secondary waste disposal sites and the time taken for waste transportation. GIS supports in optimizing the routes. Vehicles attached with GPS can be tracked in real-time and reports can be generated on stoppage locations and duration. The weighbridge reports may also be integrated with GIS to understand the utilization of the vehicle capacity and transportation.
4. **Identifying landfill sites** - Geospatial technology helps to identify suitable landfill sites for different criteria using GIS map layers including topography, settlements, roads, highway, slope, geology, land use, floodplains, aquifers, and surface water. These are evaluated and used for preparing MSW disposal plans. Thematic maps of the chosen criteria are developed on a GIS software. All the data layers are obtained and prepared from the related maps by scanning, georeferencing, geo-rectifying and digitizing the relevant information, after which the collected information is compiled and used to establish the buffer zones for each layer. The Analytic Hierarchy Process (AHP) method is often used to analyse the data for landfill site selection and the output map is prepared.
5. **Waste Segregation** - Segregation is done either at Secondary Waste Points or at landfills where fill sensors can be put separately on wet garbage and on dry garbage to ease the process.
6. **Waste utilisation** - With technological advancement, it is now possible to generate energy from Municipal Waste. GIS based monitoring or logistics management may be undertaken for the waste utilization also.

Figure 8: Stages of Solid Waste Management and the Role of Technology



Source: Author

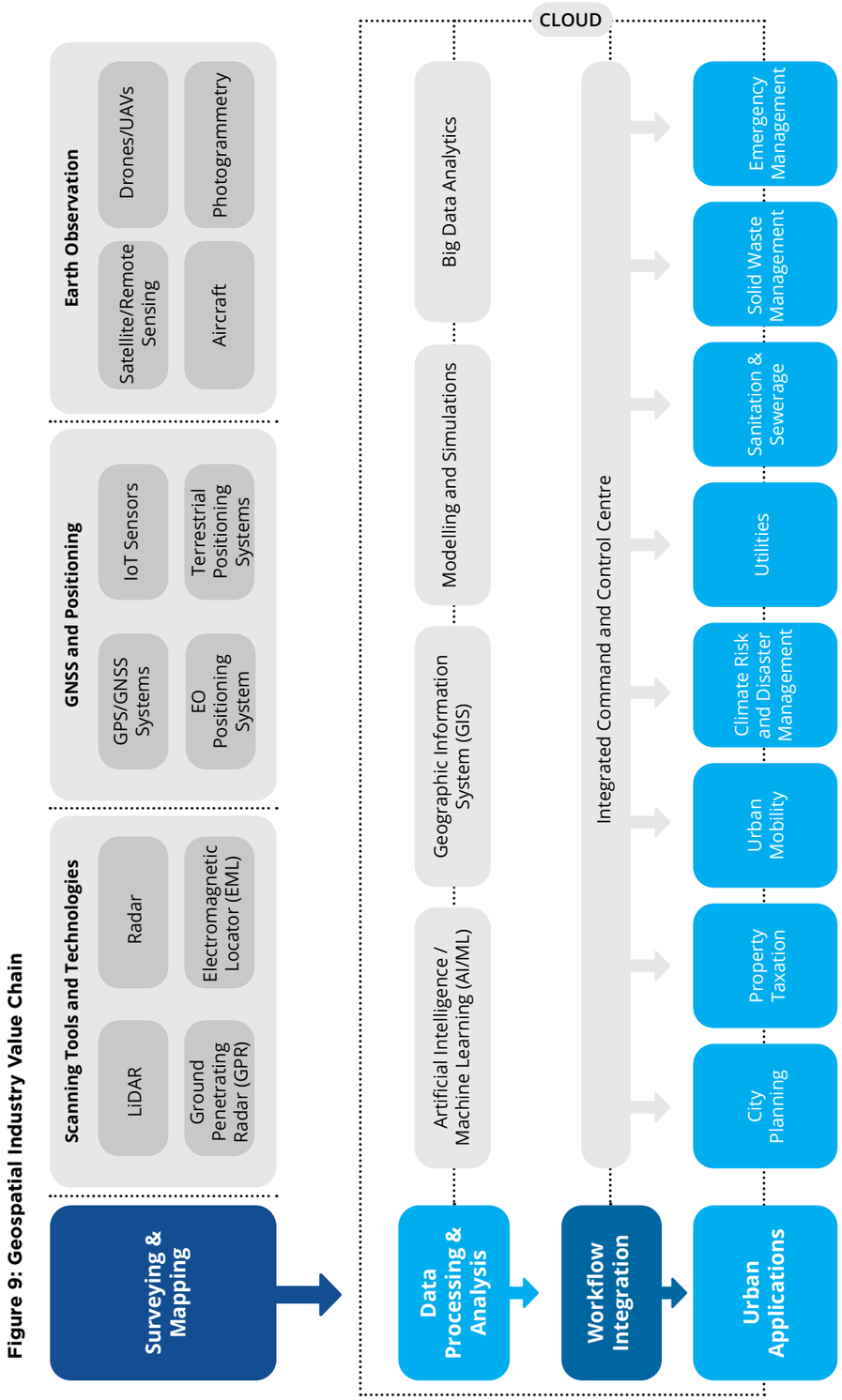


Figure 9: Geospatial Industry Value Chain

Source: Adopted from Geospatial World Analysis

Geospatial Technologies Application in Indian Urban Sector Programs

In recent times, the Government of India has given tremendous boost to the Geospatial sector by proposing Geospatial Guidelines, Draft Geospatial Policy, Drone Rules and proposed Remote Sensing Policy that are all set to unleash the potential of Geospatial information and technologies for various industries by making geospatial data collection and distribution liberalised. In addition, initiatives, like Gati Shakti, National Urban Digital Mission, Geospatial Energy Map, Survey of India Online Maps and Digital portal, are making government geospatial data linked and openly available to ensure data availability for use and integration.

Geospatial Management Information System (GMIS) integrated with the new Smart Cities Mission website is a web-based, spatially-enabled management tool that acts as a one-stop access to Geospatial data of urban areas in the country, derived from multiple sources and featuring search/filter options by topic and geographic area. The India Urban Data Exchange open-source platform was also launched, set to facilitate secure, authenticated, and managed exchange of data among various platforms, third-party authorised applications, and other sources.

Some of the specific use cases and examples are outlined below.

SMART CITIES MISSION

Launched in 2015

Mandate:

Smart Cities Mission (SCM) aims to promote sustainable and inclusive cities that provide core infrastructure and give a decent quality of life to citizens, a clean and sustainable environment, and application of Smart Solutions.

100 cities were selected to build an entire ecosystem of complete and integrated planning. This is being achieved through key strategic components, including:

1. City improvement: Retrofitting
2. City renewal: Redevelopment
3. City Extension: Greenfield Development

The objectives are to be achieved either on an area-based development plan or via pan-city initiatives in which Smart Solutions are covering large parts of the city. Pan-city operational efficiency is to be achieved through implementations of Integrated Command and Control Centres (ICCCs).

Budget Outlay:
INR 20,50,000 crores

Geographic Coverage: 100 Smart Cities across different States/UTs of the country

Responsible Agency/ Stakeholders: Urban Local Bodies, Special Purpose Vehicle (SPV) for each Smart City, Ministry of Urban and Housing Affairs (MoHUA)

Smart Cities Mission *continued.*

Geospatial Technology Applications:

- 40-layer **GIS Mapping** proposed
- **Smartnet knowledge sharing platform** launched by NIUA for exchange between cities, practitioners, academia, researchers, and technologists.
- **Integrated Command and Control Centers (ICCCs)** rolled out across 75 cities; likely to be set up in all 100 Smart Cities by 2022. Several ICCCs transformed into COVID war rooms to deal with pandemic response.
- Information on food distribution centres, shelter homes and kitchens collated and made accessible via Google Maps.
- **Geospatial Management Information System (GMIS)** – a Smart Cities Dashboard - created including data of 100 cities, 6000 projects worth Rs. 2,00,000 crores launched to collate information from varied sources, compare how cities and states are performing, monitor progress and even predict when certain projects will reach specific milestones.
- **India Urban Observatory** operationalised as a GIS-enabled interactive showcase of collective insights on cities over various parameters. Data collected through IoT, APIs, open-source databases, sensors, and third-party sources including citizens and social media offering Geospatial insights of various urban development parameters.
- **National Urban Digital Mission (NUDM)** launched in February 2021 with an array of digital infrastructure & tools for Smart Cities:

Smart Cities Open Data Portal (SCODP):

- Provides a single point of access to datasets and blogs published in an open format by 100 Smart Cities. It is a platform for sharing of data which can then be used by multiple stakeholders (municipal/ line departments, research institutes, academia, and industries, start-ups, etc.) to generate actionable insights.

Smart Code:

- Launched to serve software development demand of cities through data & solutions for various urban problems

India Urban Data Exchange (IUDX):

- BCompletely open source, based on an underlying framework of open standard APIs, data models, and the security, privacy and accounting mechanisms that will facilitate its easy adoption across the digital ecosystem. Helps cities in using data intelligently to address complex urban challenges.

Urban Platform for deliveryY of Online Governance (UPYOG):

- Program will assist the municipal bodies across India to improve service delivery mechanism, achieve better information management & transparency and ensure utmost citizen's involvement in participative governance.

Urban Outcomes Framework 2022:

- Initiative to develop a transparent and comprehensive database based on cross-city outcomes across sectors for time series analysis and progress tracking to drive evidence-based policymaking.

