https://doi.org/ 10.33472/AFJBS.6.5.2024. 3181-3204

African Journal of Biological Sciences

Smart City Eco System Management - Necessity of Map Compilation and Generalization on Indian Integrated Geospatial Information Framework (IGIF): A Review

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Article History
Volume 6, Issue 5, 2024
Received: 01 May 2024
Accepted: 09 May 2024
doi: ***10.33472/AFJBS.6.5.2024. 3181-3204***

Abstract: Maps like cadastral, thematic, or topographic maps in current practice are predominantly frameworks poised of geospatial information and communication technologies (Geo-ICT) used for geographic planning in urban architecture, landscaping, waste management, etc. Timeworn practices of small-scaled maps 1:25k are now wall hanging/atlas pages but are less used in micro-level smart cities, as well as planning green corridors, expansion, and scheduling. Drone-based photogrammetry, LiDAR, Radar Interferometry, WEB GIS, remote sensing technologies, artificial intelligence, underwater mapping, etc., prefer innovative techniques applicable to large-scale maps (<1:10000). Presently, security, the Internet of Things (IoT), surveillance issues, implicative rules, and regulations throughout the globe are preferred for map-making for smart cities and geospatial infrastructure realms. The small- scale maps are prepared by using large-scale maps(LSM), with their Metadata from a multi-scale spatial database. The compiling and generalizing are done using the metadata features through modern mapmaking software. The present need is preparing and using large-scale maps and saving them on big data platforms with their Metadata after ratification and compilation to generate small-scale maps,(SSM) for planning of smart city infrastructures. The present study elucidates the generation of SSM of Adilabad, Bhubaneswar and Banaras city declared as three smart cities of India.

Keywords: Automation of Maps, GIS/RS, GPS, GNSS, Large-scale maps, big data, Urban planning

Abbreviations: A.I.: Artificial Intelligence; AS: Arial Survey; ASPRS: American Society for Photogrammetry and Remote Sensing; B.G.: bar Graph; D.B.: Data Base; DCM: Digital Cartographic Model: DEM: Digital Elevation; DGNSS: Differential Global Navigation Satellite System; DGPS: Differential Global Positioning System; DLM: Digital master land-scape Model; FGDC: Federal Geographic Data Committee; GCP: Ground Control Points; Geo-ICT: Geospatial Information and communication technology; GNSS: Global Navigation System; GOI: Government of India; GPS: Global Positioning System; G.S.: Ground Survey; IGIF: International Geospatial Information Framework; IoT: Internet of Things; LBS: Location-based services; LiDAR: Light detection and ranging; LIS: Land Information System; LSM: Large Scale maps; MDM: Meta Data Management; MMS: Mobile Mapping System; MoHUA: Ministry of Housing and Urban Affairs; NGDR: National Geospatial Data Registry; NoSQL: No Sequential Query Language; NSDI: National Spatial Data Infrastructure; NUIS: National urban Information system; NVA: Non-Vegetated Area; OGC: Open Geospatial Consortium, Inc.; OSM: Open Series Map; RDBMS: Relational Data Base system; S-City: Smart City; R.F.: Representative Fraction; RMSE: Root Mean Square Error; RTK: Real Time Kinematics; SDG: Sustainable Development Goal; SDI: Spatial Data Infrastructures: Smart KADASTAR-3d City Model; SSM: Small Scale Maps; T.S.: Total Station; UAV: Unmanned Aerial Vehicle; ULB: Urban Local Bodies; UN-GGIM: United Nations Global Geospatial Information Management; UTM: Universal Transverse Mercator; VGI: Volunteered Geographic information; VS: Verbal Scale; WEB-GIS: Web Based geographical Information system; WFS: Web Feature Services; BIS: Bureau of Indian Standards; YBP: Years before Present; mn: million:.

Introduction:

India has about 5,000 cities, of which about 100 smart cities are at different stages of their inhabitants. By 2050, the projected Indian cities' population shall be about 70% of the total. Therefore, there is a necessity for technology, applications and values, the government will adopt many smart cities. After 2050, India shall come across a dearth of societal necessities and infrastructures related to the economy and the environment. Under such circumstances, smart cities warrant careful planning to optimize resources uphold sustainability in the management of the whole ecosystem, and provide their citizen's qualitative life. Indian Smart City (S-City) initiatives are with solutions in waste management, traffic congestion, citizen safety, affordable housing, water resource management, smart buildings, efficient use of energy, renewable energy resources, facilitating navigation of autonomous vehicles, and citizen participation, thereby contributing to economic upliftment of the society. An increasing trend in designing and maintaining a Smart City ecosystem is to use data and digital technologies effectively to plan and manage its core functionalities to become efficient, innovative, inclusive and resilient. Integrating digital technologies, especially A.I., into a city's systems and services presents new and affordable opportunities for a city to solve its challenges. In the urban area reconstruction to a 3D S-City, all entities need exact mapping as a prerequisite, [1], [2]. S-City initiatives for holistic planning, warrant large-scale maps for more than a hundred cities, like Indore, Bhubaneswar, etc., .

Representative mapmaking is part of traditional cartography. A cartographer is a professional who makes topographic maps in horizontal ellipsoidal, vertical Geoidal datum taken as reference, map projection, their conversion and MSL. Maps are visual, flat and georeferenced depictions of the land settings on the Earth used for hydrological, physical, biological geographical and political purposes. They can be classified as *topographic, WEB-based, or thematic*. [3] [4]

The small-scale maps are conservative, considered obsolete nowadays and inappropriate for smart city planning, execution and maintenance. Land surveying techniques have been technologically transformed since the beginning of the GIS i.e. Geographic Information Systems and geographic positioning system which is economical, fast and accurate.

In the smart city reconstruction, importance needs emphasis on physical, social, economic and governance (Fig-1), under the national framework, Integrated Geospatial Information Framework (IGIF) as envisaged by UNGGIM. The organization institutes geospatial data that provides location-based services (LBS) and supports various need-based applications required by Geographical Information System (GIS) to create Open Series Map (OSM) data and state-approved legal Land Information System (LIS) data, linked to Geodetic framework (Horizontal and Vertical Datum). Hard copy maps are to be made according to the scales and as part of the workflow of design, implementation and maintenance. Because the Life Cycle Management(LCM) of the data workflow is across the domains and various professions excluding the general citizen, as they need different cartographic products with domain-specific symbolization and legends derived from one data set or a database (Fig -1).

