High Resolution Remote Sensing, GPS and GIS Based Geospatial Database Creation for Disaster Risk Reduction in Lucknow City

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Abstract

This paper aims at creation of comprehensive geospatial database for emergency and disaster risk management in multi hazards prone Lucknow city which is one of the major habitations of Ganga Plain and has a population of about three million and is also the state capital of U.P, (the most populous state of India). The city is prone to man-made disasters including fire, road, rail and air accidents and collapse of buildings. Apart from these man-made disasters, the city is also prone to, floods, earthquakes, hydrological droughts and wind hazards. The tremors of 2015 Nepal earthquake were conspicuously felt in Lucknow. This study outlines the requirements to prototype a geospatial database in such a way that it can be used for preparedness, response as well as in recovery phases of any disaster or emergency in the future. During this study the critical facility database of Lucknow city was created for disaster risk reduction through conjunctive use of high resolution satellite data, Global Navigation Satellite System (GNSS) receivers and finally through integration of the data in Geographical Information System (GIS). Further, the linking of available resource data (nonspatial) of various line departments with the spatial data and maps of critical facilities was also performed in GIS environment. This database can certainly prove to be vital input for City Disaster Management Action Plan as well as District Disaster Management Action Plan. Since the geospatial database

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of health facilities and veterinary facilities of the city can be utilized for knowing the location of hospitals, available paramedical staff, number of ambulances and medicare facilities available in each of the hospitals and available resources of veterinary hospitals respectively. Location of critical facilities such as fire brigade stations, hospitals and veterinary hospitals shown on the critical facility maps of Lucknow city can help the disaster managers to know about road connectivity of these facilities to various localities of the city. This information can be used to rapidly mobilize the manpower and available resources of line departments in an emergency situation or even during disaster situation within the district or in the nearby district at the request of the local authorities. The information on these critical facilities when analyzed in conjunction with the urban density map of the city can be used to create decision support modules required for setting up new critical facilities and upgrading existing ones as per the population density. The communication also reflects major constraints in creation of comprehensive geospatial database and its effectiveness in disaster management.

Keywords: *Remote Sensing, GIS, GPS, Geospatial Database, Emergency, Disaster Risk Reduction*

1. Introduction

Disaster risk reduction aims at drastically reducing the risks of loss of human lives, injuries and economic and ecological losses. Recent advances in geospatial techniques such as availability of high resolution satellite remote sensing, GNSS and GIS etc have revolutionized the disaster risk management efforts during various phases of disaster management cycle viz. preparedness, response, recovery and rehabilitation. Global Navigation Satellite System (GNSS) technology has made it possible to precisely record the coordinates of point locations including those of critical facilities whose operations are vital for disaster risk management. Geospatial database of available resources of critical facilities, infrastructure and urban density etc can be of immense use in mitigation planning.

An effective, economical and task oriented disaster management system requires comprehensive, accurate, timely and accessible collection of baseline data (Laefe et. al., 2006). The development of data collection methods for pre and post-disaster related activities using a multi-hazard approach is critical to GIS database creation (Uddin et.

al., 2002 & 2003). Good Child (1996), recognized the need for developing a layered, integrated, GIS system for disaster management and further stressed that all the relevant data must be affiliated with a single GIS-based disaster management system. Yet, the extensiveness, inter-relatedness and distributed ownership of infrastructure directly tax the limited resources of most communities to adequately maintain up-to-date and easily accessible knowledge of the infrastructure and utilities. To better track these substantial infrastructure needs, there is an ever increasing reliance on computer tools and databases (Laefe et. al., 2006). Specifically, Infrastructure Management Information Systems (IMISs) have been created at all levels of the public and private sectors (Uddin and Engi 2002 & 2003). The data sets owned by various governmental and non-governmental organizations have to be collected prior to initiating any computer-based search and rescue operations. The enormity, complexity and temporal criticality of this task highlighted the acute and immediate deficits of currently available spatial information for disaster management. An effective system must integrate data for all facets of disaster planning and management, including photographs, architectural and structural drawings, current Geographic Information System (GIS) maps and text descriptions of major building features e.g. building location and structural system condition (Huyck and Adams 2003). To fully benefit from such a system requires the regular contribution of data from a wide variety of sources (Laefe et. al., 2006).

Examples of data standardization in India include the Technology Information, Forecasting and Assessment Council of India, where disaster information is being linked to improve disaster preparedness (Singh and Shukla 2003). The Ministry of Home Affairs, Government of India has initiated the development of a GIS-based National Database for Emergency Management (NDEM) in collaboration with various Govt. Ministries/agencies such as Department of Space, Department of Science & Technology and Ministry of Communications & IT (www.ndmindia.nic.in). Ministry of Home Affairs (MHA), Govt. of India in collaboration with United Nations Development Program has initiated IDRN (India Disaster Resource Network). IDRN is a nation-wide electronic inventory of essential and specialist resources for disaster response, covering specialist equipment, specialist manpower resources and critical supplies (www.idrn.gov.in).

Information on Disaster Management Support (DMSP) is available on the website of National Remote Sensing Applications Centre, ISRO, GoI (https://www.nrsc.gov.in/Disaster%20Management%20Support). Further, the Disaster Management Support

Services are also available on the India Geo-Platform 'Bhuvan' of ISRO (https://bhuvan-app1.nrsc. gov.in /bhuvandisaster/). Updated information on floods in U.P. is also being provided by Disaster Management Cell of Remote Sensing Applications Centre, U.P., Lucknow on http://rsacup.org.in/en/page/flood-2021. Information on hazards in U.P., and disaster management action plans is also available on the website of Uttar Pradesh Disaster Management Authority (http://upsdma.up.nic.in/).