ATAL MISSION FOR REJUVENATION AND URBAN TRANSFORMATION (AMRUT)

Launched in 2015

Mandate:

- AMRUT mission focuses on 11 reforms and 52 milestones to be implemented by 500 Mission Cities in different States. The reforms are - e-governance, constitution and professionalisation, augmenting double entry accounting, urban planning and city level plans, devolution of funds, review of building by-laws, set up financial intermediary at state level, municipal tax and fee improvement, improvement in levy and collection of user charges, credit rating, energy and water and Swachh Bharat Mission.
- There are 5 thrust areas of the Mission, including:
  1. Water Supply
  2. Sewerage Facilities and Septage Management
  3. Stormwater Drains to Reduce Flooding
  4. Pedestrian, Non-Motorized and Public Transport Facilities, Parking Spaces
  5. Enhancing Amenity Value of Cities by cleaning and upgrading green spaces, parks, and recreation centres, especially for children.
- During the process of planning, the Urban Local Bodies will strive to include some smart features in the physical infrastructure components.

Budget Outlay: Committed Central Assistance of INR 35,990 crores. INR 14,100 crores allocated to Smart Cities Mission and AMRUT Mission for 2022-23. 100% centrally funded sub-scheme of GIS-based Master Plan with budget outlay of Rs. 515.00 crores.

Geographic Coverage: 500 AMRUT cities covering all states.

Responsible Agency/ Stakeholders: Urban Local Bodies (ULBs), Ministry of Urban and Housing Affairs (MoHUA), NITI Aayog, Ministry of Jal Shakti, Ministry of Environment, Forests and Climate Change (MoEFCC), State Governments

Geospatial Technology Applications:

- Sub-scheme of Preparation of Master Plan using GIS launched with 3 major components: Geospatial Database Generation, Masterplan Formulation, Capacity Building.
- Urban Geodatabase at a scale of 1:4000 to be created. Final geodatabase of 104 towns and draft geodatabase for 104 towns prepared till 2020-21.
- Sub-Scheme of Local Area Planning & Town Planning Scheme was launched on a pilot basis for 25 cities, involving detailed area survey, mapping of physical & social infrastructure on GIS platform, land use mapping, and GPR assessment.
- AMRUT 2.0 proposes GIS based master plans of Class-II Towns with population of 50,000 - 99,999.
- Capacity Building at 3 levels

SWACHH BHARAT MISSION (SBM)

Launched in 2014

Mandate: Phase 1 of the Swachh Bharat Mission lasted till October 2019, while Phase 2 is being implemented between 2020–21 and 2024–25 to help cement the work of Phase 1. The mission aimed to achieve an "open-defecation free" (ODF) India by 2 October 2019, the 150th anniversary of the birth of Mahatma Gandhi through construction of toilets. The second phase of the mission aims to sustain the open defecation free status and improve the management of solid and liquid waste, while also working to improve the lives of sanitation workers.

Budget Outlay: INR 1.41 lakh crore from 2021-2026. INR 2,300 crores allocated for SBM Urban for 2022-23.

Geographic Coverage: Entire country.

Responsible Agency/ Stakeholders: Ministry of Urban and Housing Affairs (MoHUA) – Urban, Ministry of Jal Shakti – Rural; Implementation Partners: State Governments, ULBs; Development Partners: Bill and Melinda Gates Foundation, USAID, ADB, WHO, UNICEF, GIZ, UN, World Bank, EBTZ

Geospatial Technology Applications:

- **Bharat Maps** – a multi-scale, multi-resolution, multi-layer GIS platform built on a service-oriented framework by National Informatics Centre (NIC) launched to integrate API-based OGC-compliant (WMS, WFS, etc.) map services with e-Governance workflows associated with flagship programmes of the Government, including SBM.
- **Self-attested geo-tagged photographs** being used for final verification of constructed household toilets, along with the applicant. Photographs uploaded to SBM (Urban) MIS and monitored by ULBs and States.
- **Partnership between MoHUA and Google** to map all public /community toilets on Google maps, along with unique IDs given to CT/PTs.
- **Compendium and dynamic GIS portal** launched by MoHUA showcasing innovative practices for effective solid waste management (SWM) practices from across India on 2 Oct 2020.
- **Swachh Survekshan** entirely integrated with GIS in 2021 with two distinct components of data collection through mobile app and monitoring complete project progress.

PMAY

Launched in 2015

Mandate: Pradhan Mantri Awas Yojana (PMAY) aims to provide affordable housing to first time homeowners. It has a target to build 2 crore pucca homes with basic amenities like gas, electricity, and water by 2022. The scheme has two sections – PMAY – Urban and Gramin.

Under the scheme, central assistance is given to Urban Local Bodies (ULBs) and other implementing agencies through States/UTs for:

- In-situ Rehabilitation of existing slum dwellers using land as a resource through private participation
- Credit Linked Subsidy
- Affordable Housing in Partnership
- Subsidy for beneficiary-led individual house construction/enhancement.

Budget Outlay: INR 48,000 crores for 2022-23.

Geographic Coverage: Entire country

Responsible Agency/ Stakeholders: Urban Local Bodies, Ministry of Urban and Housing Affairs (MoHUA) - Urban

Geospatial Technology Applications:

- **Bhuvan-MoHUA Web Geoportal** developed to monitor the progress of the beneficiary houses at five different stages under Pradhan Mantri Awas Yojana (PMAY)
- **PMAY (U) MIS** (Management Information System) integrated with BHUVAN Portal of NRSC and BHARAT MAP of NIC for monitoring construction progress of individual houses through geo-tagging.
- **Geotagging of photographs** depicting the stage of construction completed used to deploy Direct Benefit Transfers (DBT) to Beneficiaries of BLC (Beneficiary-Led Construction) vertical of the Mission by States/UTs.

URBAN TRANSPORT

Since 1984

Mandate: Through the National Urban Transport Policy (2006) and Metro Rail Policy (2017), impetus is given to states for developing integrated urban mobility options for citizens. As a result, many cities are working on Metro Rail Projects. As of January 2021, India has 760.62 kilometres of operational metro lines and 540 stations. 1,016 km of Metro and RRTS systems are under construction in 27 cities.

Budget Outlay: FY 2022-23 Budget included:

- INR 19,130 crores for Metro projects
- INR 35 crores for Transport Planning and Capacity Building in Urban Transport
- INR 4,710 crores for National Capital Region Transport Corporation

Geographic Coverage: Delhi, Kochi, Mumbai, Gurugram, Lucknow, Chennai, Bengaluru, Nagpur, Ahmedabad, Kolkata, Jaipur, Agra, Bhopal, Hyderabad, Indore, Kanpur, Meerut, Noida, Patna, Pune, Surat

Responsible Agency/ Stakeholders: State Governments, Ministry of Housing and Urban Affairs, Funding Agencies like JICA, AIIB, EIB

Geospatial Technology Applications:

- **Digital Twin** with an asset management system implemented by Maharashtra Metro Rail Corporation Ltd for Nagpur Metro Asset Information Management System with the goal of eliminating information loss over the lifecycle of the project. Location of each of the 5,00,000 assets comprising the systems recorded to enable viewing of the location of the asset on a map with the click of a button in SAP, leading to estimated savings of INR 1,658 crore over 25 years of operation of the metro rail system.
- **Advanced LiDAR survey** completed by Kochi Metro Rail Limited (KMRL) along with all major surveys for its project to regenerate canals in Kochi, prepare detailed topographic maps, conduct a bathymetric survey, and to map the sub drains joining the canals. Data collected for the study of Social Impact Assessment, and water quality studies.
- **3D mapping of all stations** undertaken by the Delhi Metro Rail Corporation (DMRC) to combat terror threats in the Delhi Metro.
- **DMRC and Google Maps collaboration** to add metro routes, fares, platform details and connectivity information on the platform for passenger ease.
- **REVIT and BIM modeling** being used by DMRC for managing architectural drawings and construction for asset through drone-based survey. These surveys generate accurate topographic maps with orthophoto, base maps and volumetric analysis resulting in high resolution actionable photogrammetry information.

PAST INITIATIVES

HRIDAY

Launched/Completed from 2015-2019

Mandate: The aim of HRIDAY scheme is to bring together urban planning, economic growth, and heritage conservation in an inclusive manner to preserve the heritage character of each Heritage City. This includes the development of core heritage infrastructure projects including revitalization of linked urban infrastructure for heritage assets such as monuments, Ghats, temples etc. along with reviving certain intangible assets. It also includes development of sanitation facilities, roads, public transportation & parking, citizen services, information kiosks etc.

Budget Outlay: INR 500 crores.

Geographic Coverage: 12 cities: Ajmer, Amritsar, Amaravati, Badami, Dwarka, Gaya, Kanchipuram, Mathura, Puri, Varanasi Velankanni, Warangal.

Responsible Agency/ Stakeholders: Ministry of Housing and Urban Affairs, State Governments, Urban Local Bodies, NGOs, Spiritual Organisations, Private Sector

Geospatial Technology Applications:

- **Digital Heritage and GIS mapping** of historical locations/tourist maps and routes to increase physical and intellectual access.
- **GIS-based mapping of cultural and natural heritage assets** for heritage documentation leading to Heritage Management Plan.

URBAN MAPPING SCHEME

Launched/Completed from 1992-2004

Mandate: The scheme envisaged preparation and updating of existing base maps to be used by various agencies like Town Planning Departments, Local Bodies, Public Works Departments, Services and Utilities Agencies, Taxation Department, Directorate of Survey and Land Records, etc. A pilot scheme for 53 towns was taken up during the Eighth Five Year Plan.

Budget Outlay: Initial allocation was INR 4.57 crores which was increased to INR 20.39 crores due to increase in area under mapping, costs and change in technology from analogue photogrammetry to digital mapping. Total expenditure incurred under both phases of the Scheme eventually amounted to INR 20.19 crores.

Geographic Coverage: 25 towns from 6 states in Phase 1, 28 towns from 19 states in Phase 2.

