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Article

WebGIS map for smart city development and decision support system: A case study of Dehradun Smart City, Uttarakhand, India

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Abstract: India is one of the countries in the world which has made continuous progress in the technological revolution. The development of Smart Cities has led to a revolution in e-governance and the citizen-centric approach. The Geographical Indicators and Location-based assets can provide quick action and decision-making approaches to City Administrators. All Smart City GIS Layers on a single platform are beneficial for Smart City and Urban Planners and Administrators to find common solutions for retrofitting the environment. The common GIS Layer helps in utility services planning and drainage mapping which allows for the underground laying of all utility pipes and cables. This research is about the mapping of the common GIS Layer of a Smart City of India on a single WebGIS map to its core. The common GIS Layer will help in decision support and quick action redressal in emergency scenarios as well.

Keywords: smart city; GIS; governance; technology; urban; good governance; WebGIS

1. Introduction

Urban Planning and Development has made warfare progress in the last five years which includes rapid development in road and bridge networks and revamping of government infrastructure. The Ministry of Housing and Urban Development has made hundred smart cities in India where the progress of Dehradun Smart City has taken a reference in this study to enlighten the progress and significant effect in urban cities. Dehradun Smart City has submitted projects worth INR 1307.5 crore to the Ministry of Housing and Urban Affairs as projects related to the Integrated Command and Control Centre, Smart School, Smart Road, Smart Library, Water SCADA, Collectorate building, Digitization of Collectorate office, Electric Bus, Digital Payment, e-Governance, Web Geographical Information System (WebGIS), Traffic and Solid Waste Management. The Dehradun Smart City has developed a GIS system as a citizen service which is available on the Dehradun Smart City Website. The Geographical Information System of Dehradun Smart City has contained various layers of information which is helpful to city Administrators and Planners to make decisions in emergencies. The Decision Support System plays an important role in emergency and disaster situations in knowing the information related to evacuation routes, ambulance entry and exit, fire brigade entry in congested roads using the shortest paths, open land, collection centres and public collection points. This Geographical Information System is a landmark for the Smart City scenario. This GIS has helped during COVID-19 in tracing positive patients and movement of positive cases within the city. The city Administrators have taken rich benefits from this system and made immediate decisions in emergency situations. The major problem in Smart City scenario is to make quick decision based on the data availability which is

incomplete without the WebGIS as decision support system. The planners and administrators some time need clarity on ground scenario which is impossible without WebGIS. The different layers provide comprehensive view to make fast and quick decision in case of emergency. Smart cities major information provider is WebGIS where different departments can work together for better decision making. Based on the availability on different kinds of data it has been seen sometimes the decisions are not accurate due to lack of decision support system. The WebGIS motivates to provide better decision system. The conceptual framework is to identify the locations, landmarks, roads and building on the ground with the help of WebGIS technologies which includes collection of data, refine using GIS and Database and Programming Technologies to render them on a common platform. This is purely linked with objective of the study like to provide quick and decision-making system, save time and energy, and fuel, provide better and effective results in decision making support. The scope of this study is to gather all possible information within the city which can help administrators to make effective decision using better results.

2. Literature review

A geographical Information System is a standard tool for efficient city management and planning. GIS technology is used as a revolutionary phase for mapping utility services. The GIS is widely used in Government offices, for business purposes and in local communities [1]. The GIS is a centralized ecosystem where all IT services mapping can be visualized on the digital platform and changes can be made dynamically with less maintenance cost. The centralized helps maintain asset information [2]. The Smart City is based on three strategic factors which are a city with a clear vision, specific challenges within the city and engagement of different city stakeholders. The world of smart cities has presented excellent examples of implementing the best smart cities [3]. The Location-based services are very helpful for crime reporting, women helpline, incident handling and management, traffic and speed movement. Most cities and deployed surveillance cameras at blackspots and now they have fixed speed limits and monitoring the traffic remotely. The GIS is very helpful as an IT tool in continuous upgradation and adding new service layers for a better ecosystem of all city assets and services [4]. The GIS data can be classified based on its need and demand. The Government of India has deputed City Data Officers known as CDOs for the management of city data as various layer information systems. The data is classified as public, sensitive, restricted and protected and can be placed as different service layers in GIS system based on its classification and availability. The open data platform and India Data Urban Exchange are the entities of data management framed by the Government of India [5]. The open platform and spatial data infrastructure are example of rapid data development. The 3D city models are already available on geo data platforms which are helpful to understand the topology of any area [6]. The GIS has mapped industry, agriculture, transportation, chemical, solid waste, power, water, road, horticulture fisheries and wildlife ecosystems as a use case to closely monitor the information layers. The mapping of all services helps make decisions wisely and cost-effective driven with no financial and revenue losses [7]. The Geographical Information System has played a vast role

