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International Journal of Current Research
Vol. 9, Issue, 11, pp.60397-60404, November, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

APPLICATION OF GEOSPATIAL TECHNOLOGY FOR DISASTER MANAGEMENT PREPAREDNESS IN JODHPUR CITY

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ARTICLE INFO

Article History:
Received 16th August, 2017
Received in revised form
20th September, 2017
Accepted 03rd October, 2017
Published online 30th November, 2017

Key words:

Geospatial Technology, GIS,
Disaster Management.

ABSTRACT

The proposed study aims to demonstrate applications of Geographic Information System (GIS) and Geospatial technologies for the exploitation and analysis of imagery and geospatial information to describe, assess, and visualize features for Emergency Management in Jodhpur city, the second largest city in the Rajasthan. Developing an emergency response system is essential for a city with rapidly growing potential. Though it is having all infrastructural and medical facilities, the problem lies in finding the optimum/best facility from an incident location. GIS automates use of this information to improve response times and optimize situational awareness, leading to more effective incident resolution. It allows public safety agencies at local, regional and state-wide levels to view and work with the same consistent geographic data, helping to maximize inter- and intra-agency collaboration and coordination in the pursuit of safer communities.

Citation: Yadav, S. K., Borana S. L. and Parihar, S. K. 2017. "Application of geospatial technology for disaster management preparedness in jodhpur city", *International Journal of Current Research*, 9, (11), 60397-60404.

INTRODUCTION

Emergency evacuation planning is of critical importance to our nation's response to both man-made and natural disasters. The very essence of a disaster is what makes them hard to overcome. Disasters can be described by the following five major characteristics: 1) disasters are large, rapid-onset incidents relative to the size and resources of an affected jurisdiction; 2) disasters are uncertain with respect to both their occurrences and their outcomes; 3) risk and benefits are difficult to assess and compare; 4) disasters are dynamic events; 5) disasters are relatively rare. Because of the unpredictable nature of disaster events, emergency management is generally a relatively difficult task. A geographic information system (GIS) is a computer-based software tool that facilitates the mapping and analysis of information within a geographical area. Although mapmaking and geographic analysis can be performed via manual methods, it is far easier and faster using GIS. Using GIS a hazard mapping and its affect on the people can be easily estimated for proper rescue management. The main objectives of this study is to create geospatial database of Police station, Hospitals and Basemap of the Jodhpur city and performing spatial analysis for population affected and monitoring the situation using rescue by concerned authorities.

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Literature review

Sparse research has been conducted in the development of emergency planning tools through integration with optimization models and/or simulation models. Optimization models are mathematical constructions or representations of systems that strive for the ultimate goal of determining the globally best solution or solutions for the constrained system. These models are largely prescriptive in nature, recommending a solution or making an optimal decision. Simulation models provide a dynamic, descriptive form of modelling to enable the understanding of the behaviour of the system under a wide-variety of complex parameter configurations. Simulation models used in emergency planning consist of three basic types: micro-simulators, macro-simulators, and meso-simulators. Micro-simulators attempt to track the detailed behaviour of individual entities in the simulated situation; whereas, macro-simulators make no attempt to track the detailed behaviour of individual entities. Meso-simulators are a basic compromise between micro- and macro-simulators that usually involves discrete simulation that tracks the behaviour of groups of entities. A prime example of deep coupling is in the research of Wang (2005), which integrates a simulation model with GIS. Wang (2005) presents the benefits and challenges of integrating three components of information technology: a GIS, simulation models, and a 3D visualization. Although a few such integrated systems exist, the development

of each of these components has mostly been independent. One challenge has been the coupling of a GIS and simulation models, especially in terms of sharing information. In this approach to deep coupling, a single user interface controls both the GIS and the simulation models, even if they remain separate systems. Another challenge has been visualizing the results after the GIS and simulation models have been integrated.

transformed into a young city with more and more professionals flocking into the city. These changes led to urban development in a ribbon form around the city along its eripheries. The demographic profile of Jodhpur too acquired a cosmopolitan touch as the city's ambience changed from sedate to upbeat. It is not surprising that in the early 18th century, when Jodhpur was under British control, the city was barely 5 sq. km. in size and today spread is 243.9 sq. km.