Despite the fact that disasters are multi-factorial in their incarnations and destructive abilities, it is postulated that there is a common subset of data related to the physical infrastructure that is needed for effective disaster management both temporally (before, during and after) and irrespective of the specific disaster. Much of the required information for one disaster can be considered as common to all disasters, both because of general requirements of access and evacuation but also because a named disaster such as an earthquake may generate multiple hazards e.g. collapsed buildings, fires, road blockage, and utility interruption (RSAC-UP 2011). Geospatial databases are critical inputs for disaster management centric geoportals and mobile applications too.

Disaster managers can retrieve the information available on geoportals and the mobile applications, for swift mobilization and optimal utilization of available resources of critical facilities from the vicinity of disaster affected area. Such facilities will include fire stations, health facilities, veterinary hospitals, temporary shelters (school and community centre buildings) and warehouses (for stockpiling food grains).

2. Study Area and Hazard Scenario

Present study covers entire Lucknow city and its peripheral areas bounded between latitudes 25˚40'N to 27˚0'N and longitudes 80˚49' E to 81˚05' E (Figure 1). Gomti river is the main river flowing through the city. Small seasonal stream Kukrail also flows through the city and merges into Gomti River. Lucknow city is one of the major habitations of Ganga Plain and is also the state capital of Uttar Pradesh the most populous state of India. Today infrastructure development is main focus in Lucknow and the city with a population of about 28 lacs (according to Census of India 2011) is expanding in every respect to don the mantle of a metro. However, this city is prone to multi hazards i.e. flood, earthquake, hydrological droughts and wind hazard. Risk is viewed as the probability that a hazard will occur during a particular time period. A disaster is a hazard occurrence resulting in significant injury or damage. In Lucknow city significant part of

populace is residing in old multistoried buildings in the old city and this increases the vulnerability to earthquake hazard although the city falls in the Earthquake Damage Risk Zone III (BMTPC 2005). Some of the multistoried buildings have been constructed over the areas which are actually dried up water bodies, such constructions are also vulnerable to shocks of earthquakes (RSAC-UP 2012). Lucknow city has also felt the main shock and aftershocks of April and May, 2015 earthquakes of Nepal. The city went into the panic with people hurriedly coming out of their houses during tremors, most of the schools remained closed for a couple of days and some houses even witnessed minor cracks. Many localities of Lucknow city adjacent to Gomti river are prone to floods e.g. parts of Gomti Nagar witness floods during heavy rains of monsoon season. The city of Lucknow and surrounding area of Lucknow district (named after this city) had witnessed floods in the year 2008 and there were 25 villages affected by floods in the city during this year (RSAC-UP 2011). Furthermore, many parts of the city witness water logging during rainy season. According to wind hazard map of BMTPC (2005) Lucknow city lies in the High Damage Risk Zone.

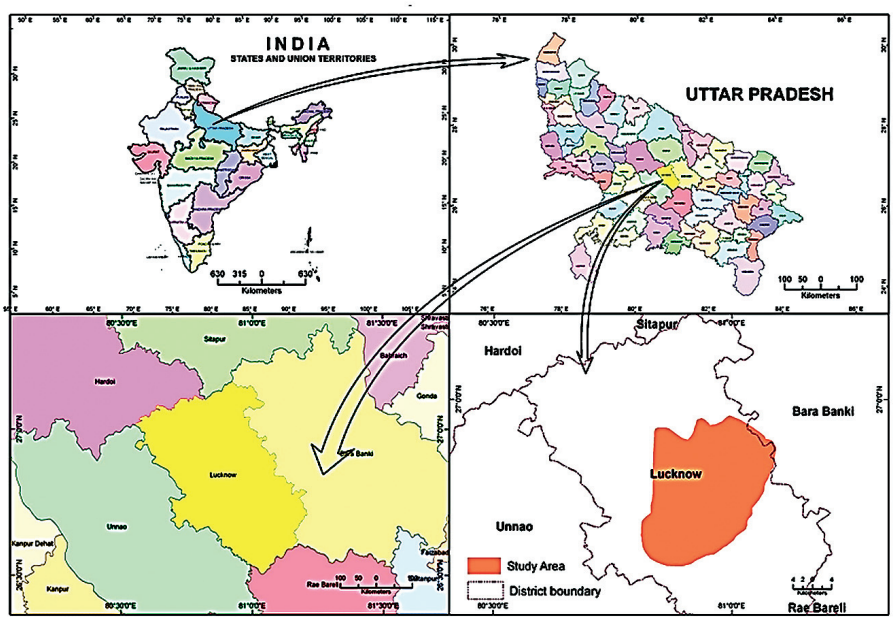


Figure 1: Location Map of Study Area

Apart from these natural disasters, the city is also prone to man-made disasters including fire and collapse of multistoried buildings. Since, the intricate road network with traffic congestion in many areas, railway lines passing through the congested areas, often crowded railway stations and bus stands, two major airports (in the northern and southern part) and pockets of industrial areas in the outskirts enhance the vulnerability of this city to accidents and manmade disasters.