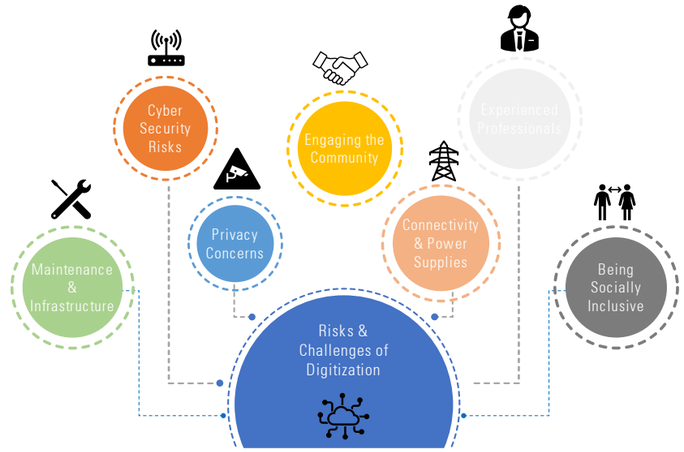
Responsible Agency/ Stakeholders: State Governments, Ministry of Housing and Urban Affairs, Funding Agencies like JICA, AIIB, EIB

Geospatial Technology Applications:

- **Large-scale urban maps** using aerial photography for 53 towns prepared, then shared with respective State Town Planning Departments
- **Base map preparation**, broadly organized into 107 feature classes corresponding to 5 land use classes - Built up structure, contours, open space/ forest, river/canal and road/rail.
- Layers with sub-features like forest and plantation boundaries, official, industrial building, contours (thick and thin), river, ponds, river fill, stream (single and double), road (metal and un mettaled) footpath etc.
- **Maps used for updating Masterplans** by the Town Planning Departments and by other allied agencies such as Water Supply Board, Telecom Department. etc.

Challenges

Figure 10: Risks and Challenges of Digitization in Urban Sector



Source: Author

Even when application of Geospatial and Digital technologies bears several advantages for the urban sector, in terms of providing an evidence-based, data-driven decision-making tool, improving citizen service delivery, saving resources, costs, efforts, and improving project turnaround time, there are several risks and challenges associated with it too.

1. **Maintenance of infrastructure –** Complicated and costly infrastructure needs to be installed and maintained for continued data generation, integration and use. The system also needs to be agile and have provisions of design flexibility for future scaling up.
2. **Cyber-security risks –** As IoT and sensor technology use expands, so does the threat level to security. Criminals can gain access to the data for illegal activities, hence cyber-security risks need to be managed adeptly.
3. **Privacy concerns –** There is a rising concern for privacy in the minds of citizens. Hence, authorities need to have a strategy that is clearly outlined and communicated on how the data collected will be managed and stored.
4. **Engaging the community –** The successful roll out of technology-driven citizen services must also involve the community voice. This will mean implementing a process for educating the community on its benefits and use. There is thus a need for online education platform that keeps citizens engaged.
5. **Being socially inclusive –** While implementing any new technology for citizen services, care needs to be taken about its affordability by the residents and also ensure that all sections of society are able to be equally catered. Thinking of these communities will improve the overall success.
6. **Need for technical experts –** Currently there is a big technical skill gap in city administrations, as far as digital and geospatial technologies are concerned. Moving forward if we are looking at wider implementation of technology, we need skilled resources at all levels for strategical preparations, identifying areas for implementation of technologies, and operating tools.
7. **Connectivity and power supply –** The basic requirement of uninterrupted power supply and strong 24x7 connectivity is needed for successful implementation of geospatial and digital technologies.

CHAPTER 3

RECOMMENDATIONS

Key recommendations for public and private sector enterprises to further the adoption of Geospatial technologies in Urban Sector are outlined below.

DATA

Currency of Data

To be useful, geospatial data must be updated continuously as it is not static information. Decision makers at the ministry, city administration and ULBs need to make appropriate provisions for continuous data update and publish it through open platforms.

Data sharing and dissemination

While a lot of steps have been taken to make the data that is developed using public funds openly available and accessible to government departments, citizens and industry, several urban local bodies and city level departments still find accessing relevant and actionable data a challenge. The industry too faces the same issues while implementing any urban project. For example, information on water hydrants are required by fire and disaster departments, but managed by hydrology department in municipalities, or in case of satellite towns there are areas that fall under different ULBs, unless data is shared effectively between such organizations, it cannot be put into effective use.

Quality of data

At the city level or ULBs, there is still a prevalence of using analogue data, or multiple versions of the same data within the same department with no metadata attached on captured date. This leads to data overload, which may not be of use to anyone. Hence, ULBs and city administrators need to invest in quality check, ensuring each dataset has appropriate metadata tags and development of Geospatial data management systems for proper use of the technology.

Developing Indoor GIS of key public buildings

The 26/11 attack in Mumbai's Taj Hotel was an important event that highlighted the need for indoor navigation data of key public buildings. However, more than a decade later, indoor mapping and GIS has not yet become a pervasive reality in India. Cities and ULBs need to work with the private Geospatial industry to develop indoor maps and GIS of key public buildings like hotels, hospitals, malls etc so that these can be used by citizens to better navigate through these buildings, while emergency responders and service providers can utilise the data for delivering services.

Adopting strategies to use crowdsourced information

A lot of the data generated by citizens through smart phones and other devices have accurate geospatial information and are vital for managing city issues. For example, reporting of potholes, reporting instances of fire, crime, power breakdowns etc. can be derived in real-time from authentic sources allowing authorities to take immediate action.

ECOSYSTEM

Deeper involvement of geospatial private sector

The Geospatial industry has expertise not only in surveying, mapping, and other data capture methods, but is also skilled in developing 3D models, providing Geospatial services, solutions, platform development and analytics. If the Geospatial industry is given the responsibility to develop platforms, while the government authenticates the data, all stakeholders stand to benefit. As a Public-Private-Partnership exercise, it can enable equal liability and responsibility on both the entities while delivering platforms that are user friendly and that create value for the users.

Adopting a holistic approach

GIS is often only thought of as a system for property taxation, land use planning, and zoning or master plan development. However, the potential of Geospatial technologies goes far and beyond. Public sector agencies need to develop a holistic approach for deploying Geospatial solutions by developing interlinked data with efficient outcomes. More integrated GIS data yields higher productivity and efficiencies.

SKILLING AND EDUCATION

Skill and Capacity development

Capacity development is required not only for increasing understanding of geospatial technologies role and relevance for the city administrators and ULBs, but also on how to increase adoption, how to integrate it with digital technologies, and methods of implementation. The Geospatial industry can play a role of hand holding agencies while implementing a new technology, as they often lack relevant human resources in required numbers who are proficient in geospatial or digital technologies.

Geospatial education and orientation

Apart from skill development, there is a need to orient officers in urban local bodies and city administrators on the larger value of Geospatial technologies, its long-term return on investment, short term benefits, comparative analysis of different technologies etc. Till date, GIS is mostly perceived as a good visualization tool, but its analytical capabilities are not yet understood and explored by most public sector users. Stories of good practices and successful implementation need to be shared as peer-to-peer examples or case studies given by technocrats to strengthen the idea. Industry too needs to engage in Proof of Concepts to convince potential users.

POLICY

Industrial Development Strategy

Geospatial Artha Report, 2021 proposes the establishment of Geospatial Industrial Development Strategy that holds the potential to jump start the Geospatial industrial capacity from a service-oriented industry to a solutions-oriented one. The strategy calls for forming a Geospatial Industry Development Board, building partnerships and collaborations with National Geospatial Organisations, creation of a Geospatial Industrial Fund, improving project bidding processes, enhancing local manufacturing capacities, leveraging international capabilities to ensure competiveness in projects, rolling out Public-Private-Partnerships for reducing data duplication, deciding on data acquisition projects and leveraging data collected by private players in national data repository, and lastly investing in Geospatial incubation centres and contract R&D for building next-generation geospatial technologies.

Such an initiative will have a significant impact on the overall Geospatial ecosystem, including the urban sector, as it will ensure wider adoption of Geospatial technologies.

CHAPTER 4

ANNEXURE

Annexure 1

Case Studies

Case Study 1: **City Planning**

Enterprise GIS Portal for Spatial Data Mapping

Location: Kanpur

Kanpur Metropolitan Region, sprawling over an area of 260 sq km, is the biggest city and the main commercial, industrial and educational centre in the state of Uttar Pradesh. As per the Government of India's guidelines, the Kanpur Municipal Corporation has formed a separate Special Purpose Vehicle (SPV) as Kanpur City Limited for the implementation of projects under the Smart City Mission.

The proposal for Kanpur Smart City includes the retrofitting of 1475 acres adjacent to the south bank of Ganga into a vibrant all-day-round destination. Poised to reflect the city's image, this region would serve as an economic engine with 'Sampann', a walkable, well-connected mixed-use area with 'Sachal', a model for achieving social equity with 'Sakriya', and a low-impact carbon neutral model with 'Swasth'. The Kanpur Smart City envisions an inclusive, vibrant city of opportunities with efficient urban services, sustainable growth and healthy living, keeping Ganga, industries and commerce in focus.

Project Focus

Challenges

Robust infrastructure development and management for Kanpur Smart City Limited (KSCL) would depend on the collection of information on different verticals with respect to citizen amenities, education, emergency facilities, travel and transport, healthcare facilities, and so on.

Gathering authenticated data from the Kanpur Municipal Corporation, and designing a geodatabase for KSCL despite limited spatial information available for this purpose was proving to be a formidable challenge.

At the same time, making data and solutions accessible for various hierarchical roles was challenging, considering the rapid growth of Kanpur city, the accompanying demand for infrastructure and technology and, thus, the involvement of diverse stakeholders. The need of the hour was to have a holistic GIS solution that takes care of different verticals associated with city management and offers visualization and analysis functions for timely decision-making.

The Solution

The KSCL Enterprise GIS portal was set up with a new geodatabase that helped capture spatial data related to mapping of various components in the smart city, such as various administrative boundaries, drains and water supply infrastructure, emergency services, building footprints and local points, civic, education and transportation facilities, and so on.

The same portal is in use during the COVID-19 pandemic for mapping of affected areas and residents, thus helping the city administration obtain a clear view of the situation to take timely action for curbing the disease spread.