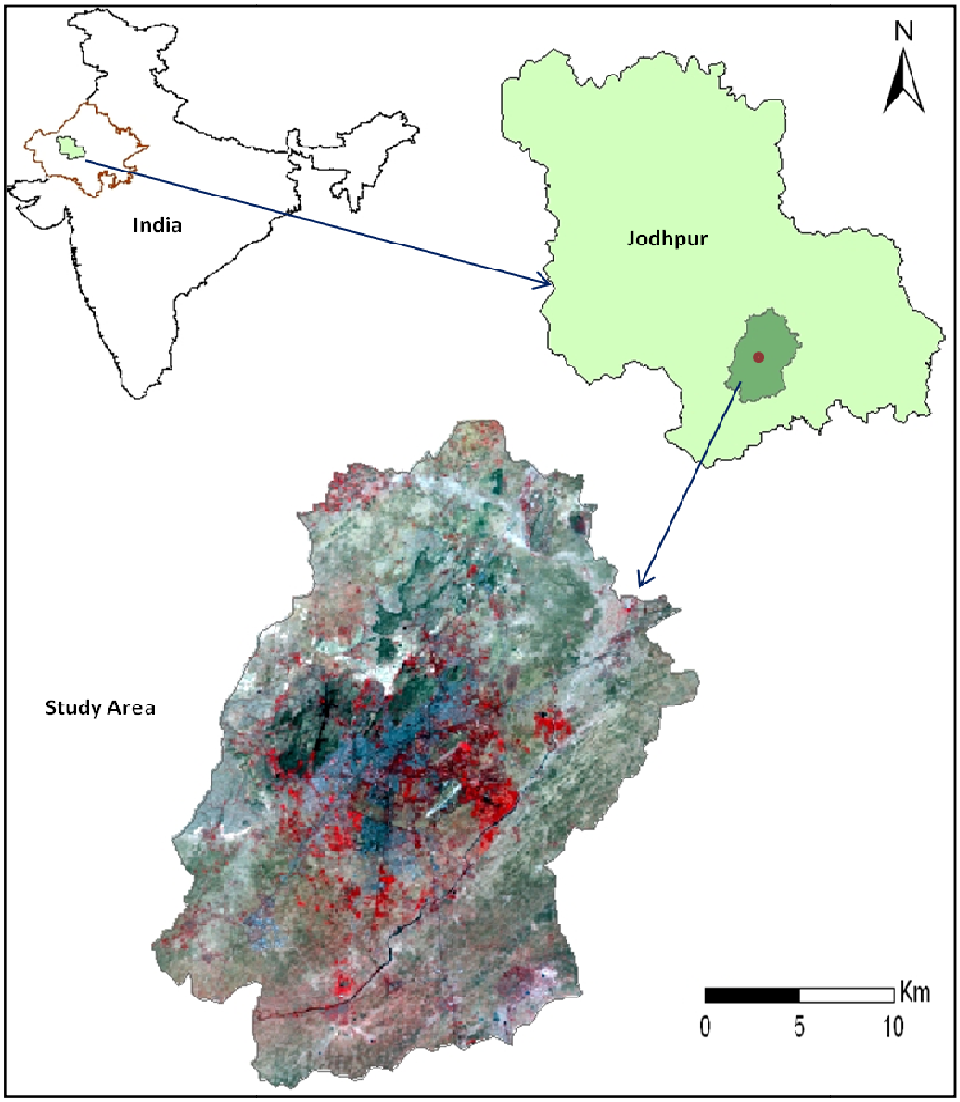


Fig.1. Location map of the Study Area

Study area

Jodhpur, one of the largest district of Rajasthan states is centrally situated in western region of the state. Jodhpur city is located at 26ºN 18' latitude and 73º E 04' and at an average altitude of 224m above mean sea level. In general the contours are falling from North to South and from North to Southeast with maximum level of 370m and minimum of 210m. The present population is about 1.05 million and has been functioning as one of the engines powering the Indian economy. Though it is having all infrastructural and medical facilities, the problem lies in finding the optimum/best facility from an incident location. Considering this, present study will be carried out taking into account any incidents like fire and accident for a part of Jodhpur city covering an area of around 50 square kilometer. Jodhpur has strategic positioning, its close proximity to India's commercial capital Jaipur (Fig.1). Jodhpur is now no longer regarded as a pensioners' heaven or just an administrative and educational centre as before; it has

Data used and Methodology

The methodology approach for this research work was to develop a GIS database of Jodhpur city using spatial and attribute data (Fig.2). The spatial data comprises of all the thematic and topographic maps viz., land use/land cover, JMC maps, Satellite imagery and town planning map etc. and the attribute data is composed of mainly detailed information collected from various government and private sectors and field data collected from the site. These steps involved in deriving all these data and sources and their transformation are discussed in flowchart. The properties of the Landsat satellite images are given in Table 1. To accomplish objective of the research work, the software used are i*) ARCGIS 9.2*, *ii) ENVI 4.5, iii) ERDAS 9.1, iv) IDRISI, v) FRAGSTATS 4.1*. Extensively field data were also collected and proper geo-tagging were also marked with GCPs.The data collection team also collect GCP data using handheld GPS unit and field photograph of each feature class.

Table 1. Basic Properties of Lands at Data

Year	Date Acquired	Spacecraft ID	Sensor ID
2014	May - 2014	LANDSAT_8	"OLI"
2015	May - 2015	LANDSAT_8	"OLI"

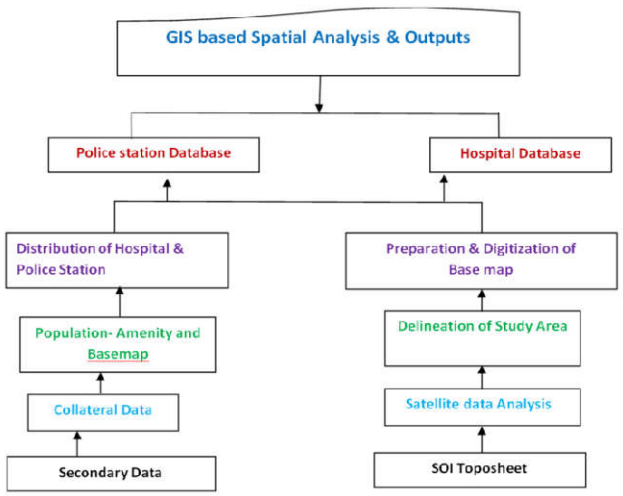


Fig. 2. Methodology of Spatial Analysis of Urban Amenities

RESULTS AND DISCUSSION

A. GIS Database Creation and Spatial Operations Analysis

GIS database is prepared as with spatial and non spatial data. Every accident spot is specifically located at their exact geographic positions. In sum, 50 Hospital, 25 Police station and 20 fire accident spots are spotted with their attributes. The designed GIS database layers and their fields are