in the environmental and energy sectors. The green mission has success based on the efforts of its stakeholders. The energy sectors include conventional and non-conventional sources which can be monitored as real-time GIS system for effective mapping and monitoring [8]. The Smart City of Rio and Madrid are the best examples for the development of a smart city from scratch. The GIS information system is very accepting and active which handles in incidents very smartly. The Government of India has framed data guidelines for smart city GIS development [9]. The geo-tagging of all assets is very helpful for smart city administrators as they make decisions based on the information displayed in GIS. The effective GIS is continuously upgraded and managed by the IT and GIS team [10]. The Government of India is planning to map all MIS systems with GIS as a National Information System as a Data Lake [11]. The WebGIS information is helpful in an emergency scenario where a quick decision is required. A centralized decision support system based on WebGIS provides an IT framework for maintaining and deploying data and its associated applications for better smart city management [12]. The web-based applications require different kinds of maps data and its associated services to rendering maps on the browser [13]. Visualization is one of the important points to convey information to city administrators. Real time monitoring helps to present clarity about ground information [14]. Different areas of the society use GIS for various advantages like in urban traffic the shortest route helps to identify the nearest path to save time, fuel and economy [15]. In recent years, the concept of smart cities is widely used in urban development where the information of already laid utilities line below the road can be identified which helps in efficient utility planning [16]. The concept of smart cities in India is new for better and efficient planning for new cities development, redevelopment and retrofitting. The major part is WebGIS which is helping city administrators during planning, execution and management of smart city infrastructure [17]. The layered information is very much important to render maps over the satellite data. The existing maps of revenue department helps to overlay the boundaries of cities and villages and finally helps to draw various layers [18]. A good planner helps in smart city development using the information of various department. The information of Traffic, Urban Development, Municipal Commission, Public Works Department and Water Department is very much important in retrofit scenario where the existing utilities are already laid [19].

3. Methodology

Dehradun Smart City has developed its GIS solution for its core services. The satellite data is procured from National Remote Sensing Centre (NRSC) Hyderabad. The District Administration has mapped its basic data layers along with satellite data as base layers satellite Map, Asset Information, Decision Support System, Tool to Extract Information and Future Updates and Upgrade. The road and drainage, land use, grid parcel network is a part of the base layer. The first layer consists of satellite data. The second layer consists of buildings, roads, drainage, green areas, open areas, forest land, vegetation, drainage network, national highway, state highway, village roads, kaccha and pucca roads. The Asset Information consists of Geo-Tag indicators, Spatial information, and MIS data. The asset information includes post offices, atm, hospitals,

blood collection Centre, traffic signals, CCTV surveillance cameras, speed governors, solid waste collection points, pollution sensors, emergency panic buttons, government buildings and offices, community halls, Aadhaar and pan Centre's, yoga Centre's, recreational service Centre's, hotels and restaurants, temples, church, mosque and museums, bus stand, railway station, airport, forest and tax stations as government informatory layers. The remaining assets related to business to consumers can be reflected along with this information. The decision support system can be used to know locations and utility services in case of planning and decision-making. COVID-19 is an example of city-wise management where administrators were making quick decisions based on the information. The tools are used to extract information for planning and information. The exact information is helpful for cost-effective decisions. Future updates and upgrades are mandatory for continuous improvement. The common GIS Map for all Smart City Domain consists of Base Layers, Assests Information, Decision Support System and Tools to extract information for various purposes. In this study, the common framework for all smart cities as a GIS Map is mentioned in **Figure 1** below. Satellite data play very important role in rendering various layers over satellite maps as ground truth with the help of geo-referencing technology. The ground truth of information rendering over WebGIS Map is very important.