The electrical wirings in many commercial and residential complexes of Lucknow city are hanging a top the roof or on the walls as bunches of cables and pose a potential risk of fire. Further, the city also witnessed few stray incidents of collapse of houses during the rainy season of 2018. According to Times of India of 4th August 2018, four lives were lost in the incidents of wall and building collapse in Lucknow due to incessant rains on 3rd of August. Some of the commercial and residential buildings in many localities of the city are more than 100 year old.

Construction of many new multistoried buildings on dried up ponds and peripheral parts of lakes doesn't rule out the possibility of subsidence of such buildings in the future.

Recently many townships in the vicinity of Lucknow have witnessed industrial disasters. Thirty two lives were lost on November 1, 2017 due to an explosion inside the boiler of National Thermal Power Corporation Power Plant Unchahar near Raebareli (Hindustan Times 09 Nov, 2017). Unchahar is about 115 km from Lucknow City. Some other recent manmade disasters/accidents in the vicinity of Lucknow city include explosions in fire cracker units in near Mohan and in Mohanlalganj in 2013 and 2014 respectively. Seven casualties were reported in a house cum firework unit at Pakra village near Mohan in Unnao district (about 35 kms from Lucknow city) on 19th Sept. 2013 (Times of India 20 Sept., 2013). Four person were killed and 10 injured in an explosion in a cracker factory in Mohanlalganj area of Lucknow on 20 Sept., 2014 (The Hindu). Most recently in 2020 and 2021 due to outbreak of COVID-19 pandemic the Lucknow district has so far witnessed more than 2.38 lacs cases of COVID-19 and about 2651deaths (en.wikipedia.org), with many of them accounting for Lucknow city. The city has also recorded 700 dengue cases since January 2021 till 20th October, 2021 (Time of India, 21st October 2021).

One of the major problems faced by Lucknow City is the lack of readily available integrated information system on rapid response infrastructure and manpower of

rescuers. This study outlines the requirements to prototype a geospatial database in such a way so that it can be used for preparedness, response as well as in recovery phases of any natural or manmade disaster in the future.

3. Objectives

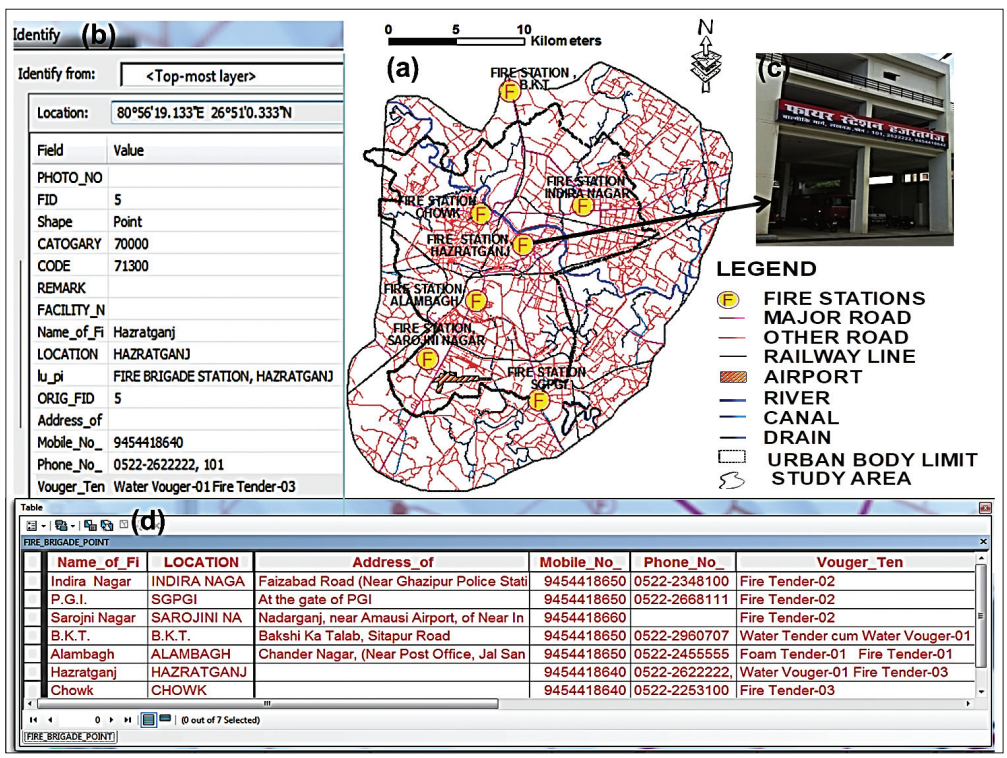
The present study aims to create geospatial database of critical facilities viz. fire brigade stations, hospitals, veterinary hospitals, schools and also that of the infrastructure and urban density through conjunctive use of high resolution satellite images, Global Navigation Satellite System (GNSS) and GIS techniques. The collection of data pertaining to available resources and manpower of different line departments and linking of this non-spatial data with the spatial data are important objectives of this study.

4. Material & Methods

Quickbird satellite images with spatial resolution of 61 cm in Panchromatic mode and 2.44 meters in multispectral mode have been merged using ERDAS Imagine software in order to generate the PAN sharpened False Colour Composites (FCCs) of very high spatial as well as spectral resolution. Some enhancements have been applied to the merged images to improve their quality. Furthermore, the mosaic of Cartosat-1 as well those of Cartosat-2 PAN (satellite images) were generated. Owing to better spatial and spectral resolution Quickbird PAN & multispectral merged satellite image was used for major interpretation work. Cartosat-1 as well the Cartosat-2 PAN, IKONOS and Indian Remote Sensing Satellite (LISS IV multispectral) images were also used for mapping some areas including those for which Quickbird image had cloud cover.