1. City Boundary (Area, Perimeter)
2. Ward Divisions (Ward No, Area, Males, Females, Total)
3. Roads (Name, One Way, Speed limits, Length, Category)
4. Fire Accident Spots (Stn_ID, Stn_Name, Place, Distance, Date, Time)
5. Hospitals & Ambulance Services (ID, Name, Address, Contact)
6. Fire & Rescue Stations (ID, Name, Address, Contact)
7. Police Stations (ID, Name, Address, Contact)

There is a wide range of function for data analysis in most GIS packages; this is what distinguishes GIS from all other information system. These capabilities use the spatial and non-spatial data in the spatial database to answer questions and solve problems. Having acquired all the necessary data, the Geographic information system operation shall be performed within the study area are: Buffering, Spatial Analyst, Classification, and 3D Analysis, Network Analysis. A composite map is generated which depicts the features of interest viz. police posts, Road, rail network, Fire stations, markets, hospitals etc. The mapped features shall have attribute information along with GPS coordinates. Spatial queries were performed to reveal disaster/incident born locations within the study area. The best route distance travelled to the rescue place from the incident spot shall be demarcated. The closest of the medical centres and Service areas of the mapped police posts were also be shown on GIS map in the study area. Base map of the study area has been created using Satellite Data and ground truth data collection using GPS. All major Rail & Road network has been integrated using GIS S/W (Fig.3). Attribute Data of each class is also interlinked in Metadata.

B. Attribute Database of Hospital and Police Station

Adopting the geospatial database of amenities essential required in disaster scenarios and observations were taken at each and every feature class using GIS queries (Table-2). Location of the site was observed using GPS, photo for reference and other details as mentioned in the data form were also recorded (Fig.4).

Table 2. List of Features used for Geospatial analysis

S.No.	Name of Feature Class	No. of Records with QC
1.	Hospitals & Medical Facilities	90
2.	Police Stations/Post	33
3.	Railway Network	8
4.	Road Network	15

C. Creation of GIS Map of Police Station and Hospitals

Using Satellite Data and ground truth database a GIS map of Police Station and Hospitals has been created using GIS S/W. Base Map and spatial distribution of Police Station & Hospitals has been integrated in Geospatial Manner for query analysis (Fig.5a&b). The above GIS output has been generated based on the attribute data collected during fieldwork and linked with satellite imagery on the GIS s/w. These geospatial outputs were used for query analysis for all disaster scenario analysis.

D. Spatial Analysis for Population affected and Nearby Hospitals in the study area

An approach has been designed to explore the scope for the combination of Emergency management and GIS. Spatial data are important segment for assessing the need to address disasters in rural areas or in towns or cities. This study mainly focuses on spatial data requirements to target the needs of asset mapping in city, where the focus is on more confined urban areas. Geospatial tools are used in geospatial analysis to visualize the hazard zone hazard zone and its impact on civil populations (Fig.6).

E. Role of Police and Hospital

Police is always first to reach the site of disaster, to provide security and maintain law and order at Disaster location. The police will keep crowds under control and can offer transportation, emergency medical care, and be a bridge between citizens and rescue personnel. They can also provide alternate route to safer roads and try to keep out all unnecessary traffic away. They can put roadblocks in the areas where the crisis is still underway. Hospitals would be among the first institutions to be affected after a disaster, natural or man-made. Because of the heavy demand placed on their services at the time of a disaster, the detail of each hospital with all facility should be stored in GIS database. This necessitates a well documented and tested disaster management plan to be in place in every hospital. The disaster management plan of a hospital should incorporate various issues that address incidents of natural and manmade disasters.