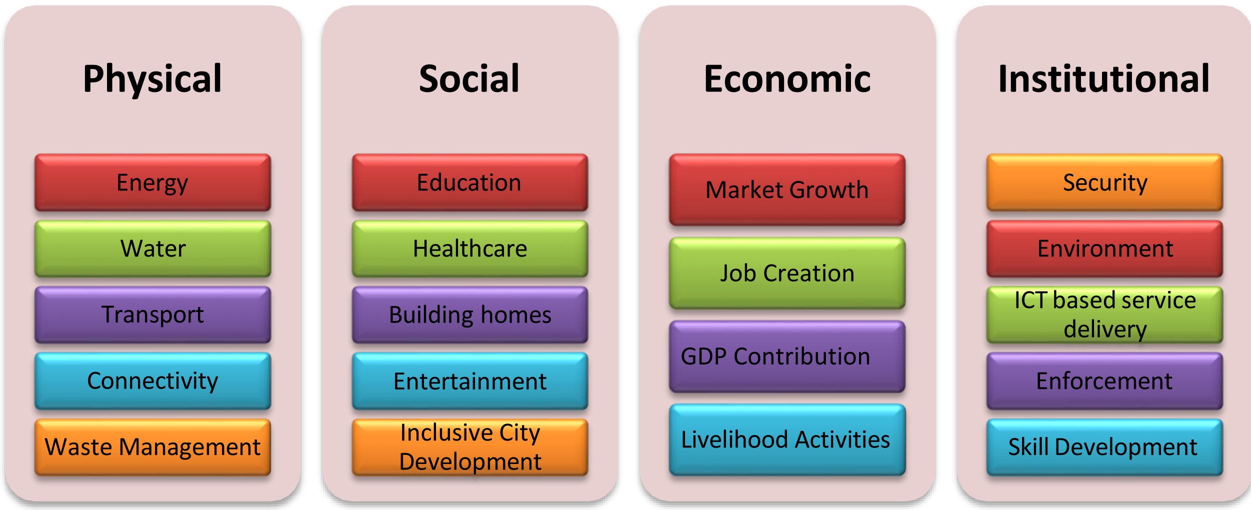


Fig 1: Four pillars of smart city planning as Physical, Social, Economic, and Institutional

Innovative technologies are LiDAR i.e., Light Detection, and Ranging, Drone photography, Unmanned Aerial Vehicle (UAV), DGPS (Differential Global Positioning System), the GPS, the Global navigation satellite system (GNSS), etc. The WEB GIS and Spatial Data Infrastructure development are the modern advanced steps. They have proved to be excellent tools for accumulating high-resolution data about different Large-Scale Map making (LSM) from small-scale maps (SSM) through cloud-based tools and systems. [5], [6][7][8]

A typical domain process handling workflow can be given as under (Fig 2):

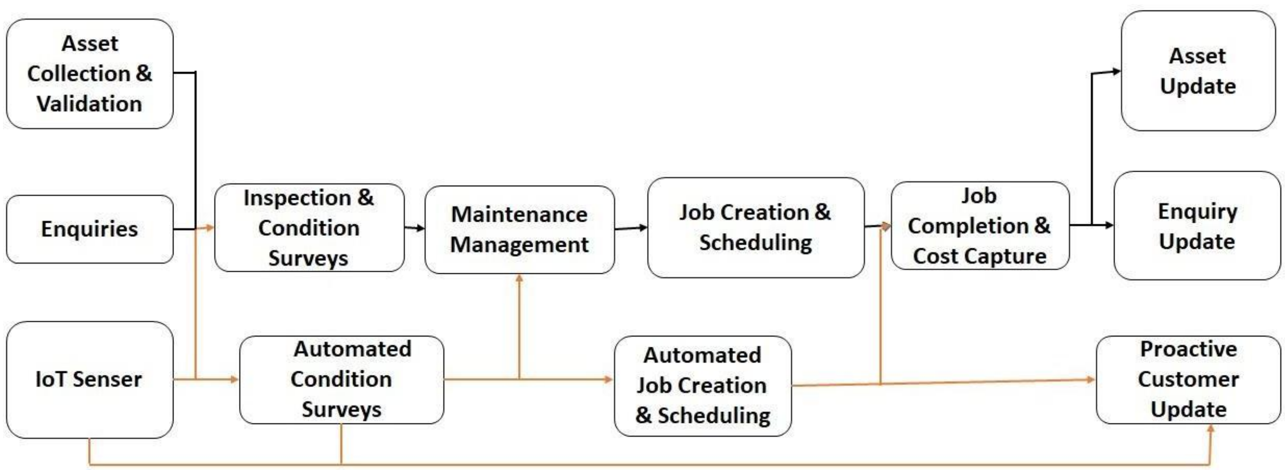


Fig 2: The flow diagram of the domain processing from asset collection to customer update.

Review of literature;

For cartography, Greece is the labour room. The initiation of mapping during 5KYBP is owed to Eratosthenes and Anaximander. Herodotus, Ptolemy, Hecataeus and Eratosthenes contributed to making the world map in 2.6KYBP clay tablets that portrayed the Babylonian World Map model. The cartography technique of China was much more technologically advanced in the 605 Common Era with the Latitude or Longitude system introduced by the cartographer Pei Ju belonging to the Sui Dynasty, followed by Hai-Nei-Hua-Yi Tu. in the 801 Common Era. During the 15th and 16th centuries, credit for mapmaking goes to Nicholas Germanus, from Europe and the American Diogo Ribeiro (Year-1527) in America[8[. The 17th century initiated the making of modern conventional maps[9]]

The emblematic representations, such as natural administrative boundaries, real-world objects, economic, societal, and other utilities, and 3D representations, are used in the maps. Land for the overall societal development, cadastral or revenue maps, though most essential yet no topographic-map feature, was able to meet the accuracy requirements of measurement as expected for the green and smart city utilities [10], [11][12].

Topographic map generalization shifted to the coarse landscape from the Digital-master Landscape Model (DLM), which has updated the large-scale digital cartographic model (DCM) or Smart

KADASTER-3D City Model, satisfying the present demand[13][14], 15], [16]. Remote sensing (R.S.) and GIS mainly generalize maps on a 2D geometry basis in the Association of Geospatial Industries and the 3D geospatial applications for intelligent city map generation.[17] [18] [19]. The distance between two places on a map or the accurate terrestrial distance among these matching points gives a ratio called the scale of the map [20]2[21]. There are three ways of representing the scale: *i. Bar Graph (B.G.), ii. Verbal Scale (VS), iii. Representative Fraction (R.F.) (1cm=100 cm)* [22].

The generalization, along with the automation of the map, was compiled from 2010 with 1:10000 or lower on large-scale, Small-Scale-Topographic (SST) maps 1:250000 and 1:1000000 was compiled from a 1:500000 scale. The medium-scale map generalization was completed on One Map Policy using a scale of 1:50000, and most of the topographic maps made by SOI are on a medium scale [23][24][25].

The present article outlines a continuing project to plan manifold pictures as a large geo-database about overlaying and editing discrete features for superior cartographic images. GIS platforms have simplified zooming along with multi-scale practices for map generalization. It is the processing of selective SSM from LSM by simple, correct, and distortions less of scale change using the computer, software, big data, and web science technology of India, [26] [27] [23]][14][28].

Objectives of the present study:

The current study is based on LSM generation from the following lower-order maps so that the specific purpose of smart city maps (SCM) can be generated and the urban agglomeration can be planned. The proposed LSM is the creation of a 1:10,000 (City Zonal Plans) map from 1:2,000 (Detailed Urban Plans) map from 1:1,000 (Under Ground Utilities depiction) maps, and 1:500 scale captured vector data both (for 2D and 3D Engineering-maps). The criterion is minimizing the loss of spatial, statistical accuracy and object complexity errors to create desired maps from the data captured from Drone mapping (LiDAR and aerial photography) Web Feature Service (WFS), IS16699/2018 (BIS Standards) and Web Map Service, I.S., or from Relational Data Base Systems (RDBMS) processed by using cloud-based data life cycle management. The *skyline soft builder software* will generate the final map products through digitized data and subsequent feature extraction. The review reveals that automated map generalization by software without customization is possible.