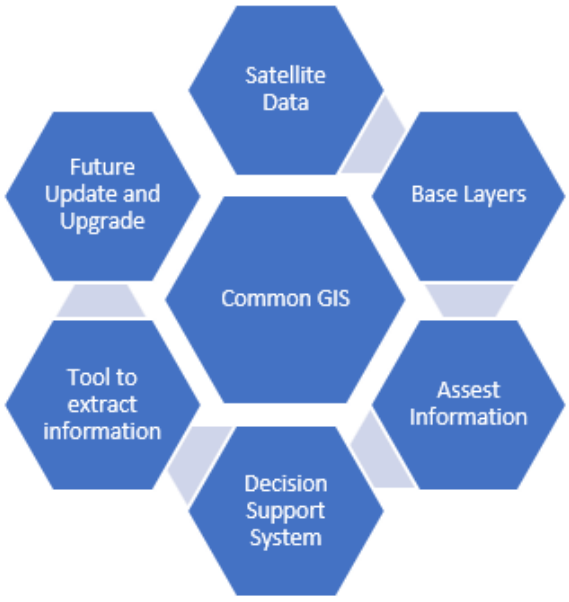
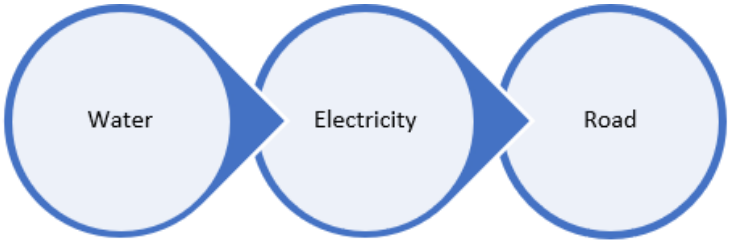


Figure 1. Common GIS map for smart city domain.
Source: https://smartnet.niua.org/.

The Common GIS Map for all Smart City Domains is a best way to trace all the layered information on a single platform. There are majorly common problems in every retrofit smart city. For greenfield and redevelopment, the problems can be overcome by a common solution. **Figure 2a,b** representing common solutions for all smart city basic problems which consist of Traffic, Solid Waste, Parking and Pot Hole Management. Water, Electricity and Roads are the backbone of any Smart City. Also, **Figure 3** represents the various layers of Common GIS Map.



(a)

(b)

Figure 2. (a) Smart City basic entity; **(b)** Major smart city problems.
Source: https://smartnet.niua.org/.

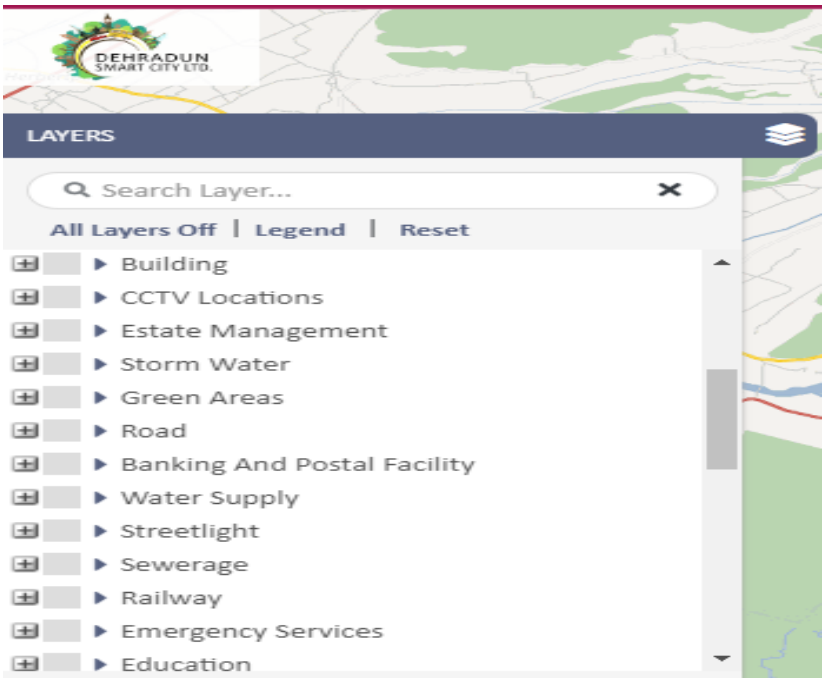


Figure 3. Various Layers of Common GIS Map.
Source: https://dsclgis.uk.gov.in/GIS/Home/GISPortal.