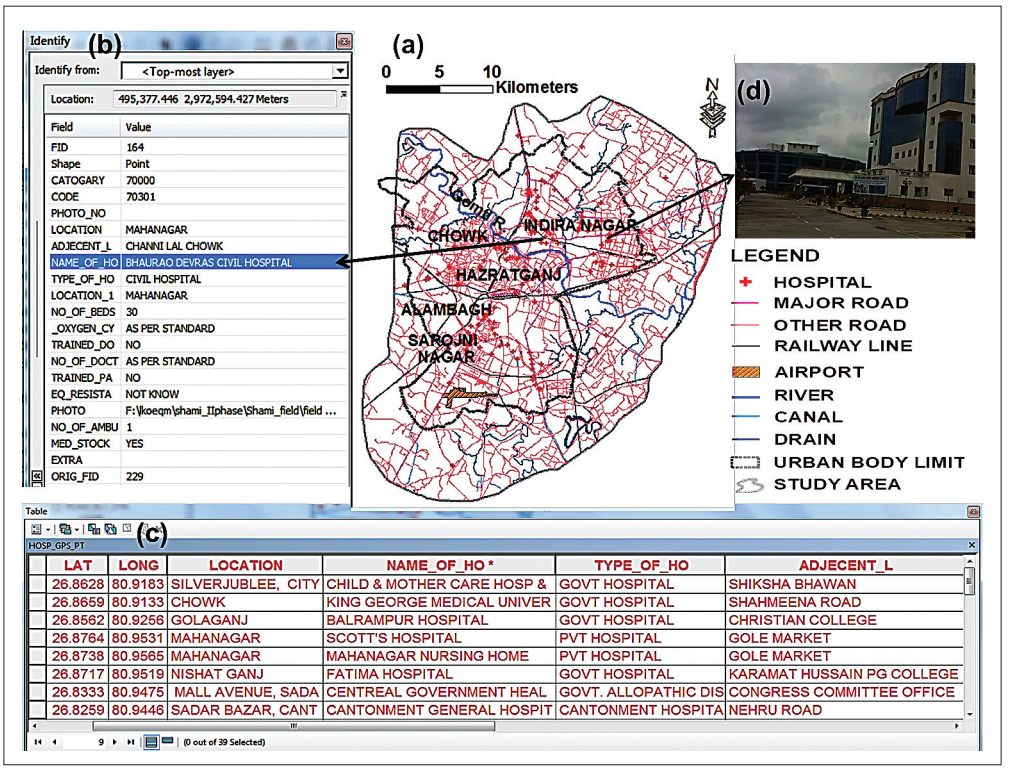
Base maps showing major roads, other roads, lanes, railway lines, railway stations, bus stands, and urban density maps were created using high resolution satellite images and through on screen digitization in ArcGIS software. Geocoordinates of all the critical facilities viz. fire brigade stations, hospitals, veterinary hospitals and educational facilities etc were collected in the field using GNSS receivers and were subsequently transferred on to the base maps (in GIS environment) in order to generate critical facility maps showing location of fire brigade stations, hospitals, veterinary hospitals and schools etc (Figure 2a, 3a & 4a). Further, the available data pertaining to human resources, equipments and other resources etc of each of the critical facility such as

health, veterinary and fire brigade etc of Lucknow city was collected in a standard format from the departments concerned. This non spatial data and field photographs of most of the critical facilities (taken in the field) were joined with the respective map (or spatial data), e.g. the manpower and available resource data received from the Medical and Health Department and also the photograph of the health facilities have been linked with the health facility map using ArcGIS software (Figure 3a, b, c & d). This is how the resources of each of the critical facilities are also shown in tabular form and linked with the spatial data (critical facility maps) in geospatial database.



Name_of_Fi	LOCATION	Address_of	Mobile_No_	Phone_No_	Vouger_Ten
Indira Nagar	INDIRA NAGA	Faizabad Road (Near Ghazipur Police Stati	9454418650	0522-2348100	Fire Tender-02
P.G.I.	SGPGI	At the gate of PGI	9454418650	0522-2668111	Fire Tender-02
Sarojni Nagar	SAROJINI NA	Nadarganj, near Amausi Airport, of Near In	9454418660		Fire Tender-02
B.K.T.	B.K.T.	Bakshi Ka Talab, Sitapur Road	9454418650	0522-2960707	Water Tender cum Water Vouger-01
Alambagh	ALAMBAGH	Chander Nagar, (Near Post Office, Jal San	9454418650	0522-2455555	Foam Tender-01 Fire Tender-01
Hazratganj	HAZRATGANJ		9454418640	0522-2622222,	Water Vouger-01 Fire Tender-03
Chowk	CHOWK		9454418640	0522-2253100	Fire Tender-03

Figure 2: a) Location of Fire Brigade Stations in Lucknow City, b) Information on Hazratganj Fire Station extracted from the GIS database using the tool identifier, c) Photograph of Hazratganj Fire Station included in the GIS database, and d) Attribute Table of GIS layer of Fire Stations showing location, address, mobile Number, basic phone number and number of Fire Tenders in each of the Fire Station in Lucknow City