Methodology:

A map represents the topography of the terrain in reality. The scale of a map stresses the accuracy and density of feature presentation. The lower the map scale, the higher the exactness of the feature compared to reality. Application of suitable software or group of software can also negotiate and reduce the feature/features loss relevant to the geo-location and appropriately place features as per requirements. General map generation methodologies are in Fig. 3.\

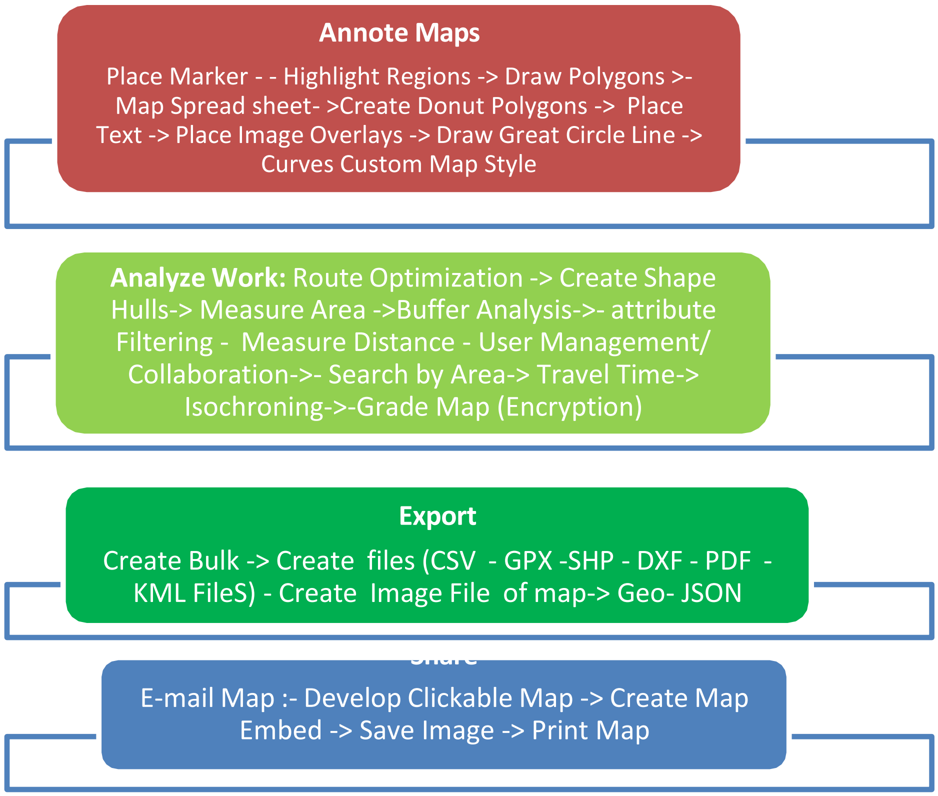


Fig 3: The General Map cohort procedures for all sorts of cartographic charts/maps

For example, the count of attributes like house count in settlements, multi-polygons reduced to a single polygon, and village feature type is shown in the following upper scale. These were a few image- or feature-oriented representations on various scales, process orientation, and step-wise generalization. GIS innovative tools receive, stack, manipulate, analyze, manage and present different types of geographic data as per requirement. Complete data is entered in standards-based designed spatial tables to achieve the desired performance.

India, in the geospatial domain, is a boon. Using RDBMS to serve the geospatial OGC-based services strengthens the security and improves the performance of searching and updating by a suitable indexing mechanism. Oracle spatial technologies and NO SQL database technologies may also ease the solution in data management requirements. Ultimately, data served online in 2D/3D mode using Geo Server, or other open-source or publishing software will reduce the data copyright issues, with geospatial data security concerns of Geospatial Policy -2022 and other guidelines. On the other hand, GIS tools can again consume the OGC-based interoperable data services or groups of services across the scales to ease planning, execution, and maintenance activities.

The GIS Milieu provides services for town planning applications like water demand and supply among demographic stratification, land use and land cover planning and infrastructural management by 2030. Maps accessible are *Topographic maps* (geographical singularities) like constructions, pavements, airports, drainage systems, water bodies, *Special maps* (meteorological, metro, aviation, or navigation paths), and *Thematic maps* (related to e-Governance, agriculture, soils, sewage, sewerage, forestry, disaster managing, and many other services. The cartography map is exclusively generated and involves map design, symbolization, and annotation placement.

Spatial Data Base:

A spatial database is a D.B. designed to optimize storage and probing data representing objects from a geometric galaxy. These databases permit the images of simple geometric objects (examples: points/ lines/polygons). Databases with spatial data handling capability can also handle complex structures of 3D objects, topological exposures, linear systems, and triangulated Irregular Networks called TINs. They are typically technologically advanced to achieve different data sets of numeric type and other characteristics. They make it necessary for extra functionality to process spatial data efficiently. Management of enormous amounts of structured or unstructured data/information is the focus of the information systems (Fig 2).

Scaled-up urban population in India

India's urban population is 377mn (Census-2011), which is assumed to reach 600 mn by 2031. The cities in India (over a million people) had 51 people, projected to be 68 cities by 2030. Indian cities lack basic houses, necessary WASH facilities to live in. and prime utilities. (MOHUA, GOI). The rural migration to Cosmopolis in 2030 is projected to put additional stress on accommodation planning, replacing horizontal and vertical expansions. The ill-structured urban planning and slum rehabilitation are slowing the growth of thoughtful city planning and execution for want of topographic /thematic LSMs. [28], [29], [30]

Methodology

The MoHUA decided 2018 to apply GIS/RS methodologies to provide data/information for town planning using drones (UAV), the unnamed aerial vehicles that are fast, realistic, economical, and accurate. Capturing the base data entrusted to NUIS (National Urban Information System) and National Spatial Data Infrastructure (NSDI).