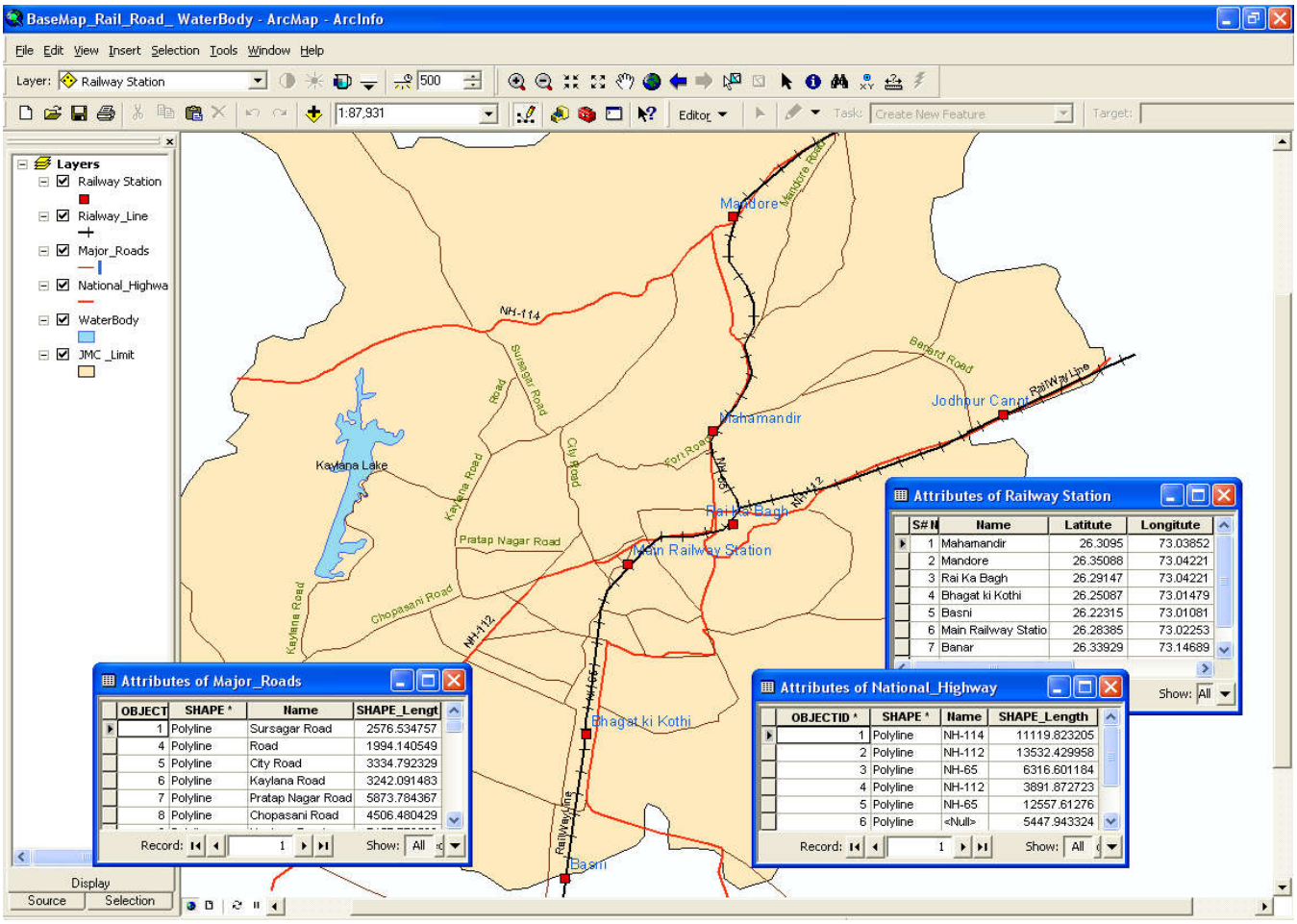
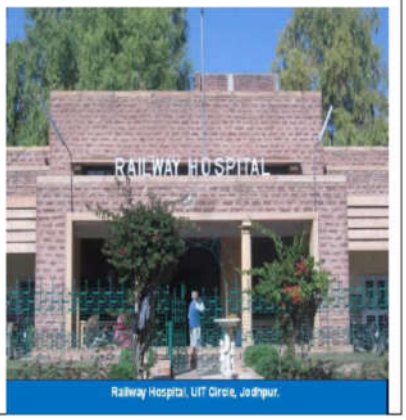
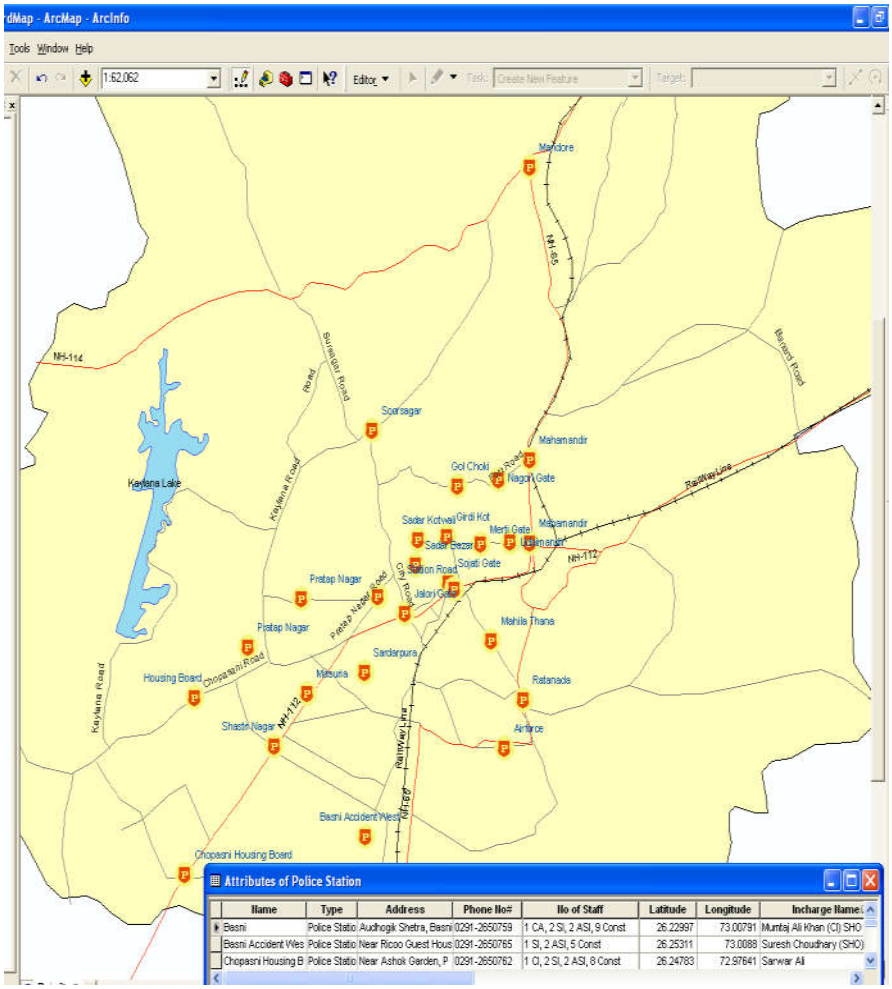