LAT	LONG	LOCATION	NAME_OF_HO *	TYPE_OF_HO	ADJECENT_L
26.8628	80.9183	SILVERJUBLEE, CITY	CHILD & MOTHER CARE HOSP &	GOVT HOSPITAL	SHIKSHA BHAWAN
26.8659	80.9133	CHOWK	KING GEORGE MEDICAL UNIVER	GOVT HOSPITAL	SHAHMEENA ROAD
26.8562	80.9256	GOLAGANJ	BALRAMPUR HOSPITAL	GOVT HOSPITAL	CHRISTIAN COLLEGE
26.8764	80.9531	MAHANAGAR	SCOTT'S HOSPITAL	PVT HOSPITAL	GOLE MARKET
26.8738	80.9565	MAHANAGAR	MAHANAGAR NURSING HOME	PVT HOSPITAL	GOLE MARKET
26.8717	80.9519	NISHAT GANJ	FATIMA HOSPITAL	GOVT HOSPITAL	KARAMAT HUSSAIN PG COLLEGE
26.8333	80.9475	MALL AVENUE, SADA	CENTREAL GOVERNMENT HEAL	GOVT. ALLOPATHIC DIS	CONGRESS COMMITTEE OFFICE
26.8259	80.9446	SADAR BAZAR, CANT	CANTONMENT GENERAL HOSPIT	CANTONMENT HOSPITA	NEHRU ROAD

Figure 3: a) Location of important Health Facilities of Lucknow City, b) Information on Civil Hospital Mahanagar, Lucknow extracted from the GIS database using the tool Identifier, c) Attribute Table of GIS layer of Health Facilities of Lucknow City showing Latitude, Longitude, location, address, landmark and type of the facility and d) Photographs of Ram Manohar Lohia Institute of Medical Sciences included in the GIS database

5. Results and Discussion

Fire brigade stations are among the first responders in the event of any disaster situation. Fire fighters are called in almost all the man made disasters such as fire, industrial disaster, collapse of multistoried building, road, rail and air accidents as well as during chemical disasters. Furthermore, if a natural disaster such as flood and or

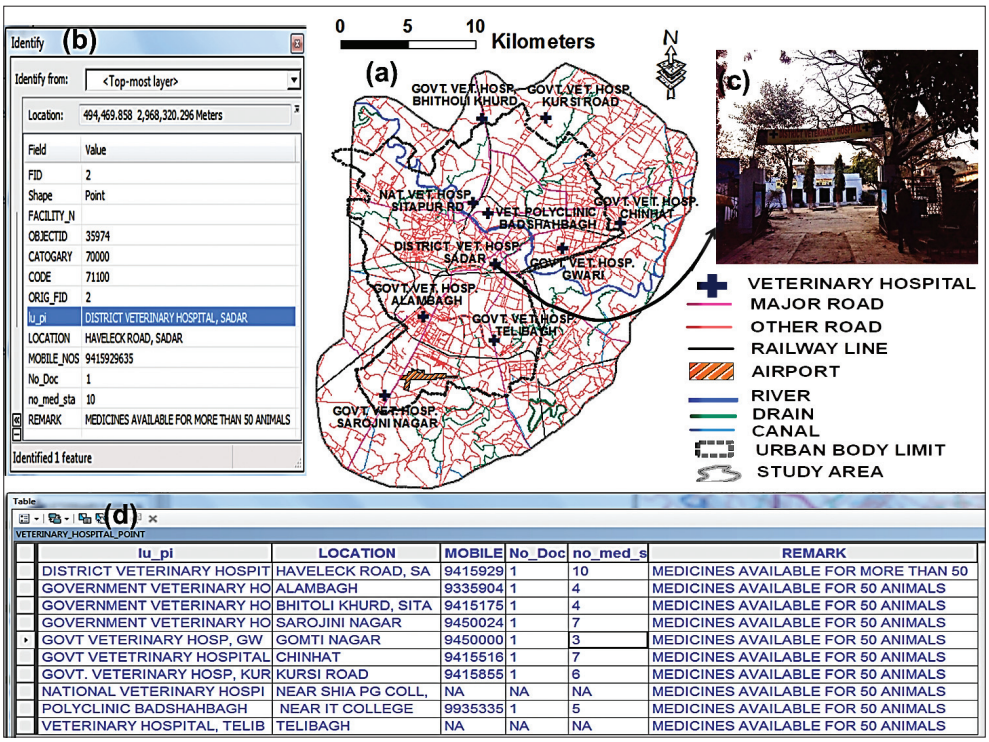
earthquake strikes in any inhabited area the fire fighters are among the first to take up the search and rescue operations in the affected area. Hence, the information about this critical facility is very crucial for the immediate deployment and optimal utilization of available resources in order to minimize the impact of the disaster. Comprehensive information about this critical facility not only helps in proactive disaster response but also in the identification of the gap areas. The geospatial database pertaining to the location and available resources of various fire stations of Lucknow city such as Hazratganj, Chowk, Alambagh, Indira Nagar, PGI, BKT, Sarojini Nagar and Gomti Nagar opens new avenues for drastically improving the preparedness by raising new resources including the equipments and manpower and this in turn can help in rapid deployment of their resources in an emergency situation (Figure 2a to d).

Geospatial database of health facilities can be used to optimally utilize the available medical resources e.g. number of ambulances, doctors, paramedical staff etc in each of the hospital in the vicinity of disaster affected area. This information may help in quick and coordinated mobilization of the available medical and health resources and hence in a disaster situation, higher number of human lives may be saved during the golden hour by providing the first aid at a short span of time and by quick transportation of victims to the hospitals. Geospatial database can be used for health preparedness as well as in medical and health response (Figure 3a to d).