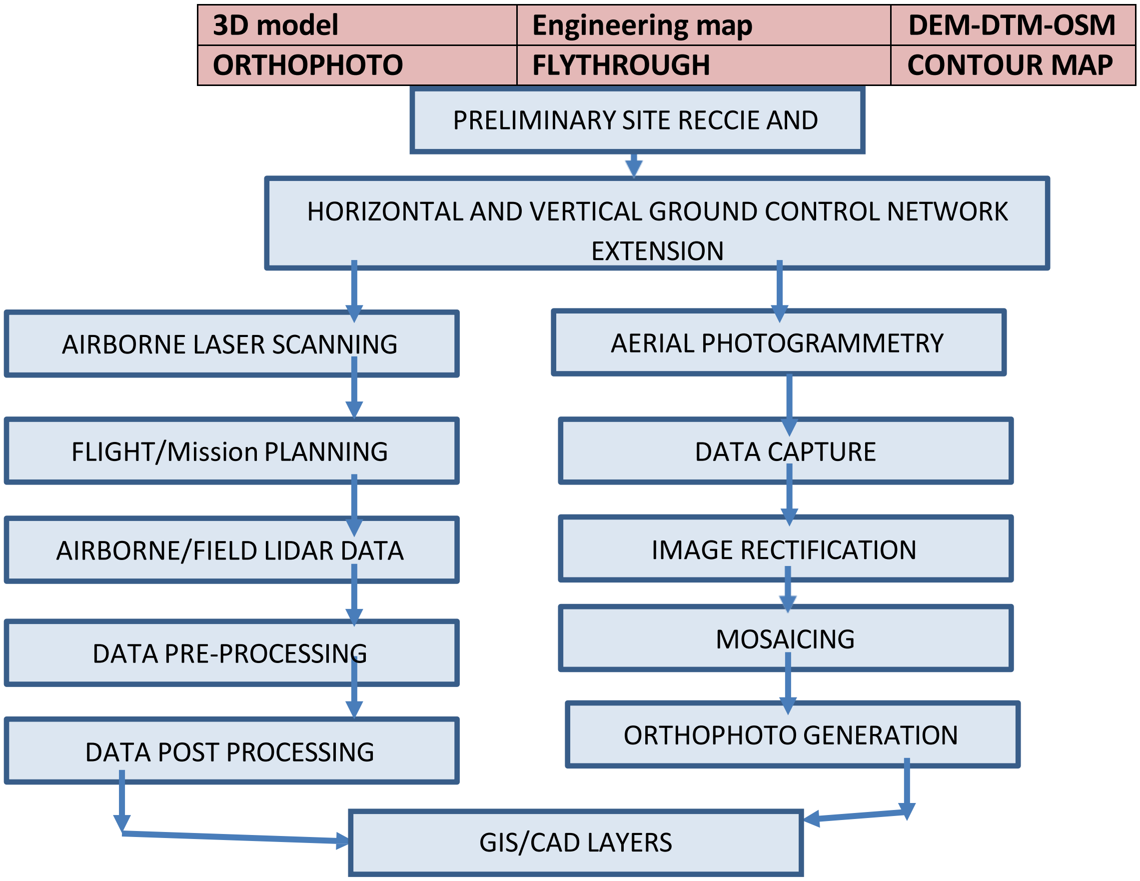


Fig 4: Processes of 3D mapping using LiDAR Technology

Environmental Systems Research Institute (ESRI) has designed 3D models for urban layouts in India. They have reviewed Models in 3D environments for quick simulation of 2D GIS data using the real world. For Smart city planning, prerequisites are infrastructure, energy, buildings, transparency, timely, security, safety, waste disposal, traffic control, and delivery service mechanisms for large-scale maps, with SDI (Spatial Data Infrastructure) Fig 4.

Large scale Maps

The accurate, high-resolution Cartographic maps can have small, medium, and large scales. The geomorphologic and location-specific features and their analysis of applications for upcoming planning for the fast urban sprawl and LSM maps are prerequisites. This is achieved by cartography and big data delineation using GIS and UAV. Hence, LSM of scales 1:10000 and 1:2000 is indispensable for town planning, land use and preparation of utility architecture. The 1:10000 scale map is less clear than the 1:2000 scale map for compilation or generalization; LSM to SSM is essential (Fig 5).

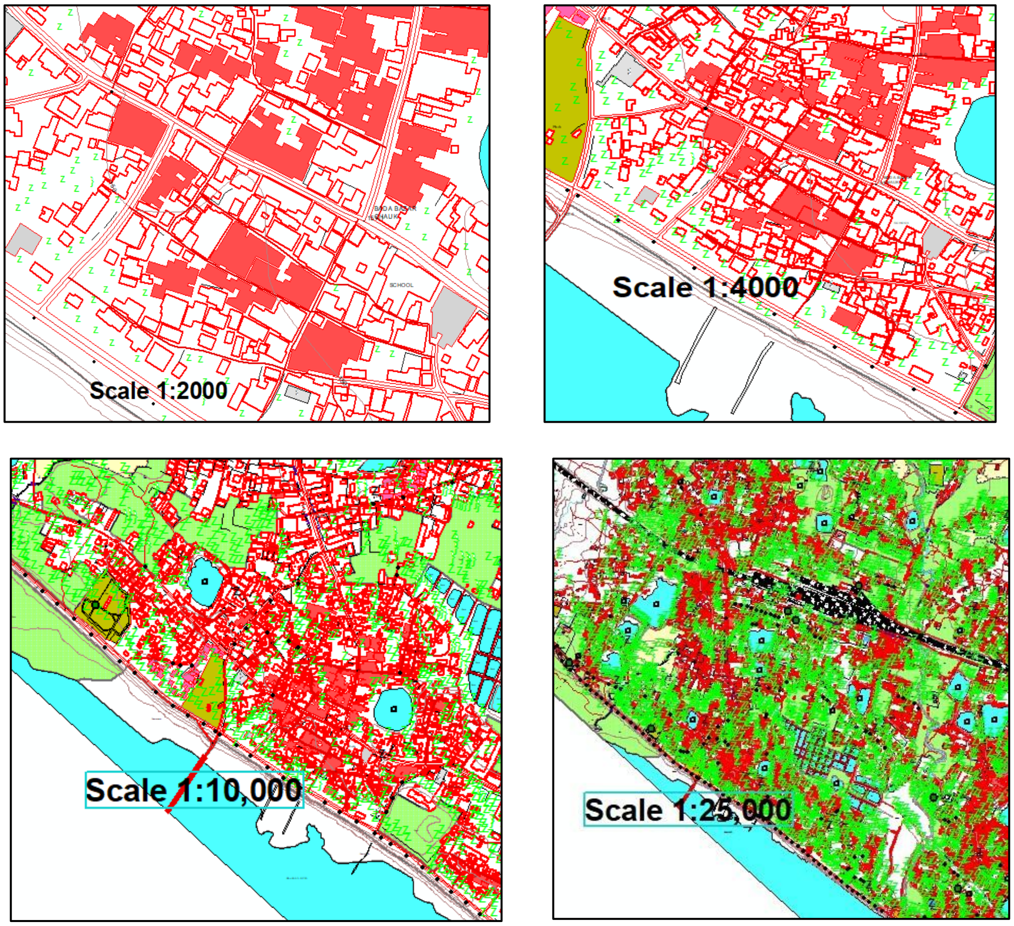


Fig 5: The LSM to SSM (1:2000), (1:4000); (1:10000), and (1:25000) of Bada-bazar Sambalpur

Meta Data and Catalogue Service Management:

Meta Data is any data which conveys knowledge about an item without requiring examination of the item itself. The Bureau of Indian Standards (BIS) has published the specification for generating Metadata (IS -16439 / (2016)), which is 13 tables. Metadata is the framework for finding, deciding, and documenting specific spatial data. The metadata standards are being followed all over India during mapmaking and geospatial data generation processes.

As discussed above, the GIS data handled under Spatial Data Infrastructure (SDI) must have standard-based Metadata. For the best use of high-resolution spatial data in any cloud platform, it is essential to construct a catalogue depicting the methodology of ingesting the repositories of the Metadata. Metadata management (MDM) must have security, be readily available, and be helpful. The earned benefits include fast data dissemination, quality enhancement, fast projects, and cost-effective, automated, and repeatable MDM systems.

Scaling distances and area coverage:

The scales of maps are linear, fraction and graphical. Various geospatial maps are prepared in the topographic and thematic form of a minimum 1:50000 scale. The different SSM shows more extensive areas than 1:25k, Medium 1:25k Scale, 1:50k Scale, 1:250k Scale, LSM less than 1:250k Scale, and Very LSM smaller than 1:1M. The LSMs are accurate in latitude and longitude compared to SSMs. The Earth geoid has an equatorial circumference ≈of 40000 km where 1deg = 111 Km, 1 min = 1.85 Km, 1 Sec = 30.83 m. Different OSM of separate scales are available in India, depending on the extent of positioning and coverage (**Table 1)**.