This approach is towards the implementation of a common GIS Map for all smart city domains. The hundred smart cities of India can be visually represented on a single platform consisting of a Satellite Map of India, various layers of drainage, water, roads, state and national highways, and kaccha and pucca roads. The second segment consists of Post offices, Banks, ATMs, Hospitals, Blood Donation Camp, Public collection centres, Helipads, Medical Stores, Police Stations, Health Centres and Government buildings. For the implementation of the Smart City on a single platform the section is divided into the following:

1) Base Layer;
2) Informatory Layers;
3) Tool Box;
4) Control Panel;
5) Legend.

The common Map for all smart city domains is a use case of Dehradun Smart City GIS Map which consists of **Tables 1** and **2** as various layers with layer numbers. The spatial information with MIS details is stored in Relational Database from where this information is rendered over a browser using GIS and Map engine. The information can be viewed from any electronic device and can be updated using secure login from any device. The toolbox is used as a common information dissemination and quick response mechanism. Control Panel can be configured as per the requirement of the GIS system based on need basis which includes utility map of roads, drainage, Fiber Cables, Gas Pipelines, Petrol and diesel lines, railway cable network. The city administrators can use this GIS system at a national level for permission related to National Level Projects which includes NHAI, RailTel, Gas Line and Electric Grid lines for issuing NOC related to land utilization and monitoring and mapping. One of the good examples is the PM Gatishakti project which is implemented at the national level for the monitoring of roads, bridges, and ports projects including financial and physical progress on a weekly and monthly basis. **Figure 4** represents the major Smart City problems.

ArcGIS, MapDot Net and SQL Server 2018 renders the map on browser. The GIS Layers are created in ArcGIS. The export function of ArcGIS and import function in SQL Server 2018 are used to store the data in the database. The dot net engine is used to collect, analyze and render the WebGIS map on the browser. The WebGIS system takes input from user by selection of layers and its related action from the tool bar and accordingly it renders data. This selection provides information related to decision support system which saves time and effort. The geographical indicators or landmarks play important role in planning, selection and decision making. This helps in planning of any utility service in a particular area. The built-in engine processes the map layers from database along with vector and raster data.