Disaster management planning includes remote area planning, logistics planning, education & training, epidemiological study and networking and timely information to media. Geospatial database can be used by planners in the pre hospital stage of medical plan to quickly carry out site assessment in order to select suitable sites for setting up temporary emergency control centres in case if, the disaster affected area has no hospital in the vicinity. However, in case if, disaster affected area has many hospitals in its vicinity the quick comparative examination of the required and available resources of each of the hospital can be done using the geospatial database (Figure 3a,b&c). This can help the Chief Medical Officer to immediately identify the hospital to be used as emergency control centre for setting up command post (in the disaster affected area) based on its available resources, specialization and also the road connectivity and alternate routes to the hospital. Further, in the hospitals stage of the medical plan the geospatial database can be retrieved for quickly assessing the available resources in terms of oxygen cylinders, live saving drugs, other life saving equipments and facilities

along with the number of doctors, specialists and paramedical staff. The execution of medical plan in the farther and or congested areas of the city requires immediate mobilization of local resources to the disaster site. This mobilization of local health resources can be done by using a set of information. Geospatial database is like a ring of large tree with n-number of branches accessible to each of the health manger and planner at different levels of hierarchy. This ensures two way communication among rescuers such as doctors of government and private hospitals and health managers mainly Deputy Chief Medical Officers or Chief Medical Superintendent and Chief Medical Officer. Further the maps of the health facility, urban density and road can be used by health managers to carry out site assessment of the disaster affected congested area and to identify shorter and safe routes for ambulances for taking the victims to the nearby hospitals for further treatment and also for logistic planning including quick identification of available local health resources. Indenting of additional medical resources at a faster pace can be done by checking from the geospatial database the availability of resources such as the number of ambulances in the hospitals or sites identified as emergency control centres (Figure 3a to d). Furthermore, the temporary morgue facility can also be identified using this database.

Veterinary hospitals also fall in the category of critical facilities from the point of view of disaster management and or emergency management. Any natural disaster such as earthquake, flood, or thunder storm and man made or technological disaster such as fire, chemical disaster, leakage of poisonous gas or explosion in a factory or vehicle with hazardous material not only claims human lives but cattle heads, domestic animals and even wild life in the nearby forest or zoo. Hence veterinary hospitals are considered a critical facility for disaster response. Apart from a number of milk dairies in various parts (particularly in the outskirts) of the city, the Lucknow Zoo and Kukrail Forest are the two well known animal habitats in Lucknow city, further there is significant number of pet, stray and other farm animals in the city. Geospatial database of veterinary hospitals showing their available resources can make it easier for the decision makers to quickly list the medicines required to overcome the disaster situation. Further, it could be an additional aid in planning and mobilizing the resources of the nearby veterinary hospitals to the site of the disaster in order to minimize the loss of cattle heads and consequent spread of epidemic among the human and animal population (Figure 4a to d).



lu_pi	LOCATION	MOBILE	No_Doc	no_med_s	REMARK
DISTRICT VETERINARY HOSPIT	HAVELECK ROAD, SA	9415929	1	10	MEDICINES AVAILABLE FOR MORE THAN 50
GOVERNMENT VETERINARY HO	ALAMBAGH	9335904	1	4	MEDICINES AVAILABLE FOR 50 ANIMALS
GOVERNMENT VETERINARY HO	BHITOLI KHURD, SITA	9415175	1	4	MEDICINES AVAILABLE FOR 50 ANIMALS
GOVERNMENT VETERINARY HO	SAROJINI NAGAR	9450024	1	7	MEDICINES AVAILABLE FOR 50 ANIMALS
GOVT VETERINARY HOSP, GW	GOMTI NAGAR	9450000	1	3	MEDICINES AVAILABLE FOR 50 ANIMALS
GOVT VETETRINARY HOSPITAL	CHINHAT	9415516	1	7	MEDICINES AVAILABLE FOR 50 ANIMALS
GOVT. VETERINARY HOSP, KUR	KURSI ROAD	9415855	1	6	MEDICINES AVAILABLE FOR 50 ANIMALS
NATIONAL VETERINARY HOSPI	NEAR SHIA PG COLL,	NA	NA	NA	MEDICINES AVAILABLE FOR 50 ANIMALS
POLYCLINIC BADSHAHBAGH	NEAR IT COLLEGE	9935335	1	5	MEDICINES AVAILABLE FOR 50 ANIMALS
VETERINARY HOSPITAL, TELIB	TELIBAGH	NA	NA	NA	MEDICINES AVAILABLE FOR 50 ANIMALS

Figure 4: a) Location of Veterinary Hospitals in Lucknow City, b) Information on District Veterinary Hospital extracted from the GIS database using identifier, c) Photograph of District Veterinary Hospital Havlock Road, Sadar, Lucknow included in the GIS database and d) Attribute Table of GIS layer of Govt. Veterinary Hospitals of Lucknow city showing Location, Mobile Number, Number of Doctors, Staff and Availability of Medicines.