Table 1: Various maps like topographic or thematic maps with scales/ scope/ metadata groups [33]

Map Scale	In deg, min and Sec		Area in (≈Km$^{2)}$.	Spatial Level Use (Map distance/ground distance)	Data Scope and Metadata making
	Lat	Long.			
1:1Mn (SSM)	4 .0deg.	6.0deg.	184320	Country/Regional spatial level (1mm=1000 m)	Compilation
1:250K (SSM)	1.0 deg	1.0deg	11520	State-level long-term planning (1mm=250 m)	Compilation
1:50K (SSM)	15 min	15 min	720	District-level long-term planning (1mm=50 m)	Compilation/GS
1:25K (STD)	7.5min	7.5min	180	Block-level prospective planning (1mm = 25 m)	AS & verified by G.S.
1:10K (LSM)	3.0min	3.0mMin	27	City/ ULB level master planning (1mm =10 m)	AS/Drone/T.S.
1:4K (LSM)	1min	1min	< 4	Development Plan /Master Plan/Cadastral Survey (1mm = 4 m)	T.S./drone/ aerial Photo / LIDAR & high-resol ^{n} optical sensors
1:2K (LSM)	36 Sec	36 Sec	≈1.1	Micro planning /Zones of Cosmopolis (1 mm = 2 m)	
1: 1K (LSM)	18 Sec	18 sec	< 0.3	Micro planning / Local area ULB/Cities-Under Ground Utilities (1mm = 1 m)	
1: 0.5K (VLSM)	<9sec	<9sec	< 0.1	Land Administration /Individual Parcel – Ministry of Panchayati Raj (1mm = 0.5 m)	

** AS: Aerial survey, TS: Total station; GS: Ground survey; ULB: urban local Bodies (source: https://ncert.nic.in/textbook/pdf/kegy305.pdf)

Data Acquisition: Initially, Ground Control points (GCPs) are marked correctly with an accuracy of order 1:20,000, about ten numbers in the whole area as per (Federal Geographic Data Committee (FGDC) or American Society for Photogrammetry and Remote Sensing (ASPRS) norms [31]. The drone captures about ten sq. km of data, <5 Cm Ground Sample Distance (GSD). The images are captured when the drone is in real-time kinematic (RTK) mode as per the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) City Guidelines Fig-7.

Fig 7: Drone flying activity by UAV to collect the large-scale High-Resolution data

Visible and suitable test points (T.P.s) need to be checked by RTK GPS/ KM^2, totalling 0.25 mm in the mapping scale. It has 12.5 cm (1:500 scale) accuracy on spatial vector data for quality certification, following the methods specified under ASPRS guidelines. All GCPs need pre-pointing on the ground for improved accuracy, with 60 to 80% of data overlapping front and side-wise and covering ≈20,000 images. The original imagery of data estimated to be about 10 G.B./sq. Km. It needs to be considered [32].

Drone mapping details (Bhubaneswar):

Experiments are carried out at Bhubaneswar City, Odisha, covering about ten sq. Km. The purpose was to generate high-resolution base data in 2D and 3D in 1:500 scale. The base map layer is on a scale of 1:2,000 and will be generated in the Bhubaneswar Municipal Corporation (BMC) area. A Drone camera collected the aerial photos (data), and other drone data were Height data by Light detection and ranging (LiDAR).

Fixation of Various Data: Area – 80 to 100 Square K.M. (Approximate), accuracy Aimed: 3 Cm GSD; No. of Control Points: ≈10 nos. within mm accuracy (RTK GPS); Check Points: 200 nos. with mm accuracy (RTK GPS); Overlap 60 to 80% Front. (a). Overlap 60 to 80% Side. (b); Measurement between DEM and Ortho Photo Mosaic

Absolute accuracy Standards (ASPRS): XY= 2 times GSD; Z = 3 times GSD

Data acquired through the Survey, GIS, R.S., or Photogrammetry were disassociated by visualization (planned or developed) and maintained for each product in databases as high-resolution vector data in the cloud platform. Automatic attenuation of the desired data is done by filtration and generalization to the optimum and is a prerequisite (Fig 8(a); Fig 8(b); Fig 8(c)).

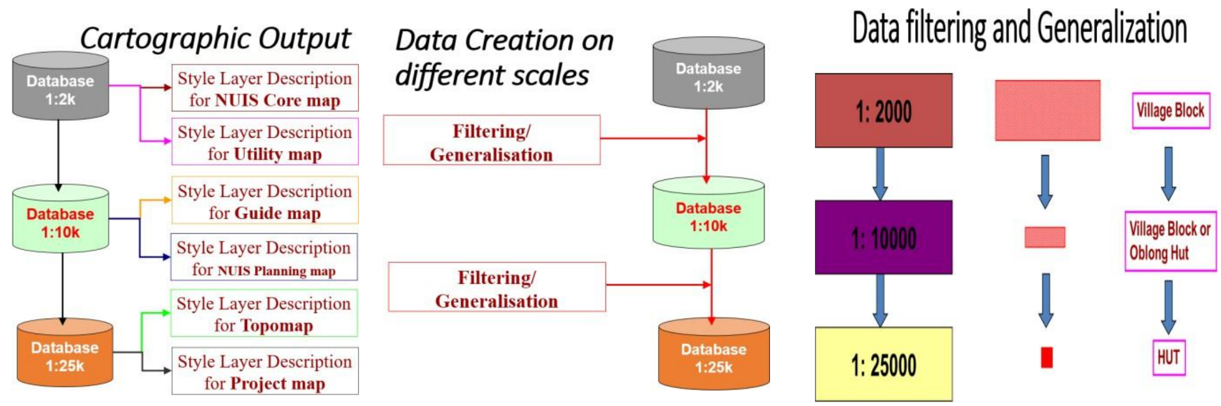


Fig 8(a): Data filtering & generation Fig 8(b): Data design on altered scales Fig 8(C): Cartographic output

LIDAR:

R.S. method is applied in LiDAR (which uses laser beams, a scanner, and a specialized GPS receiver) to examine ground objects. The common platforms are aero planes, which can be topographic (using near-infrared) or Bathymetric (by green light) water penetrating to measure sea or river beds.

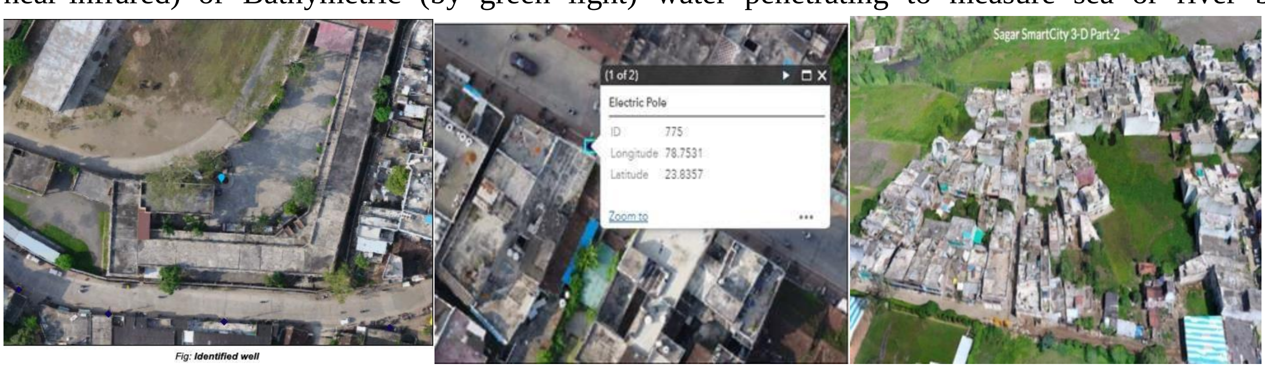


Fig 9: LiDAR maps to identify a well, electric pole, and maintenance holes (Sewage) and a city area

The advantages of LiDAR are that it is automatic, accurate, has better speed, is complete, reliable, economical, and inaccessible to small and large areas [63]. The LiDAR provides the ortho coordinate of each position of the ground attribute. The database is a dataset that offers data/ attributes as necessary Fig-9.