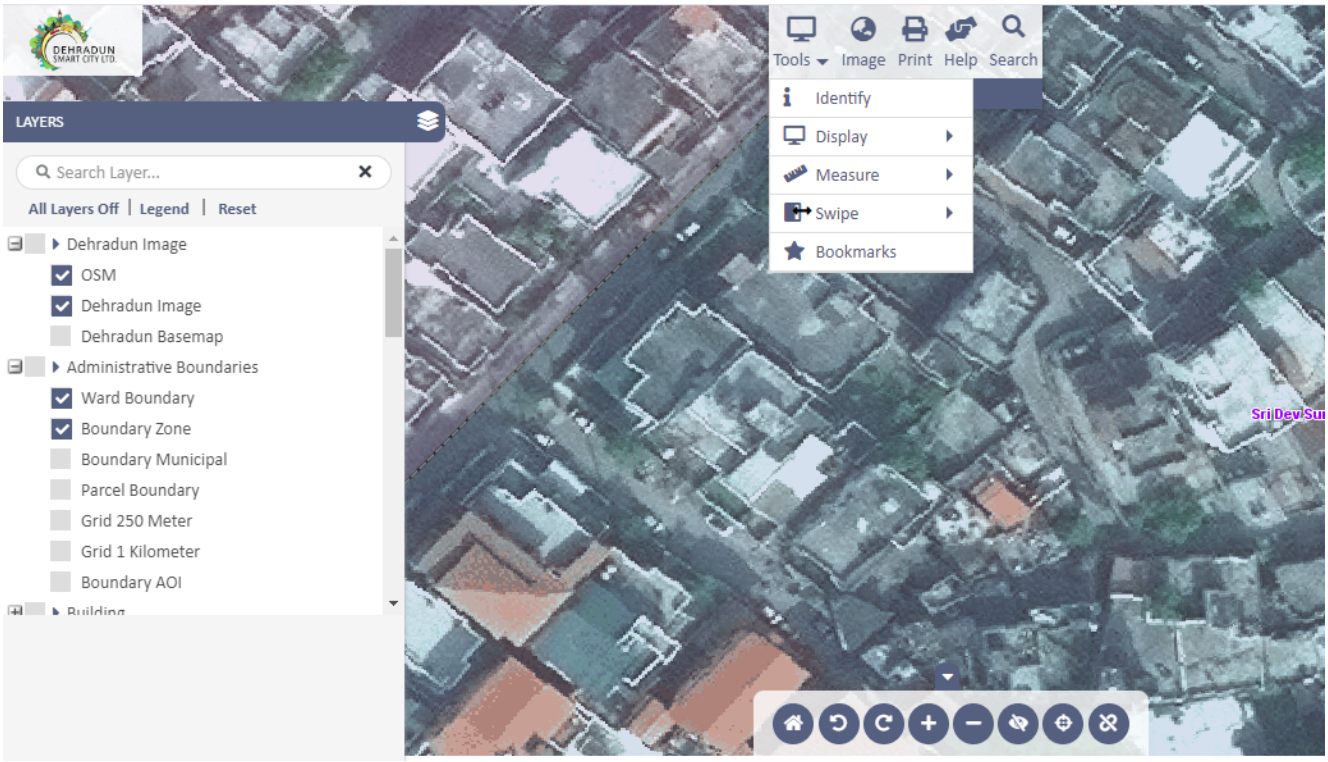


Figure 4. Major smart city problems.
Source: https://dsclgis.uk.gov.in/GIS/Home/GISPortal.

Table 1. Dehradun Smart City GIS layers-I.

Layer number	Geographic information system layers
L-0	Base map
L-1	Administrative boundary
L-2	Ward boundary
L-3	Buildings
L-4	CCTV locations
L-5	Estate management
L-6	Storm water
L-7	Green areas
L-8	Road
L-9	Banking and postal facility
L-10	Water supply
L-11	Street light
L-12	Sewerage
L-13	Railway
L-14	Emergency services
L-15	Education
L-16	Power
L-17	Solid waste management
L-18	Medical services
L-19	Recreations

Table 1. (*Continued*).

Layer number	Geographic information system layers
L-20	Religious places
L-21	Water bodies
L-22	Area base development
L-23	Pro development plan
L-24	Covid
L-25	Census

Dehradun smart city GIS map layers
Source: https://dsclgis.uk.gov.in/GIS/Home/GISPortal.

Table 2. Dehradun Smart City GIS layers-II.

Layer number	Geographic information system layers
L-26	Contours
L-27	Parks and gardens
L-28	SCADA
L-29	Environmental sensor
L-30	Public addressing system
L-31	Variable messaging display
L-32	Smart Wi-Fi
L-33	DSCL optical fibre cable
L-34	Adaptive traffic control system
L-35	Emergency call box
L-36	Integrated traffic management system

Dehradun smart city GIS map layers-II.
Source: https://dsclgis.uk.gov.in/GIS/Home/GISPortal.

4. Results

The Common GIS Map is the best solution for efficient and effective planning and decision-making in Smart City Domains. **Figure 5** represents the Dehradun Smart City satellite and **Figure 6** shows the locations of the CCTV network within the city which can be connected with all National Highway camera networks. Similarly, layers of Wi-Fi, Panic Button, Solid Waste Bins, Traffic Enforcement Cameras, and movement of Solid Waste Management vehicles are very important in planning and decision-making. The overlapping of these layers helps in emergency scenarios and management decisions.

The WebGIS can be used in emergency scenario for ambulance shortest route finder, traffic management, solid waste management and planning the services for future. The different data layers renders over map and provides the clear information and gaps in making quick decisions. The location of fire vehicles can be traced in emergency scenario. The WebGIS map provide complete information to the administrator.

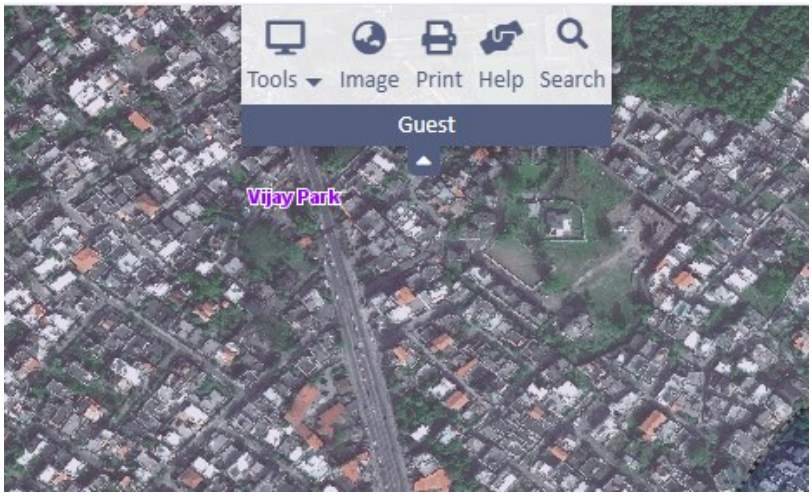


Figure 5. Satellite map of Dehradun smart city.
Source: https://dsclgis.uk.gov.in/GIS/Home/GISPortal.