Educational facilities are considered critical facilities and can be used as temporary shelters in the event of a major natural disaster e.g., high flood or earthquake or even during man-made disaster such as major fire etc in a part of the city or in the surrounding area wherein, a large populace may have been rendered homeless and or may have to vacate their homes. GIS based maps of educational facilities showing their location and connecting roads make it possible for the city disaster managers to easily identify the shelters in the vicinity of disaster or emergency site (Figure 5a to c). Furthermore, the attribute data of the educational facilities such as number of rooms,

area of rooms, year of construction etc makes it possible for the city or district disaster managers to identify the number of buildings of educational facilities (based on their capacity) to temporarily accommodate the disaster victims. Based on the attribute data in the geospatial database the decision makers or disaster managers can avoid very old and earthquake unsafe building of schools or colleges as shelter houses in the event of an emergency. Further, the geospatial database can also be used to select the sites for new school and college buildings away from the flood and water logging prone area and or dried ponds or lakes.

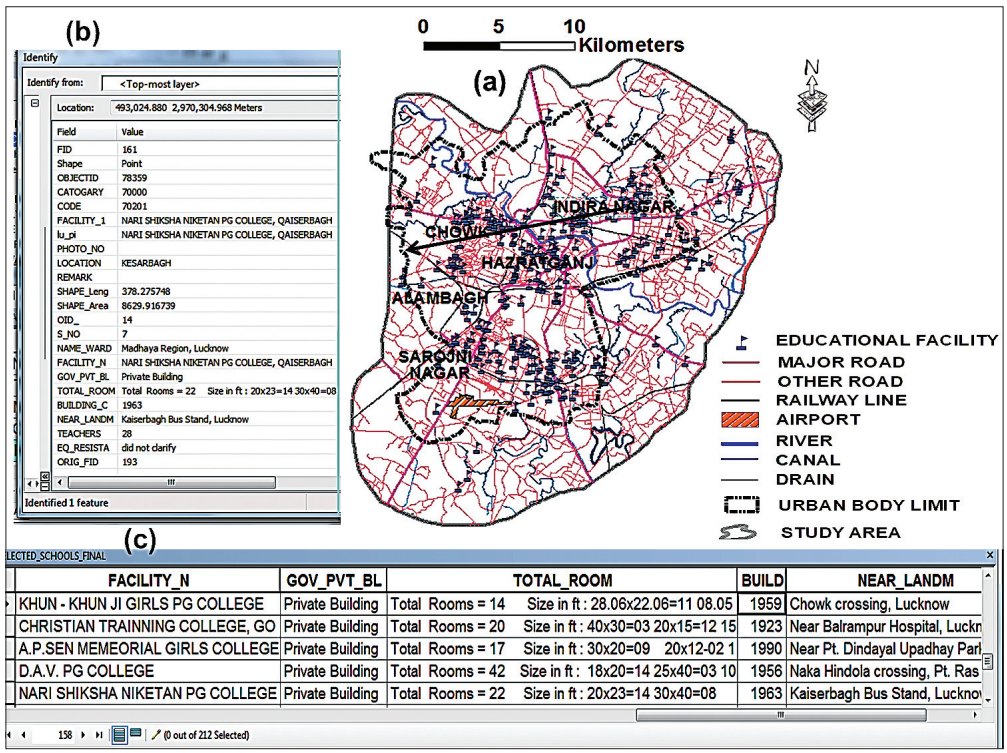


Figure 5: a) Location of important Educational Facilities in Lucknow City, b) Information on one of the P G College of Lucknow as extracted from the GIS database using the tool Identifier and c) Attribute Table of GIS layer of Educational Facilities showing name of the facility, type (Govt./Private) total number of rooms, size of rooms, year of construction and near by landmark

Urban density plays an important role in defining the vulnerability and elements at risk in a particular area when studied in conjunction with and available resources viz. critical facilities and infrastructure (particularly connectivity and critical facilities) and the probable hazards. Lucknow city is one of the fast expending cities in India and among the fastest expending cities in Uttar Pradesh with new urban agglomerations are appearing along the highways. Satellite data based urban density map indicates very high urban density in Chowk and Hazratganj areas of Lucknow city. Further the examination of high resolution satellite images has revealed that in Hazratganj area of the city in spite of very high urban density, the congestion is less (as compared to Chowk area) due to wider roads. High urban density is noticed in the peripheral areas of Hazartganj and Chowk localities. In the western part of Lucknow city Rajajipuram and Thakurganj areas also have high urban density. In the southern part of the city major part of Alambagh, some areas of Bangla Bazar and western part of Telibagh areas have high urban density. In the eastern and northern part of the city particularly the Trans Gomti areas of Vikas Nagar, Aliganj, Indira Nagar and some pockets of Gomti Nagar localities have high urban density. Pockets of Moderate urban density are noticed in large parts of Gomti Nagar, Indira Nagar and western part of Rajajipuram. Low to very low urban density is noticed in the peripheral parts of the city (Figure 6). However, in the years to come these areas of very low and low urban density may transform into areas of moderate urban density and new urban agglomerations along Kanpur Road, Hardoi Road, Faizabad Road and Sitapur Road areas of Lucknow city may witness high to very high urban density.