Together with an enterprise geodatabase, the Enterprise GIS portal offers identity management, authentication and authorization for KSCL city admins, employees and consumers, a web application for data viewing, querying, map printing, dynamic report generation and advanced spatial data editing, as well as an Android-based mobile application for field data collection, logging field activities, geofence-based data viewing and advanced spatial data editing.

The GIS solution encompasses various tools and functionalities, including Basemap Selection Feature, Layer Selection Module, Map Module, Tools Module, Measurement Tool, Routing, Place Search and Redlining functions, as well as Map Printing, Shapefile Import and Map Navigation functionalities.

Key Benefits

- Various smart city assets gathered, inclusive of citizen amenities, education, emergency facilities, travel and transport, healthcare facilities, smart parking, and so on.
- Flexibility of adding more data layers to the scalable geodatabase, which serves as the backbone of the KSCL GIS solution.
- Security and ease of web access to all spatial and non-spatial data and services
- Simplified visualization and understanding across verticals, including sign boards, traffic cameras, number plate detectors, and so on
- Editable spatial data with data modification policies and data validation rules enforced
- Facilitation of use of routing services for optimized location and multimodal transport facility finding
- Web maps exportable in various available formats

Case Study 2: **City Planning**

Geospatial Management Information System

GMIS (Geospatial Management Information System) was made open to the 100 Smart Cities of India in December 2020 by the Ministry of Housing and Urban Affairs (MoHUA) as a revamped Management Information System for all existing/ new Smart City Projects. Formally launched in February 2021, the system has been used effectively by MoHUA for real-time monitoring the progress of 7,000 + projects worth over USD 30 Billion.

The objective behind the creation of GMIS was to provide better insights for mission management, create an extensive data repository of important mission-related data, introduce geospatial capabilities, and create a single engagement and monitoring platform for all officials involved in mission implementation. Geospatial mapping of projects with watermarked tags containing project ID, date and time, location in latitude and longitude opens new horizons for evidence-based planning, project monitoring, evaluation, and providing the information for policy making

Project Focus

Challenges

Before the introduction of GMIS, the existing MIS lacked geospatial visualization capabilities. Moreover, several operational challenges prevented the department from achieving desired outcomes.

To better connect with cities, state officials, and other Smart City stakeholders on the Smart Cities Mission efforts and achievements, MoHUA was looking for a system that can collate all project- related data in real-time and enable effective monitoring of projects. The challenge was to have an intervention that can provide inputs for policy formulation from all the reports which can be created through this data.

The issues were deeply analyzed, culminating in the conceptualization and design of the new platform GMIS, with superior capabilities than the earlier MIS in terms of mission management.

The Solution

To ensure a streamlined flow of real-time information, MoHUA created a Geospatial Management Information System (GMIS) based on three guiding principles: Principle of Inclusivity, Principle of Competition, Principle of outcome orientation.

More than 7,000 Smart Cities projects have been mapped using GMIS, enabling knowledge of geo-coordinates, physical & financial progress, and viewing recent photos for every ongoing and completed project. The photos have been uploaded by cities using a mobile app which is configured on ArcGIS Survey123 for updating and visualizing the project status and progress of work.

Modules of GMIS :

1. Ranking Module: To track the city's performance and benchmark other cities towards achieving the Smart City goals.
2. Smart City Performance Module: To give visibility to the rank's movement w.r.t original rank to current rank.
3. Reports: To generate various reports for different cities on all ongoing projects, geo-tagged projects, updated projects, and active/inactive projects.
4. Output-Outcome Measurement Module: To provide information of various outcomes and impacts being generated by the Mission.
5. SDG Module: To align Mission performance with the achievement of SDGs.
6. Vendor Repository Module: To provide a view of existing vendors and adds new vendors for different smart city projects to have a record in place while providing transparency, ownership of projects, and SLAs.
7. City Progress Module: To provide visibility of the physical progress of the projects in a city.
8. NIP (National Infrastructure Pipeline): Launched in August 2020, NIP is meant for Augmenting India's infrastructure through Identifying key projects for investments.

Key Benefits

- Provides accessibility anytime and anywhere.
- Collaboration between cities, states, and central government through one single application.
- Supports the mission in generating project-related data, which acts both as a source of truth and an instrument for data management and evidence-based project monitoring.
- Seamlessly integrates mobile-based data collection, geo-enabled MIS, geospatial dashboards, knowledge repositories over one platform.
- Ensures better investments in the projects for citizens, improving their living conditions.
- Provides real-time information to key stakeholders.
- Provides a comparison between cities, states, and thus helps in defining strategies for further action.
- Serves as a program management tool that helps in feeding policies from all the reports which are created with help of data available on GMIS.
- Monitoring of smart city projects at the city, state, and center through geospatial dashboards providing details of milestones achieved.

Case Study 3: **City Planning**

Digital Twin for city planning and citizen engagement
Location: Dublin

The ability to create a digital representation of a city through digital twins is a powerful tool to simulate the physical assets of the city that can be updated and changed in real-time. Digital Twins enable more resilient decisions when it comes to building or improving physical infrastructure by providing a holistic view of all the various factors affecting urban development at the city level. At the same time, digital twins also support and improve sustainability, circularity, decarbonization and overall quality of urban living. These digital twins can be published online and explored by all urban development stakeholders, including citizens, to experience urban interventions, interact with them and report their feedback from time to time.

Project Focus

Challenges

It was envisaged that smart urban development of the city of Dublin must be based on continuous engagements between technology providers, researchers and citizens for improving the quality of life. However, there were not adequate resources or mechanisms for such an engagement, more importantly, for the different stakeholders to access and understand crucial data related to Dublin's urbanscape.

Besides, any further innovations would require continuous evaluation of multiple infrastructure types, all of which must be studied in a real-world environment where they are interdependent, instead of discrete imaginations. With a population of 1.2 million, Ireland's capital city of Dublin is already being developed as a smart city, meaning there are several layers of information to be handled simultaneously for a more comprehensive approach to data handling.

The Solution

With the help of some of the world's leading technology providers, the Dublin City Council is creating an interactive virtual environment to ensure that citizens can provide their inputs towards urban planning and development from the safety of their homes, while development projects are on track. A digital duplicate of the entire city's physical environment, the Dublin Digital Twin will be built on massive, cumulative, real-time, real-world data across an array of dimensions.

The physical assets of the city will be relayed through specs, drawings, documents, BIM models and detailed analyses using advanced geotechnology. IoT feeds, sensors, drones, cameras, LiDARs and point clouds will be deployed for the massive data collection and generation processes spanning the entire city. The Digital Twin created will offer immersive 3D and XR visualization, a 4D timeline of change and integration with AI/ML for analytics and visibility.

Key Benefits

- An adaptable and scalable solution established for future urban planning and public engagement in the city
- Visualization of infrastructure and development in their contextual environments, being used by actual people in real-time
- Greater control over complex processes and systems across various verticals in city planning, development, operations and maintenance
- Optimization of efficiency by predicting failures in real-time
- Services costs set to be reduced with insights on development in the real-world

Case Study 4: **Property Taxation/ Land Management**

Geospatial-Based Cloud Solution for City Revenue Collection
Panaji Municipal Corporation

Property taxes are the primary source of financing the development of urban infrastructure and carrying out of city operations. The vicious cycle of inadequate infrastructure leads to inefficient assessment systems for properties in cities, which leads to a huge gap in property tax collection. While a country as geographically and demographically vast as India is capable of generating $50 billion per annum in property taxes, only 37% of this amount ends up getting collected every year.

Project Focus

Challenges

The Panaji Municipal Corporation, Goa, undertakes property tax assessment based on the unit area of properties, with tax being payable on the per-unit price of the built-up area of the property concerned. The municipal corporation collects three different kinds of taxes depending on the property type – house tax for residential buildings, trade license fees for commercial buildings, and signage taxes for signboards.

As people from neighbouring rural areas constantly change geographies, shifting their base to urban areas, the ULB's inadequate data collection systems pose a persistent challenge. Not only was the dataset used for tax collection incomplete, but also massive shortcomings in realizing appropriate revenues for citizens were felt for years.

The Solution

To help streamline the process of tax collection for the Panaji Municipal Corporation, an online property tax solution based on a robust GIS platform was created. This cloud-based software solution enabled intelligent revenue management using data analytics for collection and analysis of residential and commercial property data. Data from different locations within the city were collected and integrated in real-time, enabling timely updates and database completion.

The entire process of tax collection was digitized and consequently updated with baseline maps linked with real-time property tax data. The integrated database holistically covered all-round information on property usage and ownership, along with geo-tagged photographs for complete transparency.

It was due to the deployment of this integrated technology that the Panaji Municipal Corporation realized that only 79% of the city's properties fell under the CCP House Tax net, while 21% were not taxable. 23% buildings that were not stated under the CCP database were located, 61% businesses that were not formerly paying due commercial taxes were identified, and 47% of due signage taxes not raised in a long time were detected. With these and other findings, the ULB managed to increase its tax collection revenue by INR 5 million in a single ward.

Key Benefits

- Efficient data management by the ULB without an expensive infrastructure integration
- Enabling of data field validation helped in capturing missing features
- GPS devices aided door-to-door property data capture for detailed assessment
- Region-wise real-time updates of property ownership and total tax collection supported

Case Study 5: **Sanitation and Sewerage**

Spatial Data Analysis for Household Sanitation Planning

Pune

India is the largest open defecating nation in the world, with more than 600 million having no access to sanitation facilities. In Maharashtra alone, more than 11 million people are affected by sanitation-related issues in these poor communities and slums. Sanitation problems are symptomatic of larger and more prevalent issues associated with inadequate infrastructure in these often-neglected neighbourhoods of the country.

