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Original Article

Analysis of Road Accidents using GIS

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Abstract *- Road accidents negatively impact a country's economy as people may get injured or, in severe cases, he/she may die. Road accidents shall be controlled to minimise the loss of life and permanent disability. It can be achieved by analysis of accidental data. Geographical Information System (GIS) is among the best tools for analysing and managing accidental data. In this paper, the traffic accidents are analysed police station-wise, vehicle type-wise, time-wise, road-wise, etc. An effort is also made to identify the critical and most critical points so that appropriate measures may be taken to check the accidents there. Network analysis is also carried out to find out the locations of the nearest hospitals where the victim can be hospitalised within 15 minutes of the accident.*

Keywords *- Critical points, GIS, Network analysis, Traffic Accidents.*

1. Introduction

The AIS provides a correlation of traffic accident data with the road location, inventory and condition, making it a powerful tool for road safety analysis, including identification of 'Black Spots'. It is also defined as the computerization of accident data to reduce the cost of the process and increase process execution speed. The objectives can effectively be met using digital technology to collect and transmit data to a central database, wherein information extraction with a Geographical Information System (GIS) can quickly provide traffic accident information. Cost savings can be made to collate and disseminate information leading to more efficient processes.

The AIS helps road authorities to make roads safe to the users by providing sufficient safety measures at the black spots on the roads, thus reducing the loss of human life, damage to vehicles and traffic jams due to accidents.

The benefits of AIS are many; some are as follows:

(a) Creation of an integrated traffic accident database system
(b) Geo-referencing of accident occurrences
(c) Utilization of available cost-effective technologies (e.g., GIS, GPS)
(d) Better traffic accident investigation procedure (e.g., accident site measurements, reconstruction)

2. Previous Studies on AIS

Mwatelah [1] discussed various measures to reduce road traffic accidents by including new technologies in developing countries so that proper decisions could be taken to minimise road traffic accidents. It is concluded that GIS is a technology that can alleviate this menace when incorporated into the analysis of road traffic accidents.

Khan *et al.* [4] developed a GIS-based traffic accident data collection, referencing and analysis framework for the Abu Dhabi municipality. This is a part of a strategy to implement a GIS-based Transportation Information and Management System comprising several components, including an Accident Management System. The study explains a method of using GPS observations to reference an accident location using a GIS map since the accurate identification of accident location is a critical element.

Erdogan *et al.* [6] developed a GIS-based traffic accident analysis system for Afyonkarahisar city, Turkey. They used GIS technology to visualise accident data and analyse hot spots on highways. Accident analysis study aimed at identifying high rate accident locations and safety deficient areas on the highways so traffic officials can implement preventive measures and provisions for traffic safety.

In India, the road authorities of Tamil Nadu, Gujarat, and Uttar Pradesh states are developing or have developed AIS for their states. [2] [3] [1]

3. Study Area

Dehradun is an interim capital city of the newly formed state Uttarakhand, formed on November 9, 2000. It is famous for its natural climate and beauty. The city is surrounded by the Himalayas in the north and the Shivalik mountains in the south. On its east, the river Ganga flows and on the west river, the Yamuna. Dehradun region lies within the jurisdiction of Mussoorie Dehradun Development Authority (MDDA) as envisaged in the master plan 2005-2025. It lies between 30° 13′ 0" N to 30° 29′ 0" N Latitude and 77° 52′ 0" E to 78° 10′ 0" E Longitude.

4. Data and Methodology

The data are collected from SOI toposheets (53J/3, 53J/4, 53 F/15, 53 F/16) at 1: 50,000 scale, guide map of Dehradun at 1:20,000 scale, field survey, GPS survey, government organizations, IRS Cartosat-1 of path/row number 526/258 and 527/258 of the date January 24, 2008, and November 20, 2008, respectively. Thematic layers were directly created, such as roads, railways, hospitals, police stations, year-wise road accidents from 2002 to 2006, bridges etc., from these sources. The framework of the proposed methodology involves the creation of digital layers, the addition of attributes, and the development of AIS and its analysis.