Fig.3. GIS Integration of Base-Map & its Attribute database

Sr. No.	Attribute Type	Details/ Info.	Image of Hospital
1	Name & Address	**Railway Hospital,** UIT Circle, Jodhpur. **Ph. 0291-2432302**	
2	Ownership	Center Govt.	
3	No of Doctors	30	
4	No of Nursing Staff	33	
5	No of Beds	117	
6	Specializations	General	
7	Latitude	26.274139	
8	Longitude	73.021194	
9	Incharge Details	**Dr. C. K. Lohra,** Back Side UIT, Jodhpur. **Mob.9001098500**	
10	Pathology Lab	Yes	
11	Adjoining Road	Ratanada Road	
12	No. of Ambulances	5	

Sr. No.	Attribute Type	Details/ Info.	Image of Police Station
1	Name & Address	**Basni Police Station** Audhogik Shetra, Basni, Jodhpur. **Ph. 0291-2650759, 9461189786**	
2	No of Staff	Total=14, 1 CI, 2 SI, 2 ASI, 9 Const	
3	Latitude	26.22997	
4	Longitude	73.00791	
5	Incharge Detail	**Mumtaj Ali Khan (CI) SHO Mob. 9461189786**	
6	Adjoining Road	Basni IInd Road	

Fig. 4. Attribute database sheet of Hospitals and Police Station



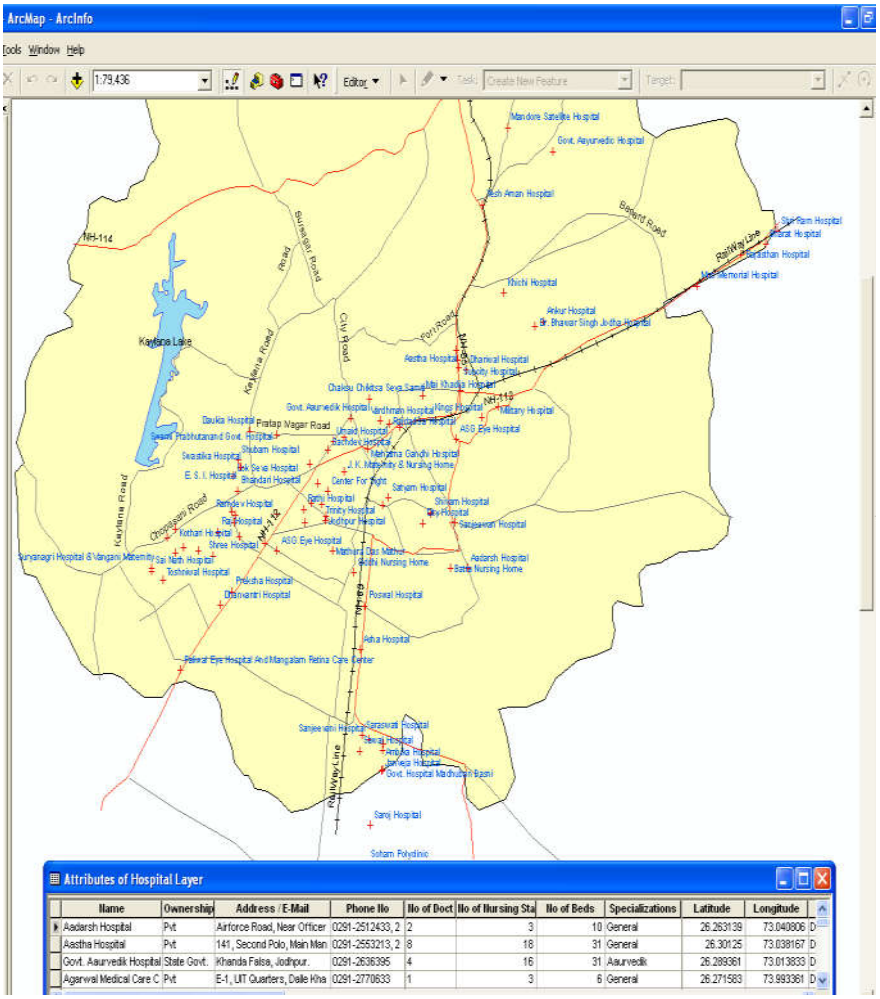


Fig. 5(a &b) GIS Map of Integration Police station and Hospital Attribute database