Established in 1993 in Pune, Shelter Associates (SA) is a Civil Society Organization that aims to convert informal settlements into housing societies for the poor. Their goal is to provide cleaner and safer environments to retain the community spirit and give access to basic services like water, sanitation, electricity, and so on. The launch of the Swachh Bharat Mission in 2014 gave an impetus to SA's work, driving it towards its "One Home, One Toilet" (OHOT) model.

Project Focus

Challenges

City sanitation plans for informal settlements in India – if they exist – are frequently based on secondary data. They do not contain a detailed understanding of the existing infrastructure or topography. This data forms the foundation of delivery of any service at city level, empowering urban local bodies (ULBs) to explore innovative solutions, carry out micro-level interventions, and bridge the gaps by providing housing and sanitation facilities.

The Solution

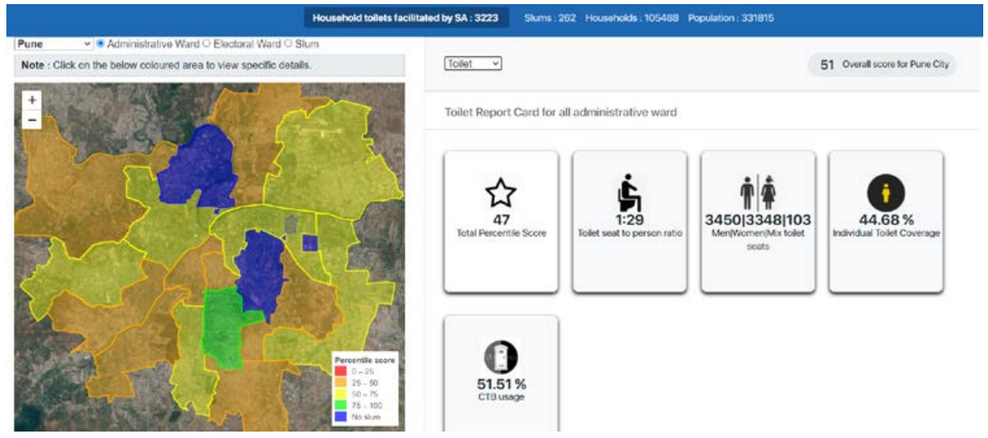
Community-led sanitation solutions based on an inclusive approach were made the pillars of the household sanitation planning programme in Pune, which uses an open data-agnostic platform for collation, analysis and study of relevant ground information. The efficient utilization of Geospatial data helps map informal settlements lacking household sanitation and for studying any existing drainage networks, besides providing a comprehensive, real-time dataset needed to strategically target slums for intervention.

The data is subsequently published on Google Earth, enabling open viewership for all. In addition to providing a portable dataset, the platform also offers accuracy and cross-querying tools that enable different teams to integrate data effectively. This helps strategically target those households that lack sanitation, prioritizing the efficient delivery of toilet to households with the greatest impact. They can also efficiently coordinate community mobilization activities and accurately monitor and track toilet construction processes.

Key Benefits

- Setting up of a robust spatial data platform helps pinpoint gaps in delivery and families lacking access to basic sanitation services
- Construction of individual toilets facilitated
- A forum created for discussion on sanitation issues in the country, thus driving awareness

Figure 11: Toilet Report Card for all Administrative Wards, Pune



Source: Shelter Associates Dashboard

Case Study 6: **Urban Governance**

GIS-Enabled Collaborative Platform for Intelligent Decision Support System

Gurugram

Gurugram Metropolitan Development Authority (GMDA) is responsible for the planned development of the area under the authority which is currently estimated to be covering 675 sq km. The main function of GMDA is to prepare policies, plans and proposals for guiding GMDA's planned development. In order to accomplish the mission of GMDA, to be a major support in governance by embedding GIS in all aspects of decision-making, planning and management, Onemap Gurugram was developed by GIS division of GMDA.

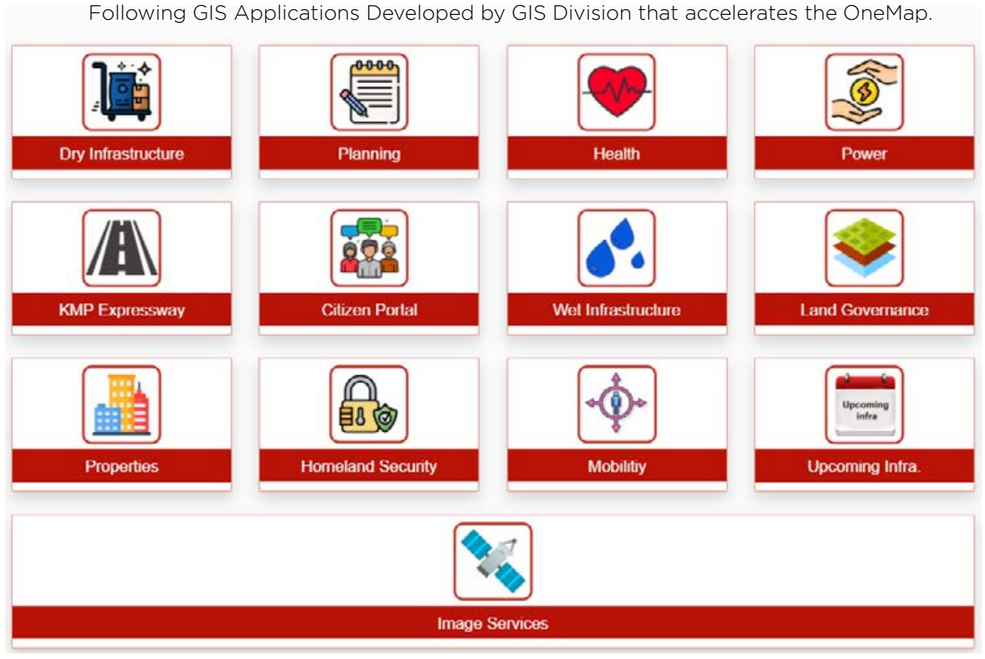
Project Focus

Challenges

The primary challenge was the lack of a common decision support system or common decision-making platform for various departments and bodies like multiple stakeholders like Municipal Corporations, Gram Panchayats, TCPO Haryana, Revenue and Disaster Management department, Haryana Industrial Development Authority, Public Works Department, Haryana Urban Development Authority, Public Engineering Department, and so on, which was resulting in lack of coordination among different departments and delay in execution of development initiatives as per plans.

Other challenges while formulating and implementing development schemes arose due to existing data management systems. These were not fully equipped to address the information prerequisites for planning purposes. Since it was an information intensive task, GMDA had to also deal with incompatible and non-standard datasets inhibiting integration, inefficient inter-sectoral data flow, lack of information on quality, completeness and lineage of data.

Figure 12: Applications of One Map Gurugram



Source: One Map Gurugram Web Portal

The Solution

GMDA created a central and robust GIS-integrated Decision Support System with spatial information as well as citizen engagement for GMDA in particular and for other allied departments & district authority of Gurugram. One Map Gurugram, a GIS-integrated support system, was developed to reshape the urban governance processes and provide an impetus to infrastructure development. The platform clustered multiple GIS layers of information into different applications as per departmental requirements. An enterprise-wide GIS portal was established to facilitate integration of all departmental works, improve collaboration of different departments on common base maps, and to create a Spatial Decision Support System.

Details of dry infrastructure like rail, road, telecom towers and metro lines, besides wet infrastructure details like water distribution networks, sewage networks, drainage networks and recycled network with asset details are available on the platform. Information on power infrastructure, public transportation facilities, land governance layers, health facilities, homeland security, image services and similar other information can also be obtained.

The detailed and accurate geo-enabled decision support system is aligned with the objectives of development of the state, thereby increasing effectiveness of land acquisition, planning, compensation and urban services provision, to name a few. The hub-type framework is also being leveraged for Integrated Command and Control Centre (ICCC) through various interactive dashboards under the mission.

Key Benefits

- Facilitates a conjunction platform for spatial and non-spatial details about the city, providing all departments with updated datasets
- Establishes a collaborative platform for different departments to interact with one another and take more well-informed decisions
- Offers intelligent governance through map-based decision-making
- Improves visibility of ongoing and upcoming projects
- Links to different organizational apps
- Provides citizen engagement avenues through greater visibility of their area on the portal

Case Study 7: **Utilities - Water Supply**

Survey and Digital Elevation Model for Water Distribution Network Planning

Jhansi and Mirzapur

In November 2020, the Prime Minister of India launched the Har Ghar Jal scheme to provide clean and safe drinking water through functional taps in the remotest parts of India. This project intends to find out sustainable water sources and provide tapped drinking water to every household through precise planning and hydraulic design by 2021.

With the same purview, the state of Uttar Pradesh rolled out the Har Ghar Jal Mission in Bundelkhand and Vindhya regions so that people could have access to clean drinking tap water. A total of 9 districts were selected for the community-led and participatory projects. The districts of Jhansi and Mirzapur were facing one of the worst scenarios, with only 10% of the rural population having access to piped water supply, while the rest were forced to walk long distances to get water.

Project Focus

Challenges

The districts of Jhansi and Mirzapur are significantly different from each other, especially from a geographical point of view. Jhansi has no active sources of water, whereas Mirzapur is situated on the banks of the River Ganges, but which is not fit to be used as a source of drinking water due to the extremely high level of pollutants in it. The structural instability and shifting trend of the river poses additional challenges. To top it all, there was no readily available data on the areas of interest, thereby making project planning itself extremely difficult. The total area spans 2252 villages and a population of 5.76 million.

The Solution

A survey was carried out to identify every village and hamlet in Jhansi and Mirzapur districts to be covered under the proposed scheme. The survey included information on total number of houses in Jhansi and Mirzapur, total populations, probable sources of water, number of villages to be covered under the scheme and number of villages already catered to that they do not require further action.

After the completion of the GIS survey, demarcation of existing assets of water supply was carried out on GIS systems with all required attributes. Using or discarding the components was

left to be decided by the design team. All probable land plots were also demarcated on GIS, helping design engineers select from the pool and put forward the best iterations.