Since a large amount of attribute information, such as road characteristics and conditions, vehicles involved, time of accidents, the person injured or died, name of the bridge, type of bridge, hospital, police station etc., is required for AIS, intensive field visits were carried out from November 18-27, 2010, December 13-16, 2010 and January 15-17, 2011, to collect these. This attribute information was attached to the thematic layers in the GIS environment. Table 1 shows data collected/obtained from various sources. Figure 1 shows the cartosat-1 data.

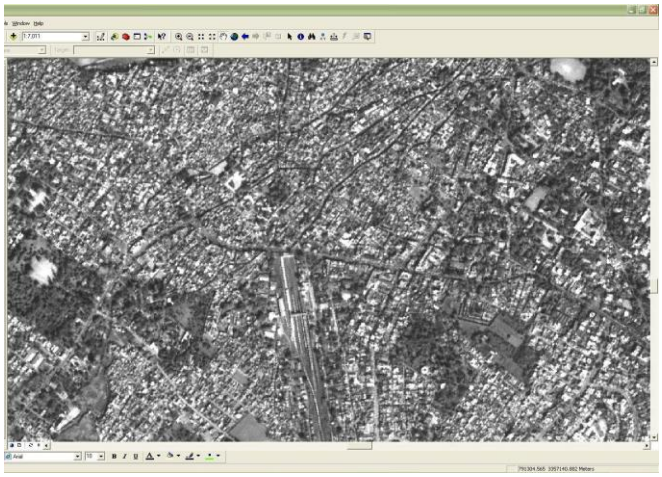

Fig. 1 The Study Area on IRS Cartosat-1 Image, Dated January 24, 2008, and November 20, 2008

Table 1. Data Collected/Obtained from Various Sources

Data Requirement	Data obtained from Geospatial Techniques	
	Data obtained from maps and satellite image	Data Collected with the help of GPS
(a) Roads & railways (b) Accident Locations (c) Hospitals/Medical Facilities (d) Police/fire stations (e) Date and time of the accident (f) Hospital's name, address, name of owner, doctors and their specialization (g) Roads name, type, width and number of lanes (h) Presence of a road divider and footpath (i) Road top surface (j) Road one-way or two way (k) number of persons injured or died (l) Date and time of accidents, (m) Vehicles involved in accidents	(a) Roads & railways	(b) Accident Locations (c) Hospitals/ Medical Facilities (d) Police/ fire stations
	Note: Data from (e) to (j) was collected by field visits from November 18-27, 2010, December 13-16, 2010 and January 15-17, 2011.	

5. Results and Analysis

Table 2 shows the accident record available police station-wise. It is clear from the table that the maximum number of accidents took place in Dalanwala police station and the least accidents in Doiwala, Vasant Vihar and Garhi Cantt. Police station. Table 3 shows the number of persons injured and died year-wise. Maximum accidents occurred in 2004 and then in 2003, while maximum casualties and persons injured occurred in 2005.

Table 2. Number of Accidents Police Station wise

Police Station	2002	2003	2004	2005	2006
Dalanwala	56	60	40	43	13
Doiwala	3	2	1	0	0
Raipur	10	11	16	15	11
Rajpur	5	6	9	13	14
Vasant Vihar	0	5	6	6	7
Garhi Cantt.	0	0	18	3	2

Table 3. Number of Persons Injured and Dead Year wise

Year	Total number of Accidents	Injured	Death
2002	74	61	17
2003	84	75	25
2004	90	80	38
2005	80	97	41
2006	47	47	17

Table 4 shows the vehicle involved in the accidents. It is clear from the table that two-wheelers are the most vulnerable to accidents. Every year, two-wheelers are involved in 50% of accidents. A pedestrian covers the second largest, and in third place, four-wheelers are involved. In 2004, the maximum number of accidents occurred with six-wheelers. Table 5 shows the injured and dead persons in accidents and the vehicle involved. It is clear from the table that the maximum number of injuries and deaths occurred in two-wheeler accidents. Table 6 shows the month-wise accidents. Table 7 shows the typical query formed under different categories and their results.