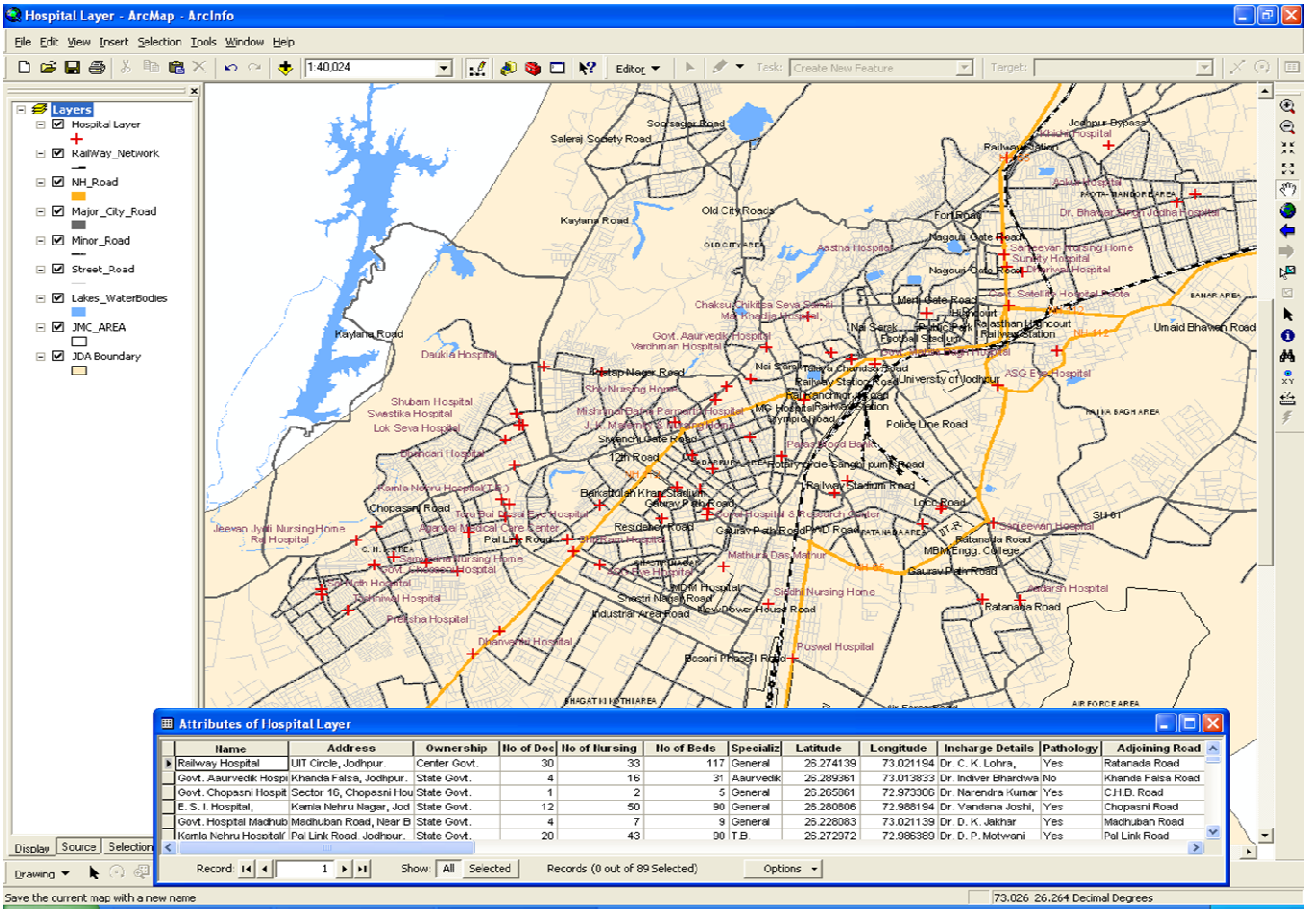


Fig. 6. GIS Map of Hospitals database on Base map with