A Digital Elevation Model was then developed using elevation survey data to encourage maximum gravity flow to reduce CAPEX and OPEX. The survey, model and other detailed information helped gauge that a total number of 160 water schemes need to be channelized for all 2252 villages of Jhansi and Mirzapur to have tapped drinking water. It also suggested than 19 Water Treatment Plans of 508 MLD capacity would be required for the transmission network of 1800 km length (150 mm to 800 diameter).

455 Service Reservoirs of 100 million litres capacity would be needed in the two districts. Other major contents of the Detailed Project Report prepared on the basis of survey highlighted relevant topographical and geographical details such as village boundaries of the block on GIS-based maps, population projections for the next 15 and 30 years, and design stages of the project.

Key Benefits

- Assured access of piped drinking water based on the detailed distribution network planning and infrastructural requirement delineation
- Improved water quality leading better health conditions, sufficient water quantity and better standards of living of the people
- Generation of local employment and increase in revenue of the block
- Reduction of water-borne diseases arising due to contamination of water supply.
- Improved block-level governance through the proposed water supply scheme.
- Improved service delivery prospects.

Case Study 8: **Urban Redevelopment**

Jaaga Mission
Odisha

The rapid urbanization of the Indian state of Odisha, with a decadal population growth rate of 13.97% and a 26.8% growth in urban areas, is also the reason behind an unprecedented increase in urban informal settlements in the state. According to the 2011 Census, 23.09% of the urban population of the state, including almost 500,000 households, was living in slums without any security of tenure.

In an effort to document the growing informal settlements and generate sufficient data for projects to transform slums into liveable communities, the “Jaga” mission – an innovative project designed to improve the living conditions of informal settlements – was initiated in 2018. More than 700 community data collectors were trained to document and map 1725 slum communities and 1,73,162 households, thus helping create an official data set for further steps.

Project Focus

Challenges

The genesis of the Jaga Mission is based on the revolutionary Odisha Land Rights to Slum Dwellers Act, 2017, which was passed as an ordinance. With a number of stakeholders – governing authorities, institutions, partner organizations, technology providers, innovators, Urban Local Bodies (ULBs), NGOs, Slum Dweller Associations (SDAs), and so on - involved in the overall project planning, implementation and monitoring, there was a strong need for establishing accountability frameworks for the project lifecycle.

Working towards slum upgradation required addressing the primary inequalities prevailing in urban areas to integrate informal settlements into the mainstream city fabric. This required empowering the SDAs to make decisions and take on implementation of infrastructure upgradation, which meant that accurate data on land, services, housing and other necessities was crucial.

Similarly, local communities, ULBs and the Odisha State Government needed access to this crucial data for urban development and planning decisions. The “world’s largest slum titling initiative” also required comprehensive, accurate and updated land data for issuing formal land rights certificates and land entitlement certificates. Manual survey of the area, which comprises congested slums with very high-density occupancy and several accessibility problems, would have taken several years.

The Solution

The pilot project with these objectives in mind was initiated in one ULB in Puri district and eight ULBs in Ganjam district. Unmanned Aerial Vehicle (UAV)-based high-resolution aerial photography was used for data collection and preparation of base maps for all individual slums as well as georeferencing of areas. Differential Global Positioning System (GPS) surveys were used along with Drones for data application, helping conduct the entire process in a transparent manner.

The aerial imagery captured by drones were field verified by a group of NGOs, who conducted door-to-door surveys to check both spatial information (using physical tapes) and household data, such as size of houses, and so on. Occupants listing and verification was carried out,

followed by the issuing of certificates and linking of slum households to affordable housing schemes including the Pradhan Mantri Awas Yojana (PMAY) of the Government of India.

The Geospatial and demographic data so collected were relayed to the GIS-based state map, covering all relevant details. Masterplans and designs for the transformation of three slum areas of Odisha into "liveable" habitats was initiated as pilots of the JAGA Mission. Residents were also involved in the preparation of "vision maps" and "wish lists" of amenities they desired in their surroundings. Special focus was given to public spaces and facilities.

Key Benefits

- 40,000 land titles have been issued so far with zero cases of dispute, due to the trust that slum dwellers have developed on the robust data collection and verification processes adopted.
- The entire project was extremely economical in terms of implementation, costing only INR 800 per household
- Local authorities are using the data to make decisions around installation of essential civic urban infrastructure, including housing, road types and location, drainage, individual household toilets, public toilets, street lights, regular piped water supply, common work sheds, parks and playgrounds, among other amenities, emergency corridors, LED street lighting, and so on.

The comprehensive Geospatial and demographic data collected is also helping authorities address other slum-related issue

Case Study 9: **COVID-19 Management**

Smart City Control Centre Developed as COVID-19 War Room

Bruhat Bengaluru Mahanagara Palike (BBMP)

Gathering information, ensuring rapid communication and actively managing risks have emerged as the common denominators for both smart cities and COVID-19 management in the last year-and-a-half. Smart cities harness technology and data analytics to provide optimal citizen services, augment efficiency and sustainability, and ease key challenges of urban life.

The pandemic threw light on those pillars of smart city infrastructure that already exist in cities around the world but hadn't been exploited so far. The importance of partnerships been infrastructure, technology and experts were also underlined and the challenge of producing sustainable infrastructure with maximum efficiency and minimum costs emerged as more important than ever before.

In this light, the Government of India's Smart Cities Mission (SCM) has actively provided support for rapid response in COVID-19 management through efficient information collation on food and shelter provisions, location and contact details of food distribution centres, shelter homes and kitchens, hospitals, beds and oxygen cylinders, vaccination centres, and so on.

Project Focus

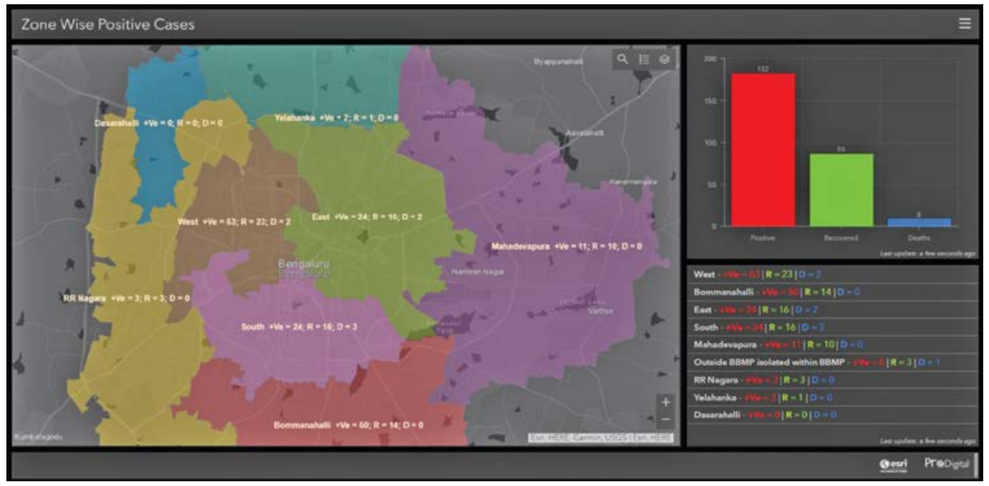
Challenges

Bengaluru is one of Karnataka's biggest commercial and residential hubs, with a large floating population of daily workers and migrations augmenting is population of 12.7 million. The city became one of the first COVID-19 hotspots in the state, leaving the Bruhat Bengaluru Mahanagara Palike (BBMP) with no suitable infrastructure to tackle or track the spread of the pandemic.

The Solution

BBMP officials responded quickly to the pressures of the pandemic, beginning with identifying measures for its containment. The existing Smart City infrastructure was leveraged, launching a war room to address the pandemic on March 23, 2020. Set up at the BBMP head office, it operates 24x7 with 11 collaborating agencies, 5 solution providers and overall 40+ resources, with a team of 10 people working in shifts. Key activities include real-time information gathering for situational analysis, actionable insights and information sharing with citizens.

Figure 13: COVID-19 GIS Dashboard, BBMP



Source: Empowering better Decision-Making around COVID-19, BBMP COVID-19 War Room

Using GIS technology, BBMP has been mapping the critical and less critical zones in the city for effective quarantine measures. GIS templates and dashboards were deployed for date-wise, zone-wise, hospital-wise, age-wise and gender-wise details on a daily basis. The multi-layer comprehensive data visualization and spatiotemporal analysis at BBMP COVID-19 War Room also kept track of sanitation work in the city, including cleaning of roads and disposal of waste.

Key Benefits

- Integration of various technologies like GIS mapping, real-time dashboard, and analytics, along with CCTV monitoring helped in tracking, testing, monitoring, isolation, quarantining and treatment of patients at the earliest and minimizing the spread of the virus.
- The GIS war room supports the vigorous Trace-Test-Treat method employed by Karnataka and responsible for the state's low positivity rates.
- Greater engagement of experts, civic bodies, state government departments, and citizens to fight the pandemic together through well-informed steps forward
- Creation of a hub in the form of the ICCC war room for making data-driven decision-making and coordinated response.

Case Study 10: **Urban Mobility**

Full-Scale Switch Out of Backend Services, Driver and Rider Application

Bengaluru

Intelligent transport systems (ITS) not only help citizens save valuable hours of commute every day, but also achieve greater traffic efficiency by minimizing common problems. Users have access to real-time information about transportation, including timings, running information, seat availability, density of passengers, next location, and so on. Such systems take care of road safety and efficient infrastructure development to prevent congestion as well. The entire application of ITS is based on data collection and analysis, which are used in operations, control and research concepts for efficient traffic management. Location intelligence plays an indispensable role, and sensors, information processors, communication systems, roadside messages, GPS updates and automated traffic prioritization signals are important for advanced applications.