GNSS in Mapmaking

UAVs or drones equipped with GNSS receivers transmit the coordinates of the visible station without any GCS. The DGNSS is to be connected to drone equipment GPS/GNSS Systems to achieve high accuracy. The IRNSS (Indian Regional Navigation Satellite System) delivers precise data in India, spreading 1500km beyond its edges.

Automation by Geospatial Infrastructure:

Spatial objects offer evidence of many geographical locations on the terrestrial Earth. The physiognomies of the site depend on the scale, contents or purpose. On large-scale maps, single or several indications occur at the point, but the Location is a collection of settings in SSMs. During the conservative mapmaking process, one or many concurring facts can be presented as necessary.

Smart City mapmaking:

Smart city mapmaking can be very well termed as Urban informatics in the 21st century as it is more technology-driven than rudimentary procedures. Broadly, Urban informatics deals with *Urban Sensing and Urban Big Data Infrastructure. Urban Sensing pertains to using collective technologies to sense and obtain information about physical space and human activities in urban areas. The urban big data infrastructure is concerned with the type of data providers (private or public sectors), types of data with its source of generation (voluntary, private, public), and nature of data (open or protected). Particularly for the urban context, a clear understanding and notified distinction between open and protected data is imperative, as many data sources come with limited uses because of inherent restrictions to share among potential users.* The various components in map-making the Smart City information are data collection, Metadata features, Location and stage transition, colour allocation, quality checks, error detection, etc.

Map Compilation:

A field survey can help to prepare LSMs, but it isn't easy to convert SSM from it. Wherein a considerable number of maps are needed for jointing. During the process of merging, retaining the geographic features/ data cannot be represented on a map without transforming. The data needs production in maps at a definite scale, showing a defined/readable legend through automation of the big stored data, called map generalization, which is only possible through *map compilation*. Map generalization is part of map compilation.

The map compilation process represents geographical data to produce a map at a specific scale with a defined and readable legend [35]. The method comprises broadly reprojection, layer selection, simplification, classification, symbolization, and induction, considering the number of maps of the following order: a larger map.

For example, to prepare a 1:1 mn scale, full sheet, Open Series Map (OSM), compilation of 16 numbers of 1:50000 scale map sheets incident in the area, generalize and incorporate them in the new map. Out of two kinds of maps or information, the present open series map (OSM) topographic maps are 100% ground validated. They possess positional accuracy of up to 0.25 mm of the scale or 12.5 meters of positional accuracy digital elevation model height accuracy of +/- 50 cm and do not represent highly elevated topography. Thematic maps are on the same scale but are less accurate and meant for other audiences to use; they deal with positional accuracy of 1 mm of the scale or 50 meters and the DEM accuracy of 10m. Due to massive digital use, the requirements have forced the application to use high-resolution data.

There is a need for a base map LSM to be refurbished with exact positioning and minimum error. It is more pertinent to say that land value has increased and needs better management; therefore, accurate measurement on the ground and map. An appropriate scale of the base map is essential to restrict desired accuracies. The estimated length of the Earth's surface is ten arc = 110 km, 1' arc = 1.6 km, and 1" arc = 30m.

Foundation of Map Generalization

Map generalization is a simplified process of representing geographical features and attributes. The data is produced for a map at a definite scale in a defined and readable realm. Various methods are espoused in this extensive class of generalization. Optimization processes include assortment, generalization, combination, dissolve, merger, smoothening, enhancement, displacement, exaggeration, and aggregation. Though there is a necessity of different scale maps are required for other activities to have better urban and City planning LSM (scales of 1:1000 or 1:500). The topographic map data is vital as the base, DEM (50 cm x 50 cm grid and has 20 cm vertical accuracy), at 30 cm contour interval with Orth photo at 5-10 cm GSD. [33]

Metadata a qualifier to data:

Metadata is an essential component of any spatial data management, facilitates registering in the National Geospatial Data Registry (NGDR), Geospatial Policy 2022, and allows for search across the digital domain. Metadata information is being handled in all activities as per IS-16439 of 2016, which comprises identifying data, contacts, geographical place, coverage, and dialect/ dataset category. For imagery, these are in format, as well as the date and time of the image. Other optional features are type, subject, description, quality, attributes, entry of attributes/entity, manual correction, summaries, and much more essential information (IS-16439-2016[34]).

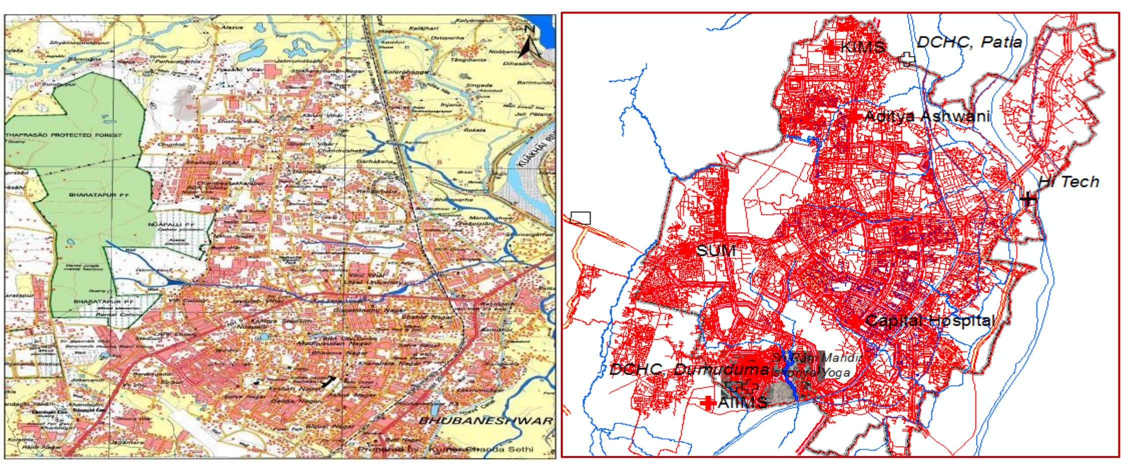


Fig10 (a and (b): The GIS map with Ground features & geospatial map on cloud platform by UAV (Bhubaneswar city)

Geospatial data is the data of a position either with attributes or as imageries, videos, voxels (graphic simulation) with/ without raster datasets, vectors, and digitized/non-digitized forms used for web services [35]. The town LSM map making has been given to NRSC to prepare using satellite imagery data with source input cartons at – 1 imagery, mono mode, resolution 2.5 meters, and absolute accuracy of better than 5m thematics. The map of Alidabad township in Madhya Pradesh has been made of Scale 1:10000 and 1:2000, shown in Fig 10(a), Fig 10(b)and Fig 10(c)