Table 4. Accident Vehicle-wise

Year	Total Accidents	Two Wheeler	Three Wheeler	Four Wheeler	Six Wheeler
2002	74	35	2	14	1
2003	84	45	3	14	3
2004	90	44	6	14	11
2005	80	34	2	18	4
2006	47	24	3	16	2

Table 5. Vehicle and Year Wise Injured and Dead Persons

	2002		2003		2004		2005		2006	
	Injured	Dead	Injured	Dead	Injured	Dead	Injured	Dead	Injured	Dead
Pedestrian	2	4	9	10	9	7	22	4	2	0
Two wheeler	31	9	42	10	31	16	36	9	11	12
Three wheeler	2	1	4	1	12	3	1	1	5	1
Four wheeler	9	1	19	1	13	2	22	4	29	2
Six wheeler	0	2	1	2	15	10	16	23	0	2

Table 6. Month-wise Accident

	2002	2003	2004	2005	2006	Total
January	5	7	8	8	8	36
February	4	7	8	6	6	31
March	7	1	5	9	6	28
April	8	3	8	5	2	26
May	9	7	12	8	2	38
June	6	4	8	4	3	25
July	3	12	6	5	2	28
August	5	9	4	3	6	27
September	6	6	10	9	6	37
October	10	8	8	7	2	35
November	8	9	6	6	2	31
December	3	11	7	5	2	28

Table 7. Queries formed under Different Category and Their Results

Sl No.	Category	Query Type	Results
1	Police Station wise	Accidents under police station Dalanwala in 2002	56 accidents, 9 persons had died, and 49 persons injured
2	Vehicle type wise	Accidents of two-wheelers in 2004.	44 out of 90, 16 persons had died, and 31 persons injured
3	Time wise	Accidents on or before 12:00 noon in 2005	42 accidents, 62 persons had injured, and 26 persons died
4	Road	Accidents on East Canal Road in 2006	In 4 accidents, 6 persons had injured, and 1 person died

Fig. 2 shows the accidents between 2002-2006 while figure 3 shows the location of police stations/chowkis and hospitals.

Based on the frequency of accidents, the accident spots are classified as most critical, critical and less critical spots. In this study, the accident data from 2002 to 2006 were used. First, a 100 m buffer of all accident spots was prepared. The intersection of these buffers of different years was done where all five or any four buffers intersect, designated as the most critical spots. Where three or two buffers intersect, they are designated as critical spots, and the single buffer is designated as less critical spots.