A government agency operating bus transport service in Bengaluru, the Tech City of India, sought to implement data-driven ITS for more efficient and advanced transport management. With the highest number of Volvo bus fleet operated by a public transport company in India, the agency required a robust Intelligent Transport System for services within and beyond the city.

Project Focus

Challenges

Considering the busy urban environment of the city of Bengaluru, coming up with accurate ETA calculations on the basis of real-time information collection was proving to be a real challenge. Services such as navigation and routing for the bus drivers also required an easy-to-use interface, considering the data dissemination would be beyond control rooms, relayed to bus operators, drivers, passengers and other commuters. The need for developing a scalable backend service was strongly felt, proportionate to the volume of ridership and number of assets.

The Solution

The GPS-enabled Intelligent Transport System so created helps transmit real-time location information in the form of bus routes, bus stops and current location to commuters as well as ITS control rooms. The geocoding-enabled platform is available as easy-to-use SDKs for Android and iOS platforms with a neat and simple interface. An Interactive Dashboard presents the user with different menus, depending on the category in which they fall (commuters, bus drivers, control room personnel, and so on).

Key Benefits

- Better customer experience through more precise ETAs
- Increased service quality and passenger satisfaction
- More accurate and fresh location insights with driver feedback (traffic incidents, hazards)

Case Study 11: **Safety and Security Planning**

Mobile Mapping Systems using Advanced LiDAR Technology

Nagpur

Geospatial technologies can play an important role in the planning and design stages of urban public realms and streets, besides day-to-day usage of these spaces. Cities around the world are using Smart City Control Centres to monitor real-time city-wide information through live location data collection. Beyond protecting citizens from physical dangers, Geospatial intelligence helps shape advanced techniques for controlling access to digital systems. At the same time, emergency response can be sped up and made more efficient when real-time updates are available readily with control rooms.

Project Focus

Challenges

One of the most densely populated areas of India, the city of Nagpur is being developed into a Smart City, with safety and security planning as a high priority area. However, implementing the city-wide surveillance project, as envisioned, required detailed surveys, such as of all road junctions in the city.

Baseline data was required to be updated with real-time updates, including traffic congestion routes for producing meaningful information. Just like any other city left to grow on its own, Nagpur has several sensitive zones and blind spots with higher occurrences of criminal or intimidating activities, which needed to be identified and prioritized for attention by officials.

Informal settlements and encroachments, thus far ignored, needed to be validated in the real-world scenario. Such comprehensive data collection was imperative for bridging the gap between design and execution stages, the latter being the one with the most faulty and inadequate provisions in general.

The Solution

Advanced Mobile LiDAR survey (MLS) was conducted to acquire accurate street-level building profile data throughout the city to meet the expected requirements for preparing a detailed database. The acquired MLS data was supplemented with high-resolution panoramic imagery, resulting in an information-rich GIS.

With this detailed data, security planners, implementation engineers and contractors could be provided with accurate drawings, enabling faster and more well-informed decision-making. The as-built data together with the underlying point-cloud data were authenticated with the panoramic images collected from field. This resourceful visual data was then relayed to command-and-control centres.

Even the most complex structures in the city can be visualized realistically, and so were roads, junctions and streets, in the form of a 3D model enabling authorities to identify view-shed blind spots and install CCTV cameras at appropriate locations at the best positions and angles throughout the city. Snapshots are being archived for periodic records, while the integrated environment has improved the coordination and collaboration between different stakeholders.

Key Benefits

- Data provides end-to-end solutions in creating a larger canvas to draw and map the built environment and resources accurately in a 3D depiction to develop the Smart City proactively
- City stakeholders can use the data to adopt a holistic development methodology using socio-economic models for resilience, sustainability and inclusivity
- Scientific methods established for camera visibility analysis
- Built drawings provide ways for efficient planning and management
- Iterative view-shed/ blind spot analysis enabling responsible security planning and coming up with the most effective camera positions and angles
- Fast turnaround time and cost savings throughout the project lifecycle

Annexure 2

Initiatives

SiMPlify Sustainable Urban Mobility

SiMPlify's Mobility Tool is a globally applicable tool to help cities develop fact-based and integrated sustainable urban mobility plans based on 19 sustainable mobility indicators. Endorsed by the European Commission, the indicators are grounded in science and span four dimensions: quality of life, economic issues, global environment and mobility system performance. Target audiences include small, medium-sized and large cities as well as metropolitan regions. The tool is used for purposes of data gathering, analysis, scenarios and measure selection, appraisal and assessment along with evaluation and monitoring.

Link to Website: ***http://www.wbcsdsmp.org/***

Urban Transport Data Analysis Tool (UT-DAT)

The Data Analysis Tool for Urban Transport is simple Excel-based tool that enables users to compare several urban transport-related indicators in a city with similar indicators in peer cities. Such a comparison would allow users to identify areas where the city under study is performing well or is performing poorly. The tool has been developed using a database on urban transport covering 93 cities with data collected only from secondary sources. The output is a report presenting how the city is performing vis-à-vis peer cities with respect to a set of performance indicators. The tool aims to provide a comparative framework for urban transport experts so that they can better identify the main deficiencies in the city's transport system and recommend the most appropriate remedial measures.

Link to Tool: ***https://pubdocs.worldbank.org/en/643061485462691416/Urban-Transport-Data-Analysis-Tool.xlsm***

Download User's Manual: ***https://documents.worldbank.org/curated/en/2014/01/20133572/urban-transport-data-analysis-tool-ut-dat-users-manual***

Solid Waste Emissions Estimation Tool (SWEET) version 3.1

SWEET us an Excel-based tool that quanitifies emissions of methane, black carbon, and other pollutants from sources in the municipal solid waste sector. The tool provides emissions and emissions reduction estimates at the project-, source-, and municipality-level. Cities can use this information for multiple purposes, including establishing a baseline scenario, comparing a baseline scenario to as many as four alternative scenarios, analyzing specific projects for potential emissions reductions, estimating the contribution of activities in the waste sector to overall city emissions reduction goals, and tracking progress over time, among other things.

Important Links: ***https://www.waste.ccacoalition.org/document/solid-waste-emissions-estimation-tool-sweet-version-31***

India Climate Atlas

The Energy and Resources Institute (TERI)'s web portal – TERI Climate Tool (TCT) or India Climate Atlas aims to assist policy planning at the regional level, helping decision-makers be climate ready. Backed by robust scientific knowledge, the TCT is helping mainstreaming climate information, early warning and risk reduction services into policy and decision-making. The tool has been conceptualized to address the current gap in the understanding and provisioning of scientific knowledge towards regional policy planning. It also provides valuable information on climate variables like temperature, precipitation and various climate statistics including extreme climate indices for past and future periods over national, state-wise, district-wise and city scale.

https://www.teriin.org/press-release/teri-launches-indias-climate-atlas-provides-decision-makers-city-level-analysis

NEXUS Urban Risk Assessment Tool: NEAT+

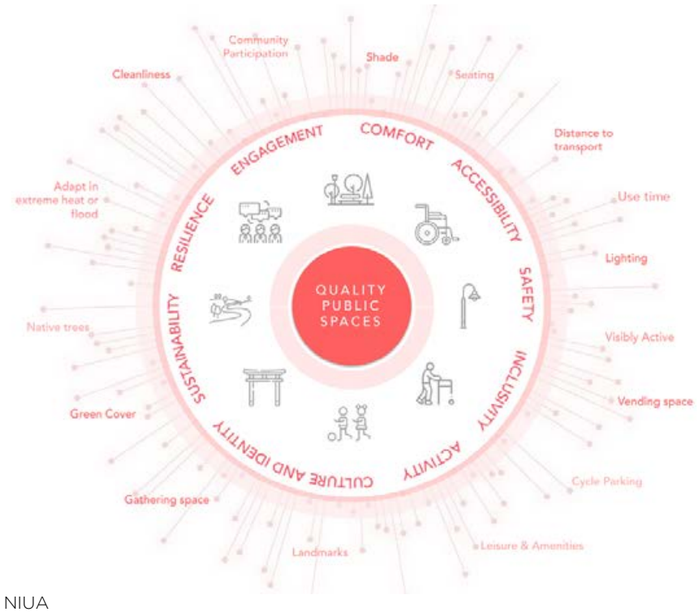
The free and open-source Nexus Environmental Assessment Tool (NEAT+) targets humanitarian actors, including field staff, community members and team leaders working in camp, peri-urban or rural/informal settings, to quickly identify issues of environmental concern, helping make emergency and recovery interventions more sustainable. The project level screening tool has been specially designed for situations of displacement, and combines environmental data with site-specific and activity-based questions to offer automatic analysis for flagging priority environmental risks. The tool can be seen as an easy way to assess myriad potential environmental threats and sensitivities, besides understanding how to mitigate them. Users and organizations can collaborate on mitigation, advocacy and implementation of greener humanitarian operations.

Link: ***Link: https://neatplus.org/***

Public Space Design and Assessment Tool

The assessment framework and tool developed and integrated with the Bhubaneswar. Me app took three primary stakeholders into consideration – Citizens, Experts and City Administration. The primary objective was to provide a platform to citizens to view and rate public spaces in their city based on chosen parameters. A common channel, in the form of a digital platform, has been set up for enhanced participation of citizens in the improvement of public spaces in this manner. At the same time, expert assessment in the form of a detailed checklist is made available for evaluating public spaces, identifying gaps is service delivery, proposing interventions as well as identifying crucial design components. The city administration can then easily compile all relevant data, visualizing spatial distributions of public spaces using a dashboard and analyze areas of improvement.