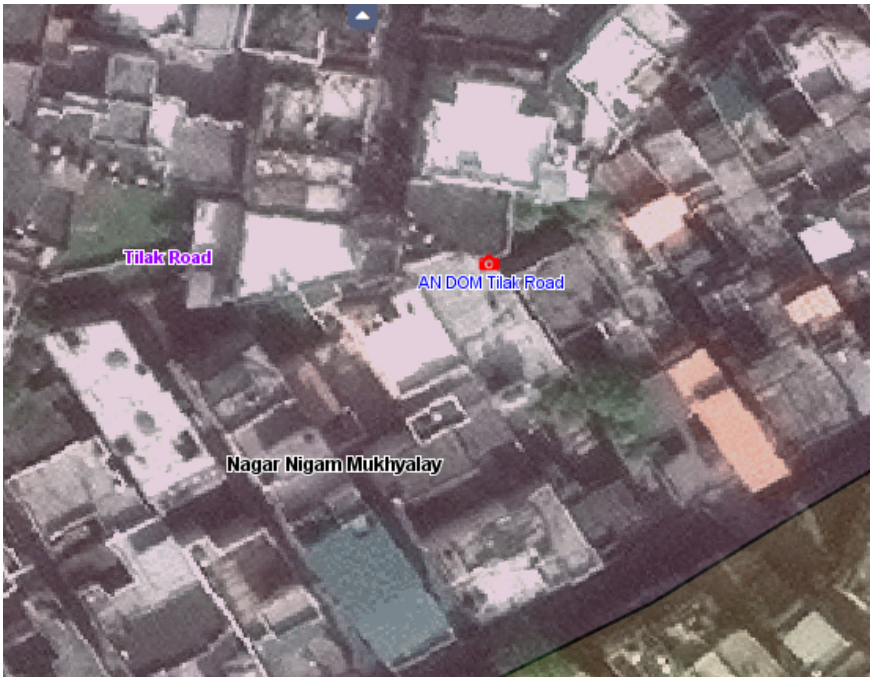


Figure 6. CCTV locations in Dehradun Smart City.
Source: https://dsclgis.uk.gov.in/GIS/Home/GISPortal#.

5. Discussion

The WebGIS is used in planning and decision support system. The different layers of city data are very useful in deciding the future utility. The Integrated Command and Control Centre plays a very important role in overall commanding the field functionaries. In the previous studies the decision support system was used to a limited extent but by using Mobile App the two-way information exchange system helps in timely decisions. In this study the information is processed using different data which helps to produce quick and informative results. The Decision Support System is purely based on information and satellite imagery. The system is dependent on raster and vector data. This study is basically focused on WebGIS maps and their benefits in smart cities to city administrators and the general public. The main source

of planning is satellite data which is dependent on a Satellite data agency. The study is limited to a particular city however by collecting different data from various parts the study can be broader to a large extent area. The WebGIS system is not prepared for Artificial Intelligence and Machine Learning. The IoT devices can be trained using Machine Learning software and the WebGIS system can be worked on auto intelligence model in future studies by improving the WebGIS system on next-generation technologies. The data accuracy is dependent on ground truth verification, exact location of milestone which is one of the weaknesses of this study. The per square metre cost is dependent upon number of locations, structures and other landmarks identification and collection and verification of latitude and longitude.

6. Conclusion

The study is focused on the Dehradun Smart City where a satellite map is used for rendering various digital layers and the final Map is prepared for planning and decision support. The layers of Fire Alert, Traffic Movement, Public gathering, and Emergency Ambulance Evacuation can be created. The WebGIS Maps are very helpful in such a scenario where new planning is scheduled for construction, planning and management. The complete information of Smart City assets can be managed over a single WebGIS Map. The base layers of WebGIS map are very useful for matching the exact location of different utilities on ground.

Conflict of interest: The author declares no conflict of interest.

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