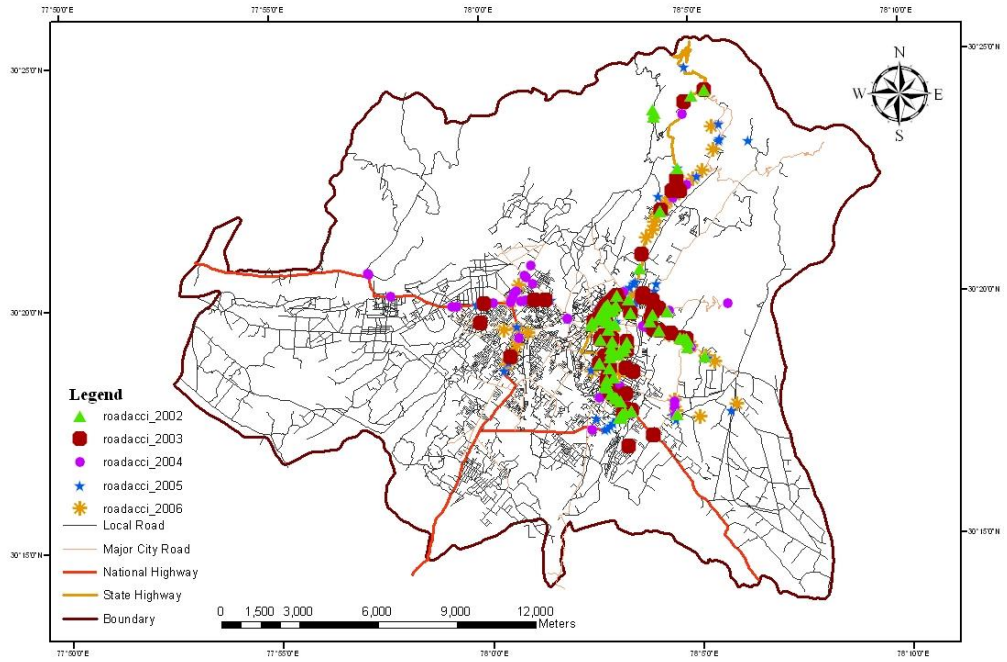

Fig. 2 Road Accidents Between 2002-2006

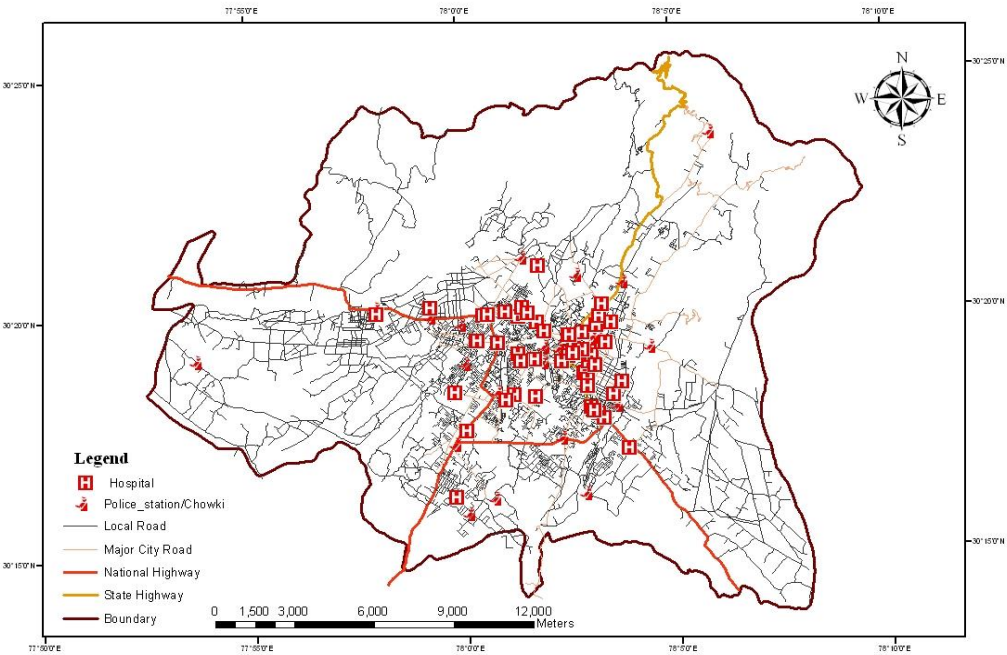

Fig. 3 Locations of Police Stations and Hospitals

Fig. 4 shows the intersection of all five buffers. These points are either on Rajpur road where East Canal road intersects or on East Canal road in between the intersection of Crossroad and Amrit Kaur road. The buffers of four years of accidents have intersection points on Rajpur road, East Canal road, Haridwar road, Haridwar bye pass, Shahastradhara road etc.

Fig. 5 shows the critical points and intersection of any three buffers. These points lie on Rajpur road, East Canal road, Subhas road, Haridwar road, Haridwar bye pass, Ring road, Raipur road and Shahastradhara road etc. The intersection of three years of buffer lies on Chakrata road, Race Course Road, General Mahadev Singh road, Rajpur road, East Canal road, Subhas road, Haridwar road, Haridwar bye pass, Ring road, Raipur road, and Shahastradhara road etc.