Buffer of 2km & 5km

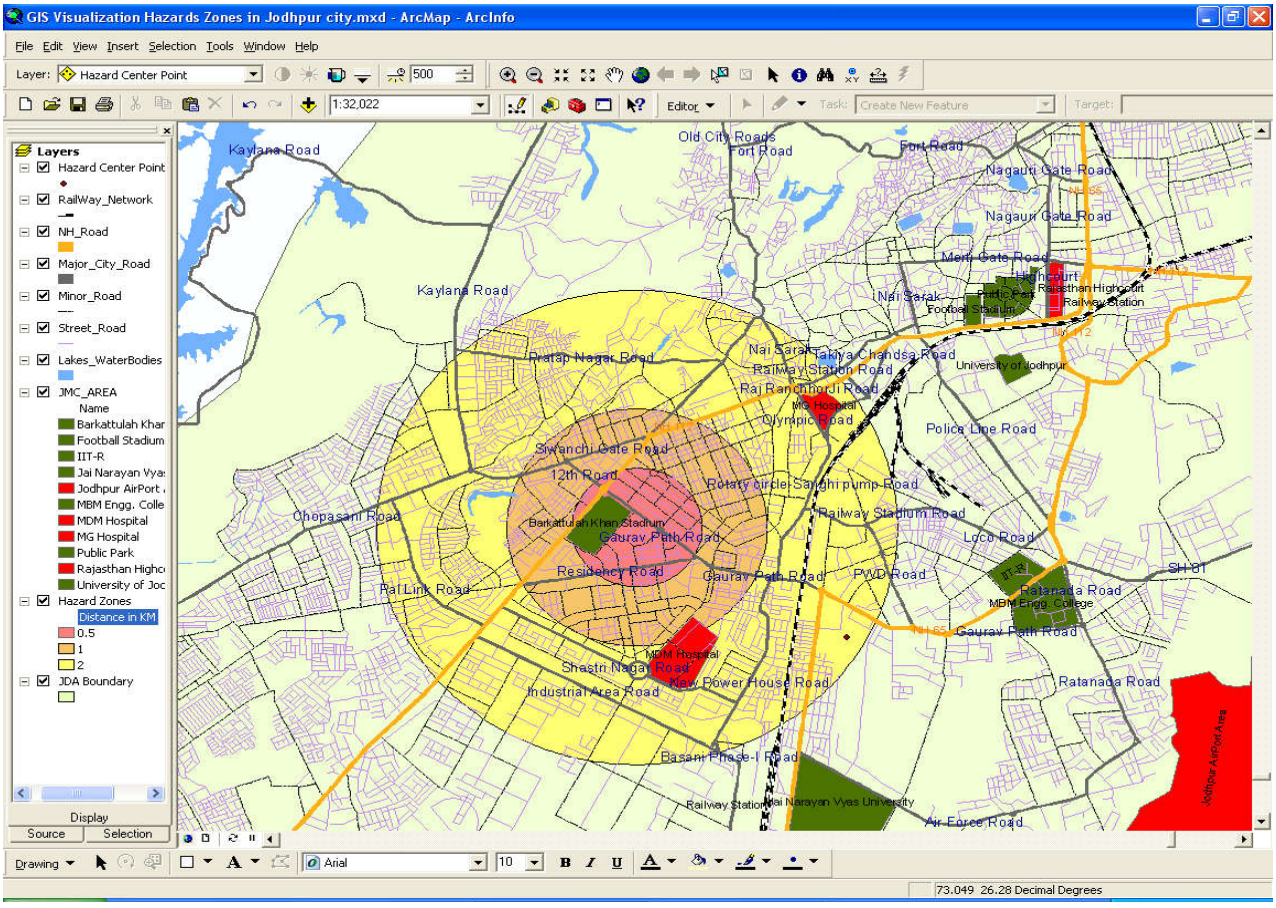
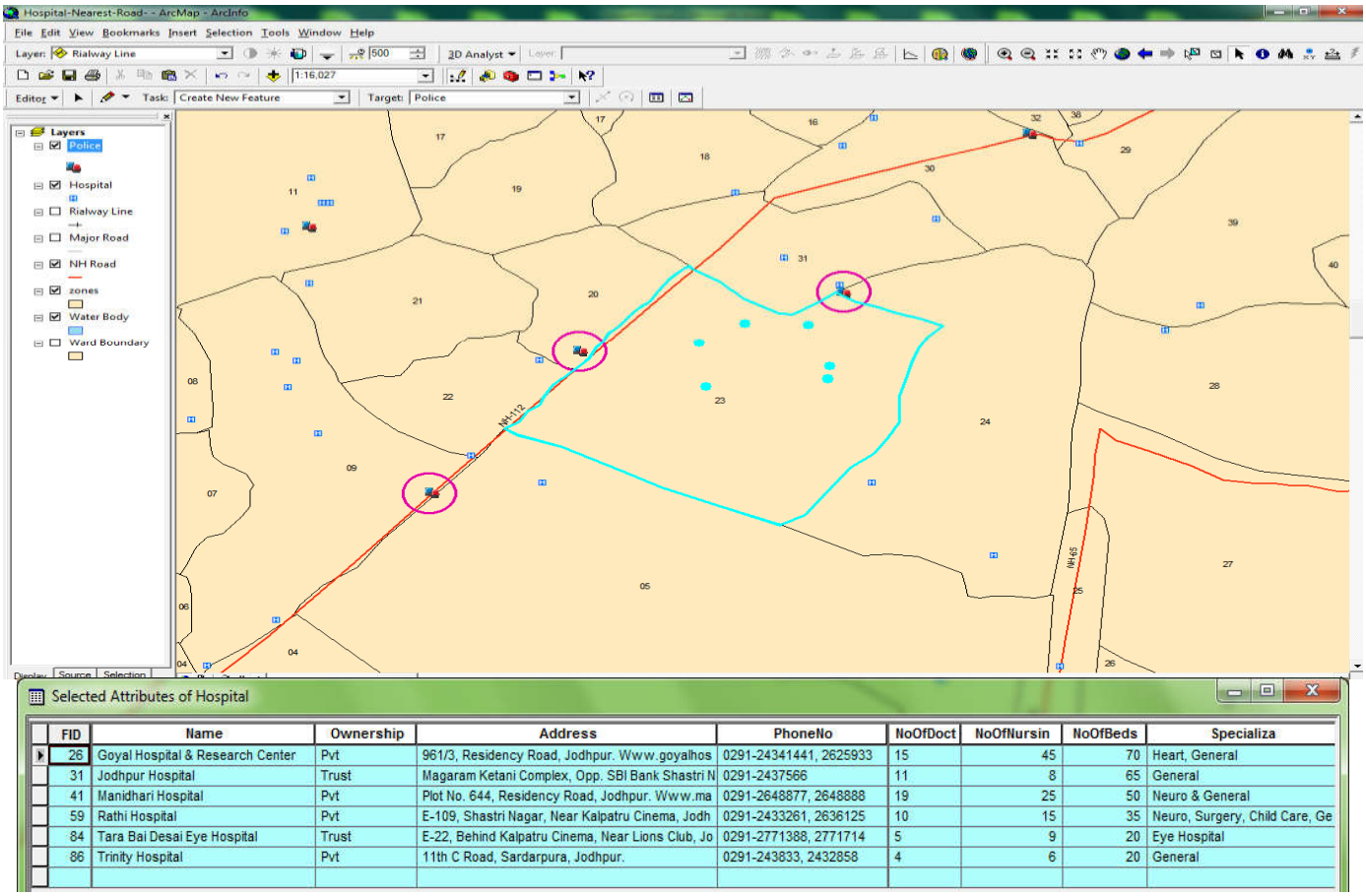