Figure 14: Public Space Design and Assessment Strategy



Source: ISCF, NIUA

Links: ***https://www.niua.org/iscfip/compendium/project/public-space-design-and-assessment-tool***

ClimateSmart Cities Self-Assessment Tool (CSC-SAT)

CSC-SAT has been designed to support Indian cities in understanding emissions from indicators covered under the ClimateSMART Cities Assessment Framework. The tool helps authorities integrate and prioritize climate-sensitive action into city planning, based on the Global Protocol for Community-scale Greenhouse Gas Emission inventories (GPC). Meant to be a starting point for cities to initiate mitigation action within existing governmental setups, the tool presents data in various tabs – Emissions & Analysis providing a summary of total city-wide GHG emissions, and Potential Emission Reduction tab based on performance evaluation levels, giving cities current, recommended and desired levels, along with emission reduction potential for quantifiable indicators and qualitative recommendations based on the framework for the others.

Figure 15: The TERI Climate Tool (TCT)

Link: ***http://tct.teriin.org/ClimatePortal/Default.aspx***

Sanitation Manager SANMAN

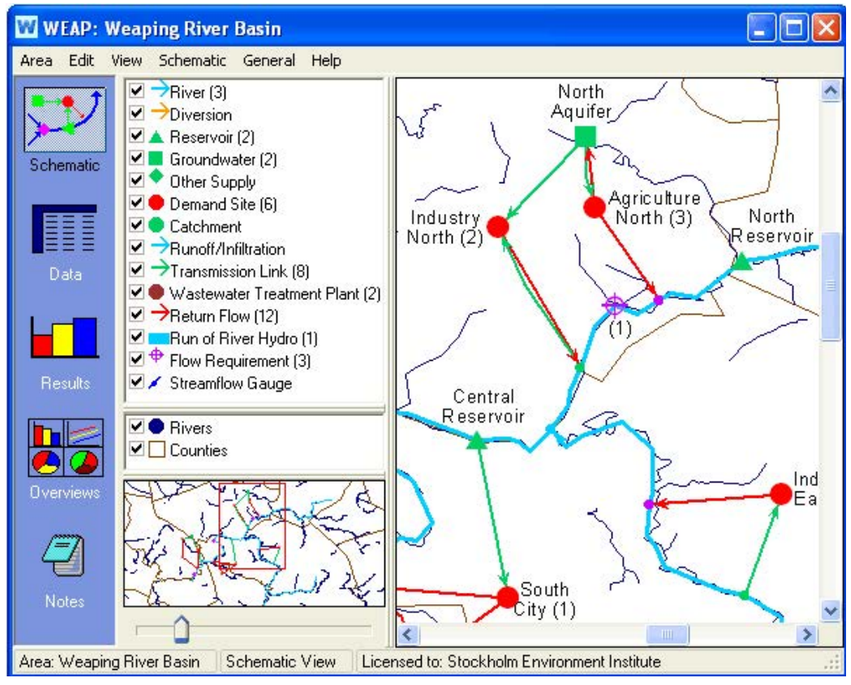
Sanitation Manager or SANMAN is a planning tool developed by Centre for Urban and Regional Excellence (CURE). The tool uses a GIS digital platform to layer sanitation data onto city maps for sanitation investment projections for under-serviced populations living in slum and squatter settlements in Indian cities. SANMAN was initiated by CURE as a means to collate relevant data generated from slum communities using detailed mapping and participatory processes. The understanding and analysis of spatial distribution of services inside slums, besides the area's proximity to city infrastructure helps in the incubation, innovation and simplification of equalizing, integrated and inclusive sanitation solutions. CURE has converged and digitized SANMAN after multiple successful collaborations with ULBs, parastatal agencies and state governments over crowdsourcing of large amounts of spatial and non-spatial data. The tool has been combined with Geospatial and other technologies, including GIS, GPRS, GMS and web-based applications for holistic documentation, analysis and data visualization purposes. As a result of SANMAN's support to smart and intelligent solutions, easily accessible city-wide information systems have been established, redundancies and duplication of efforts have been reduced, seamless inter-departmental and inter-agency coordination has been ensured, and workflows, resources and city overall city management systems have seen continued improvement over time.

https://cureindia.org/page35.html

WEAP: Water Evaluation and Planning System

Offering a unique approach for conducting integrated water resources planning assessments, the Water Evaluation and Planning (WEAP) system is a first-of-its-kind user-friendly software tool. Its transparent structure facilitates engagement of diverse stakeholders in an open process. The WEAP database maintains comprehensive data on water demand and supply to help build a mass balance model on a link-node architecture. Following this, the tool performs calculations on water demand, supply, runoff, infiltration, crop requirements, flows and storage, pollution generation, treatment, discharge and instream water quality under different hydrologic and policy scenarios. WEAP offers a graphical drag-and-drop GIS-based interface with flexible model output as maps, charts and tables. It also comes with dynamic links to other models and software, such as QUAL2K, MODFLOW, MODPATH, PEST, Excel and GAMS. Developed by the Stockholm Environment Institute's US Centre, WEAP aims to incorporate pertinent issues around allocation of limited water resources for agricultural, municipal and environment uses.

Figure 16: Water Evaluation and Planning System portal



Link: ***https://www.weap21.org/index.asp?action=200***

REFERENCES

1. When Cities Rule the World, Parag Khanna, McKinsey & Company; Link
2. Combating the Challenges of Urbanization in Emerging Markets: Lessons from India, Suveer Sinha, McKinsey & Company; Link
3. HPEC Report and Recommendations, Dr. Isher Judge Ahluwalia, 29th September 2011; Link visited on August 15, 2021
4. Mandate, Ministry of Housing and Urban Affairs, Government of India; Link visited on August 22, 2021.
5. Small-to-medium enterprises
6. Micro, small and medium enterprises
7. Stakeholder Analysis for Smart City Development Project: An Extensive Literature Review; Link
8. Urban Policy, Science Direct; Link visited on September 11, 2021
9. Scheme for Satellite Towns around seven megacities, Ministry of Housing and Urban Affairs website
10. Lumpsum Provision scheme for the benefit of NER including Sikkim, Ministry of Housing and Urban Affairs website
11. 'Heritage City Development Scheme (HRIDAY) launched: Centre to fund entire expenditure', PIB News, 21 January 2015
12. Guidelines for HRIDAY, Ministry of Housing and Urban Affairs website
13. "NIUA to check impacts of HRIDAY scheme: MOHUA", Economic Times, 29 November 2019 online edition
14. AMRUT Mission website, visited on 6 September, 2021
15. 'Budget 2021 – What is there for the cities?' Observer Research Foundation, 2021
16. Smart Cities Mission website
17. Revitalising 'India's Smart Cities Mission', India Brand Equity Foundation, site visited on 6 September 2021
18. Swachh Bharat Mission website, visited on 23 August 2021
19. PMAY, Ministry of Housing and Urban Affairs website, visited on 6 September 2021
20. PMAY website, visited on 6 September 2021
21. Outcome Budget 2021-22
22. Urban Transport, Ministry of Housing and Urban Affairs website
23. The Metro Rail Guy, 2021
24. Metro Rail News, 2021
25. Abstracted from the Webinar on IT Infrastructure for Geospatial 2.0 organized by AGI India on 23 September 2021
26. COVID-19 & Geospatial Industry, World Geospatial Industry Council website, visited on 18 October 2021
27. India Smart Cities COVID 19 Response, Case Studies, Deloitte, June 2020
28. Extracted from Geospatial World article, "Role of Geospatial Systems in Making City Utilities Efficient and Cost-effective", authored by Prof. Arup Dasgupta
29. Case Study, "How Hexagon Geospatial is helping an Indian city to resolve hygiene problems" published in Geospatial World
30. Article, "GIS For Water Utilities: Efficiently Mapping Water and Sanitary Infrastructure" published in GIS Cloud
31. Town and Country Planning Organization website, visited on 13 October 2021
32. Town and Country Planning Organization website, visited on 13 October 2021
33. Scheme for Satellite Towns around seven megacities, Ministry of Housing and Urban Affairs website
34. NIC website
35. Swachh Bharat Mission Guidelines, 2017
36. 'Revitalising India's Smart City Mission', India Brand Equity Foundation website, visited on 24 August 2021
37. National Urban Digital Mission website, visited on October 20, 2021
38. India Urban Observatory website, visited on October 22, 2021
39. Adopted from presentation by Saurabh Rai, Global Head Analytics and Strategic Initiatives, Tech Mahindra at online Summit, 'Sectoral Value Proposition for the New Geospatial Policy' held on 15-16 September 2021
40. 3D BIM + geospatial full lifecycle metro rail project aims at eliminating data loss by Geoff Zeiss, Geospatial World, 2 April 2019
41. Kochi Metro Rail Completes LiDAR Survey for Kochi Water Metro, GIS Resources, 13 Oct 2020
42. 3D Mapping of Delhi Metro Station to Help CISF, GIS Resrouces, 7 April 2017
    Delhi Metro, Google Maps join hands to improve connectivity, Geospatial World, 13 Sept 2017
43. Dr. AR. Namrita Kalsi, Joint General Manager (Arch)/ Property Development, Delhi Metro Rail Corporation, Webinar on Geospatial Technologies for Asset Management in Railways, Association of Geospatial Industries, July 2021
44. Ministry of Housing and Urban Affairs Annual Reports - 2015-16, 2016-17, 2017-18, 2018-19, 2019-20 and 2020-21
45. Advisory for all States/UT's on Geo-Tagging of 'Beneficiary led Individual House Construction' component of the Mission
46. Pradhan Mantri Awas Yojana - Housing for All (Urban), Ministry of Housing and Urban Affairs website, visited on 7 February 2022

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The Association of Geospatial Industries (AGI) is an industry-led non-profit non-government professional organization that represents the interests of geospatial industry in India and works towards the advancement of geospatial technologies and their applications. AGI serves as a forum for exchange of ideas, techniques, approaches, and experiences by those who design, implement, and use geospatial technology solutions. Our primary goal is to accelerate the adoption of geospatial industry in India and to ensure that government, industry, academia, and society as a whole understand both the needs of this industry and its contribution to the nation's development. Established in 2009, the Association of Geospatial Industries is headquartered in New Delhi, India.

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