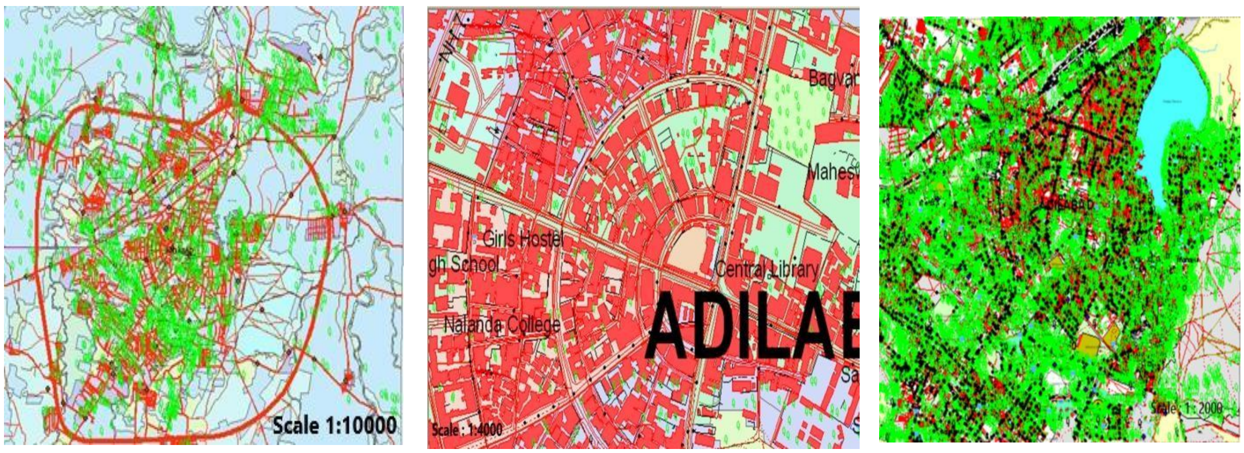


Fig 10 (C): The map of Adilabad city in 1:10000, 1:4000, and 1:25000 Scale (Visualization of data)

Colour allocation:

By conscious decision, previously in the national mapping agency, Survey of India, limited colour combinations were considered from cartographic principles for publishing topographic or choropleth maps. The general recommendation is given in the table given below Table 3.

Table 3: Colour combinations considered in choropleth maps in Cartographic principles.

Sl No	Colour	Features	Physical bodies
1	Black	Natural features	Rails,
2	Red	Artificial	Building, Roads,
3	Green	Trees	Forest, vegetation, plantations
4	Yellow	Cultivation	As ripe paddy is yellow
5	Blue	Water	Water, Lagoon, Waterbody
6	Grown	Hexographic	Contours
7	Purple	Restricted	Restricted features to civilians

Currently, the RGB (red, green, and blue) colour combination is applied to make multiple colours to signify various fundamental ground features or groups of features (Layer). The colour compositions allowed multiple features to be identified per the site conditions.

Quality Assurance and Quality Check :

The complete area's ortho photo is generated with ground sample distance (GSD) up to 5cm from 3 Cm GSD original data to reduce file handling difficulties. 5 GSD has been chosen, keeping the final mapping accuracy of 1:2000 scales. The estimated data size is to be about 2.5 TB (Terra-bites). Orth photo accuracy will be tested using test points above para c with the coordinates observed from the ortho photo. Statistical methods with the Least Square Adjustment will be deployed to generate an Error Ellipse and reach (Root Mean Square Error) RMSE of 6 CM in X.Y. and 9 CM in height. Target accuracy is being considered as per recommendations made for digital geospatial data handling by the American Society of Photogrammetry and Remote Sensing (ASPRS) in conjunction with the recommendation of the Federal Geographic Data Committee (FGDC) with the requirement of 2D map on a 1:2000 scale and 3D building heights with 15 CM accuracy captured from ortho-photos, [36][37]

Plottable error:

The plottable error for map printing that determines the map's scale is taken as a pencil dot on the map that determines the level of accuracy. It is approximately accurate up to 0.25mm in measurement. It is the optimally smallest dimension of the features represented on the map page. For example, for a large-scale map of 1:1K, the plottable error is 0.25m on the ground. But in SSM, it is 62.5m on a 1:250k scale. The topological feature with a dimension less than 62.5m cannot be shown on this map scale so a point symbol represents the features.

Photogrammetric survey errors:

During gathering the GIS data there is the chance of incorporation of error, inaccuracy, and imprecision that may upset the precession and quality data structure that may distract the map accuracy. In a 3-D frame, the errors can be horizontal and vertical which can be measured by the root mean square error (RMSE) as model results depending on the input parameters and Metadata. The horizontal errors occur along X and Y directions and total as RMSEx, RMSEy, and RMSEr whereas vertical error as RMSEz for the non-vegetated area (NVA). [38]

Table 4: Horizontal and vertical accuracy standards of Geospatial data (Source: [36])

Horizont accuracy	Absolute Accuracy				Ver. Accu.	Absolute Accuracy			
RMSE x of the class	RMS E y of the class	RMS Er of the class	Horiz. accuracy at (95%CI)	Ortho-imagery Mosaic seam line mismatch	of the class (z)	RM SEz	NVA at 95% CI (cm)	VVA at 95% CI (cm)	Relative Accuracy (cm)
(Cm)	(Cm)	(Cm)	cm	cm	*cm*	*cm*	*cm*	*cm*	*cm*
X	<= X	<=1.414 * X	<=2.448 *X	<=2*X	Z-cm	<= Z	<=1.96* Z	<=3.00*Z	<=0.60*Z
5	5	7.07	12.24	10	5	5	9.8	15	3
10	10	14.14	24.48	20	10	10	19.6	30	6
15	15	21.21	36.72	30	15	15	29.4	45	9
20	20	28.28	48.96	40	20	20	39.2	60	12
25	25	35.35	61.20	50	25	25	49	75	15

N.B.: NVA: non-vegetated terrain Accuracy; VVA: vegetated terrain

The Table3 above gives the absolute and relative vertical accuracy standards for Digital data of the Digital Terrain Model (DTM), Digital Elevation Model (DEM), or Digital Surface Model (DSM)) which can generate a Unmanned Aerial System (UAS) map to formulate Master Plans and Local Area Plans. The error of WGS84 is believed to be < 2 cm to the centre mass,

Geospatial technology:

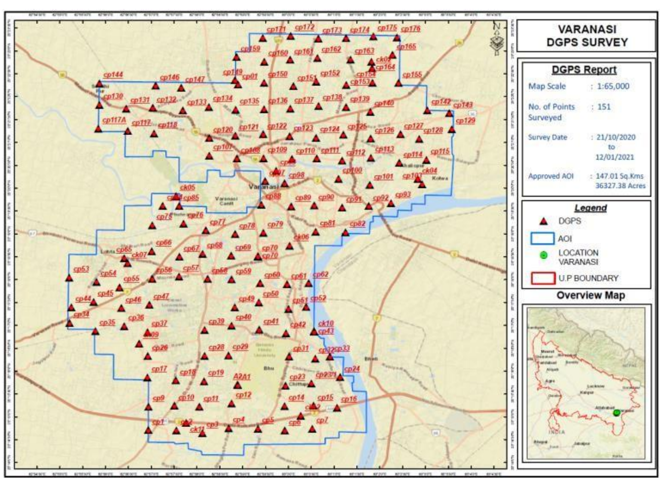
Geospatial Technology includes ground survey Aerial / UAV Photogrammetry, drones, Radar Aerial / UAV LIDAR, satellite-based R.S. techniques, interferometry, artificial intelligence, and underwater mapping, [39] Considering the WGS84 a reference ellipsoid, a standard coordinate system, altitude data, and a geoid can have an error of less than 2cm. https://gisgeography.com/wgs84-world-geodetic-system/. Geospatial data has gained popularity and is widely accepted by VAS (value-added services). The ground survey data must be ground-truthed, aerial survey data must be compiled, and need ground verification must be required.