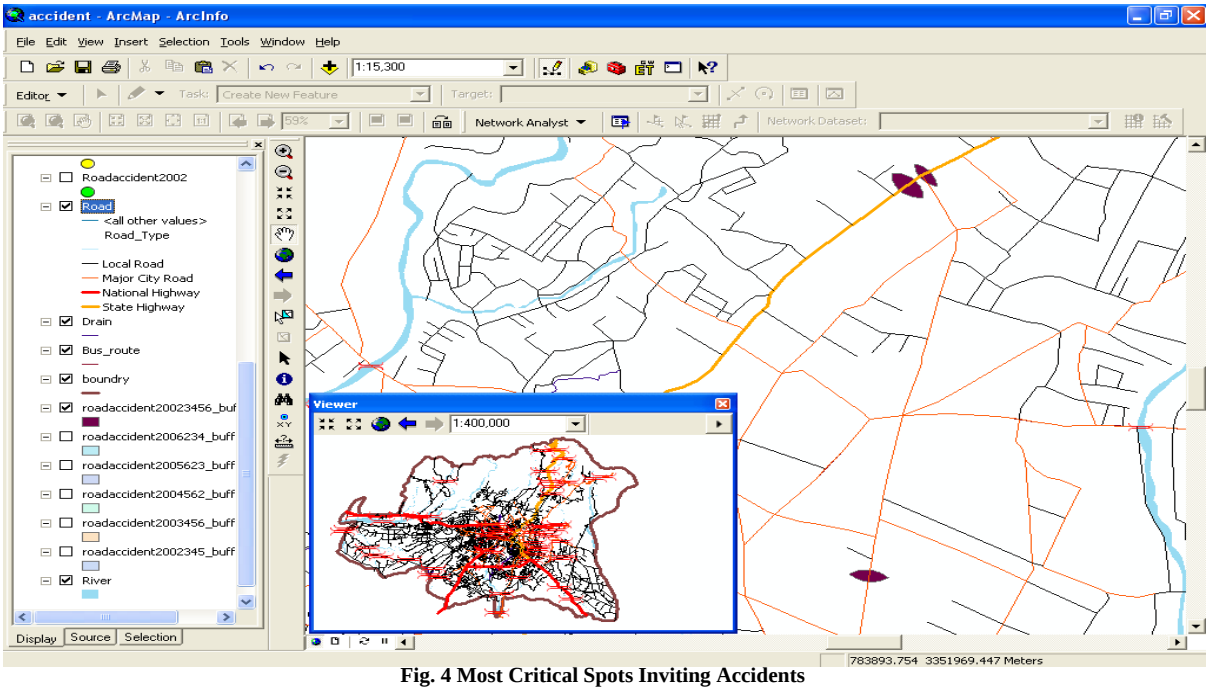

Fig. 4 Most Critical Spots Inviting Accidents

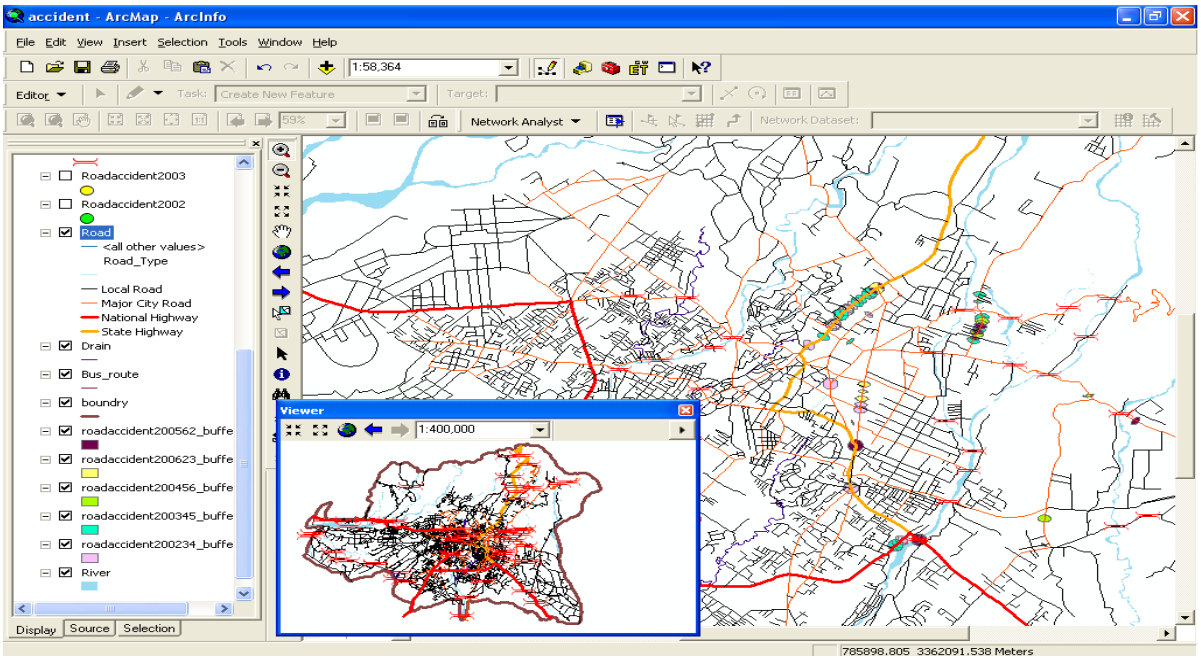

Fig. 5 Critical spots where any three buffers meet

The less critical spots lie on Shaeed Kashmira Singh road, Chakrata road, Race Course Road, General Mahadev Singh road, Rajpur road, East Canal road, Subhas road, Haridwar road, Haridwar bye pass, Ring road, Raipur road, and Shahastradhara road etc.

With the help of network analysis, the AIS can provide a way to reach the hospital in case of injury/emergency. For example, if an accident occurs on Ring road, the nearest hospitals with a travel time of 15 minutes were determined through the query. Figure 6 shows the results of the query. Five hospitals were found: Samadhan, Vaish Nursing home, Drishti eye hospital, S K Memorial and Rawal Nursing home. Out of these five, Samadhan, Rawal and S K Memorial will be closer to the accident spot.

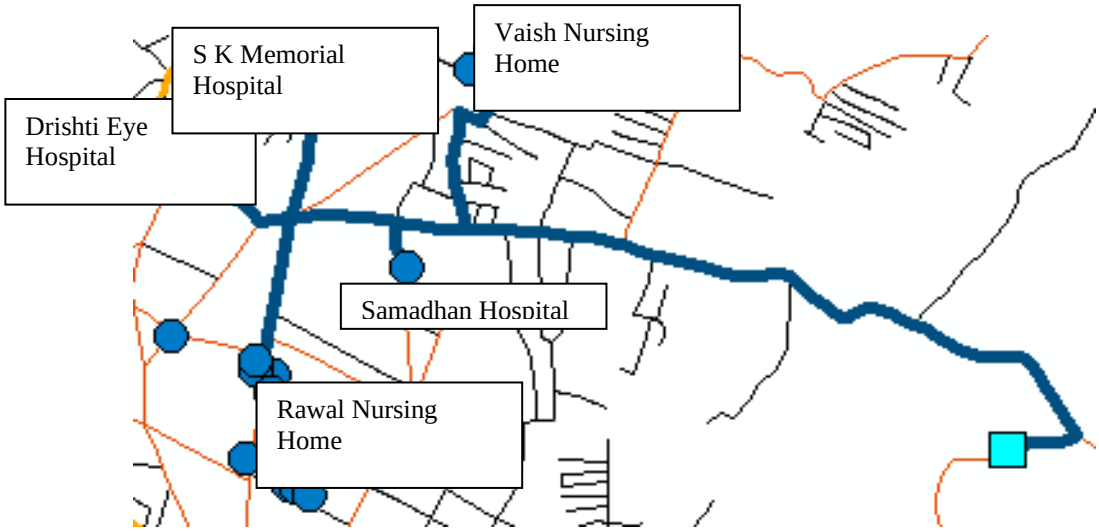

Fig. 6 Network Analysis Showing the Accident Spot and Five Nearest Hospitals Within a Travel Time of 15 Minutes

6. Conclusion

AIS has been developed using geospatial tools. To demonstrate the utility, some queries are made. An example of each category is presented, and the results are tabulated. Buffer analysis was also carried out to identify the most critical, less critical, and critical spots prone to accidents. With the help of this analysis, an administrator can identify and prioritize the remedial methods to minimize accidents. After analysing these critical spots, a visit was done on September 12, 2011, to these places, and it was found that many streets/roads are open to major roads. A lack of proper rotary, traffic lights and road dividers, etc., makes the roads prone to accidents. Therefore, it is recommended that the street/minor roads should be connected to the major roads with proper rotary. Network analysis was also carried out to find the nearest hospital location with a travel time of 15 minutes.

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