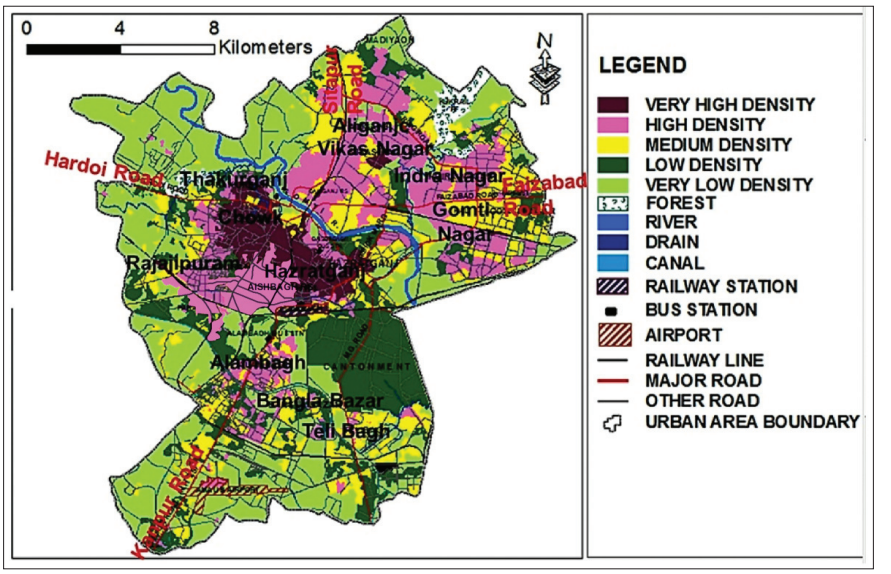


Figure 6: Urban Density Map of Lucknow City (based on satellite images)

6. Constraints

Major constraints in creation of comprehensive geospatial database and its effectiveness in disaster management are elaborated below:

(i) Lack of data about resources of private sector including facilities and resources with most of the private hospitals and nursing homes and veterinary hospitals.

(ii) Lack of available information about equipments such as electrical and hydraulic shovels, gas cutters and drillers available with "A" grade contractors of line departments such as Public Works Department and Irrigation Department and National Highway Authority. Since these equipments are essentially required for rescue operations in the event of an emergency or in a disaster situation.

(iii) Lack of well defined mechanism for regular updation of geospatial database of available resources of various line departments due to absence of GIS cells in District Control Rooms.

(iv) Mechanism for providing the geospatial database to end users/disaster managers in real time at any place through mobile applications is only partially developed.

7. Conclusion and Future Scenario

Remote sensing, GPS and GIS based geospatial database can be used to create elaborate and effective City Disaster Management Information System (CDMIS) as a part of an integrated approach for using scientific and technological advances in order to mitigate and manage natural as well as man-made disasters. By using these techniques even minor details pertaining to infrastructure, critical facilities (along with available resources of each of these facilities) can be depicted. Furthermore, this database can certainly provide vital inputs for City as well as District Disaster Management Action Plan. In the event of an emergency and or disaster situation in Lucknow city this kind of database can certainly help the local administration/disaster managers in rapid mobilization of rescuers and medical teams within a relatively short span of time. This can be done through visualization of the fire station, health facility and veterinary hospital location maps and GIS database of their available resources. Roads demarcated on Fire Brigade Station, Health Facility and Veterinary Hospital maps can help the decision makers and disaster managers (of the city) to know the road connectivity of these critical facilities to the disaster affected area. The health facility database and maps can be utilized for knowing the location, approach road, phone number, available paramedical staff, number of ambulances and critical care facilities in each of the nearby hospitals (Figure 3a to d). Similarly, the maps and database pertaining to veterinary hospitals in Lucknow city and surrounding area can provide a detailed information about the location and available resources of each of the veterinary hospital (Figure 4a to d). Immediate indenting of additional resources can also be done by each of the line department after quick checking of available resources using geospatial database. Educational facility database can provide critical inputs for identification of the temporary shelters for affected populace in a disaster situation.

This geospatial database (geodatabase) comprising datasets (maps) of different critical facilities, road network and urban density can be used by planners as important inputs for disaster management planning including upgradation of existing critical facilities and setting up of new ones such as new fire stations, hospitals, veterinary hospitals as per the population density. Further the database can also be updated for incorporating elements of disaster resilience into development by including safe sites of new critical facilities and identification of their old buildings which need to be renovated, retrofitted or even shifted, if unsafe.

As the scientific community and disaster management fraternity continues to pursue innovative solutions to the numerous spatial problems in disaster management and its related fields, the future role of these technologies in disaster management is expected to expand significantly. High resolution remote sensing and GIS techniques are being used for identification of the sites for waste disposal away from the populated areas in order to prevent epidemic. In the days to come these techniques will be used more and more for health situation analysis including epidemiological surveys and real time updation of available resources of line departments at ward level in almost all the urban and semi urban areas of the country. In some of the vulnerable localities of Lucknow city such as along the Haider canal, Gomti river and Kukrail nala etc, the geospatial techniques will prove to be useful for critical input generation for health situation analysis including extent of stagnant water bodies and water logging prone areas (which serve as breeding sites for mosquitoes). Further, these techniques in conjunction with structural engineering techniques shall be used for identification of earthquake unsafe buildings (of critical facilities) and also the clusters of very old multistoried buildings which are still habited and are vulnerable to collapse. This can certainly help the prioritization process for retrofitting. However, more comprehensive geospatial databases should be available with District Disaster Management Authority and disaster managers across the country. Geodatabases are now a becoming available on geoportals and mobile application.

High resolution remote sensing, UAV, Mobile LiDAR, Terrestrial LiDAR, GNSS and GIS techniques based more comprehensive and site specific databases will be created in the days to come and would be available on geoportals and mobile applications. This in turn will enhance the level of preparedness and efficacy of response in a disaster situation in order to mitigate its impact.

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