Fig. 7. The Risk Analysis GIS Map Layer shown the various risks are color-coded as Low(yellow), Moderate (orange) and Maximum Risk (red)



FID	Name	Ownership	Address	PhoneNo	NoOfDoct	NoOfNursin	NoOfBeds	Specializa
26	Goyal Hospital & Research Center	Pvt	961/3, Residency Road, Jodhpur. Www.goyalhos	0291-24341441, 2625933	15	45	70	Heart, General
31	Jodhpur Hospital	Trust	Magaram Ketani Complex, Opp. SBI Bank Shastri N	0291-2437566	11	8	65	General
41	Manidhari Hospital	Pvt	Plot No. 644, Residency Road, Jodhpur. Www.ma	0291-2648877, 2648888	19	25	50	Neuro & General
59	Rathi Hospital	Pvt	E-109, Shastri Nagar, Near Kalpatru Cinema, Jodh	0291-2433261, 2636125	10	15	35	Neuro, Surgery, Child Care, Ge
84	Tara Bai Desai Eye Hospital	Trust	E-22, Behind Kalpatru Cinema, Near Lions Club, Jo	0291-2771388, 2771714	5	9	20	Eye Hospital
86	Trinity Hospital	Pvt	11th C Road, Sardarpura, Jodhpur.	0291-243833, 2432858	4	6	20	General

Fig.8. Emergency monitoring scenrio in Ward No.23 of the study area

Table 3. Fire and Road Accident prone areas the study area

S.No	Fire Prone Risk Area	Road Accident Risk Area
1.	Basni Industrial Area	Poata Junction
2.	Marudhar Industrial Area	Jolori Gate Junction
3.	Tripoliya Bazar	Amrita Devi Circle
4.	Ghanta Ghar	Akhliya Circle
5.	Pratap Nagar	
6.	Tranport Nagar	

Identification of risk zones GIS visualization of risk analysis

Fire accident history recorded six places of frequent fire and had maximum economic loss. These places can be called as fire prone risk zones. The risk zones (Table No-3) are given below. Time based analysis reveals that the time interval 12 hrs to 15:59 hrs is most prone to fire accidents in the years 2012- 2016. In sum, 30% of accidents in 2012, 24% in 2013, 27% in 2014, 30% in 2015 and 26% in 2016 were happened in this specific interval of time. From month based analysis we can conclude that the months April – June has the maximum fire accidents in all the years 2012 to 2016. Nearly 33% accidents were occurred. Fire accidents have been classified in to Serious, Medium and Small accidents by considering the amount lost. Road accidents have been classified in to Fatal and Non fatal accidents (Fig No-7).

GIS based emergency preparedness system

An Emergency Response System was conceptualized using available feature and database generated in geospatial context for Jodhpur city. This database is aimed to solve routing problems effectively and it also provides shortest as well as efficient route for speedy transportation of a patient when an accident or emergency occurs in Jodhpur city. The system has the query for emergency response for accident analysis in the study area. For accident analysis scenario near NH-112, there are three Police station and six Hospital in the ward no 23(Fig No-8).The all police station and Hospital has all communication details of authority in click menu of attribute window in the system.

Conclusion

Geographic information system (GIS) and Geospatial technologies are used in the exploitation and analysis of imagery and geospatial information to describe, assess, and visualize features for monitoring of various disaster and incidents. Information about incidents can be entered into the GIS database, appropriately labeled, referenced by geolocation, and displayed on imagery. Geospatial tools are used in geospatial analysis to visualize the hazard zone. GIS database can be accessed for damage assessment and to locate critical infrastructure such as public utility buildings and residential area to be inspected and secured. The database is an important element of the system as it is holding all thematic as well as geographic data along with their metadata and

cartographic specifications. GIS Database is used to store and maintain all the data of the system and enables the application to perform direct data queries on demand. GIS based applications provide salient features for hazard alert, emergency response, emergency management and interagency coordination.

Acknowledgement

The authors are thankful to the Director DL, Jodhpur for help and encouragement during the study. The authors are also thankful to Head Mining Department, J NV University, Jodhpur for his critical suggestion and encouragement.

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