Big data gathering for map generation:

The old data-gathering methods, such as manual or aerial surveys, by compass, dumpy levels, and theodolite, have been less used. The present innovative methods used for gathering foundation data are total station, GPS/GNSS, photometry, satellite imageries, Radar, UAV, LiDAR, satellite-based R.S. techniques, interferometry, artificial intelligence, and underwater mapping for baseline survey for a small area. These methods of generating foundation data are time-consuming, have survey errors, are not germane to inaccessible/hilly terrain, and are incomplete (due to forests and shadows [40].

Global Positioning Systems

Global Positioning Systems (GPS) and Global Navigation Satellite Systems (GNSS) are part of the positioning technique launched by the U.S. Dept. of Defense in the 1970s.



Nanda Rabindra Nath / Afr.J.Bio.Sc. 6(5) (2024). 3181-3204

Fig 11: The ground control point survey by using the DGPS Report of Banaras City

The GPS is based on positioning, navigation, and route guidance, whereas the GPS framework is an innovative technology, expert technology, geographic database, user-friendly, and context (like day/night, cloud and moving vehicle, etc.), [41].[42]. GPS satellite orbits are designed to ensure the availability of a minimum of 4 satellites whose visibility is above a 15° cut-off angle anywhere on the Earth's surface, day and night Fig 11.

Global Navigation Satellite System

The GNSS globally delivers positioning, navigation, and timing (PNT) facilities. It has applications in receiving and recording data of the complete range of signal strength and frequencies with accuracy up to a level of 1m and even up to a centimetre or millimetre by DGNSS. The GNSS data dissemination through smartphones is to expedite the local or location-based Volunteered Geographic Information (VGI) services at a low cost [43], [44], [48]. Radio signals from a satellite constellation are received through a GNSS device, and the coordinates (x, y, z) of a ground point are determined by the mobile. [46][47][481][49].

Topographic map generation:

Topographic cartography techniques deal with cartography (nature & scope), scales (concept & application), graphical construction of plain (comparative and diagonal scales), Bonne's and Mercator's map projections (classification, properties & uses), graphical construction (polar zenithal & stereographic), and is presently used as universal transverse Mercator's (UTM) projection. [50].

Thematic map generation:

The challenges in getting data and map generalization were acknowledged in the late '80s, published in the book' Map Generalization: Making Rules for knowledge representation' [51], [52]. Thematic map generation deals with classification and types, principles of map design, and schematic presentation of data - lines, bars, and circles. Thematic mapping techniques show properties, uses, and limitations. The map uses areal data (choropleth, point, proportional circles), point data (isopleths), and cartographic overlays (point, linear and areal data. The ultimate methodologies are the preparations and interpretations of those maps [53], [54]. The result obtained will be tested against the result arrived at by the master plan/zonal plan and detailed ward plan of the City by central/state agencies using manual methods. The result is expected to match the 95% confidence level by visual inspection and correlation methods.

Spatial Reference Frame

GIS is database-oriented, so the software manages big data in the database, and cartography epitomizes the natural world through relevant entities and graphics based on the DLM database. The horizontal (Datum/projection) and vertical (datum / ellipsoidal height) are the unique reference frames used in the coordinate system. The datum of the reference system is WGS84 (Semi-major axis as 6378.137Km and flattening, unit less as 1/298.257223563) for both horizontal and horizontal. The projection against horizontal is a Universal Transverse Mercator (UTM), and vertical can be calculated from MSL with the help of the Geoid model (Model 2008), which is less accurate and can be reduced very accurately by levelling (The data input by GIS should be such that the tenet involves the simultaneous running of both the DLM and DCM databases of GIS to generate the map. [55], [56]).

WEB GIS Cartography:

GIS in real time has advanced technologically to the extent that huge geospatial datasets, specifically semi or unstructured data, under clustered cloud base storage, are collected from GIS, Drones, and LiDARs. In the terrestrial plane, mobile technology helps the user in city modelling -3D along with emergency responses, trafficking, tourist navigation, communication, Aerial mobile mapping, internet services, road mapping, *etc*. Mobile mapping knowledge is an advantage to food supply, energy services, health care, *etc.*, through available opportunities for mobile GIS skills. [57], [58]).

Discussion:

There is an urgent need for smart, user-friendly, innovative map-making. The ICTS (Information and Communication Technology Survey), Drone photography, Relational Database Management System (RDBMS) an ORACLE Spatial software, Mobile Mapping System (MMS), GIS, Global Positioning System (GPS), Interferometer, or Differential Global Positioning System (DGPS), and mobile phone sensors were the tools used for maintaining data storage deployed for map generation in India. [59]. To add to the multidimensional aspect of map-making, geospatial data must be comprehensive, precise, accurate, and updated.

Concurrent map generation through cartography is complex where data is accumulated from the map as sources and graphically signified to interconnect themes of the map. GIS-based cartography splits this process into three parts:

Compiling the geographic database, overriding data as per the database, processing based on geographic information to be transformed from one form to another, and rendering tools to convert objects into symbols on the map. Under Smart City initiatives, the Cartographic map generalization will be used in spatial databases for justified querying, efficient transmission, and good visualization of target information while achieving the accuracy required for town planning applications. **Fig…**

Fig 3: Varanasi Monuments in the 20th century, During Reconstruction, TOI, Dec 07 2021, after Inauguration Day News 18 (Dec 13, 2021).

The geographic information system technologically developed in the late 1960s has urged for automatic algorithmic generalization techniques. Later, national mapping agencies (NMAs) became accountable for gathering and preserving 3-D datasets. They have tried to hold onto only one official representation of a given attribute/feature in detail at the optimum level. Large-scale data must be ideal, and multiple automated generalizations are needed to produce maps at different required scales. The substitute is maintaining distinct meta D.B. (databases).

Conclusions:

The maps of the topographical form are large-scale or point maps that are more accurate in locating ground latitude and longitude. They also give precise elevation, benchmarks, urban sprawling, settlements, forests/vegetation, land use, drainage anastomosis, waste disposals, and road networks. Incessant improvements in map-making technology and lashing shifts in the digital economy have facilitated big data management in the mapmaking industry. Today's concern is the security, safety, surveillance, and implementation issues with UAVs and modification of regulations and guidelines of the old Aircraft Act, 1934 section 14 (22 of 1934), revised in UAS Rules- 2021 to fly the drone, and its boundaries and possible resolutions. Nowadays, data are collected through UAVS using drones, photogrammetry, and LIDAR, which should be implemented for future mapping processes.

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