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Identification of Accident Hot Spots at Different Roads of Midnapore Municipality Area: A Geoinformatic Approach

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Abstract

Road traffic injuries (RTIs) are a huge public health and development problem, killing almost 1.2 million people a year and injuring or disabling almost 20 to 50 million or more. Both WHO and World Bank data show that without appropriate action these injuries will rise dramatically by the year 2020, particularly in rapidly-motorizing countries. The study identifies the volatile traffic areas where road accidents are almost regular events and assess the temporal variation of these traffic accidents and injuries in Midnapore municipal area through Spatial Information Technology (SIT). By applying Kernel-density method in identifying accident-prone locations in Midnapore municipal area, three accident-prone zones are observed. This result shows highest concentration of a particular type of accidents and is useful for looking at patterns rather than at locations of individual features. This work gives an insight into the present scenario of the traffic conditions, road width, land use/land cover of the area and shows the most accident-prone roads. In future, accidents can be reduced by eliminating unsafe conditions and reducing unsafe acts. This work will give an insight into the traffic scenario and will give planners and traffic authorities some breathing space when considering long-term objectives and likely solutions of the problem.

Keywords: *Kernel density, spatial information technology (SIT), temporal variation, pattern analysis*

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INTRODUCTION

Worldwide, the transportation problems mainly road accidents have increased. It has been estimated that India currently accounts for nearly 10% of road accident fatalities worldwide. In addition, over 1,300,000 persons get seriously injured on Indian roads every year [1]. So, for the public, traffic safety has become a major area of concern. The advancements in GIS and GPS [2] can be put to effective use in accident analysis [3].

Although GIS has been used for over thirty years, however, it has only been recently used in the field of transportation and road injuries cases. In addition to promoting linkage between various types of data and maps, GIS is able to manipulate and visually display numerous types of data for easy comprehension and location and related information for managing and processing these data. It visually displays the results of analyses thus enabling sophisticated analysis and quick decision making. Thus GIS will offer a platform to maintain and update road network and accident record [4] database and use it for further analysis.

STUDY AREA

Midnapore (Figure 1) is the district head quarter of Paschim Medinipur, a district of West Bengal. It is situated on the banks of Kassai river. Its latitudinal extension is between 22°26′25″ N and 22°24′26″ N and longitudinal extension between 87°18′15″ E and 87°20′24″ E and it is 23 m above sea level. The railway station is situated in the west, connecting Kharagpur towards south and Bankura towards north. The NH-60 lies in the east.

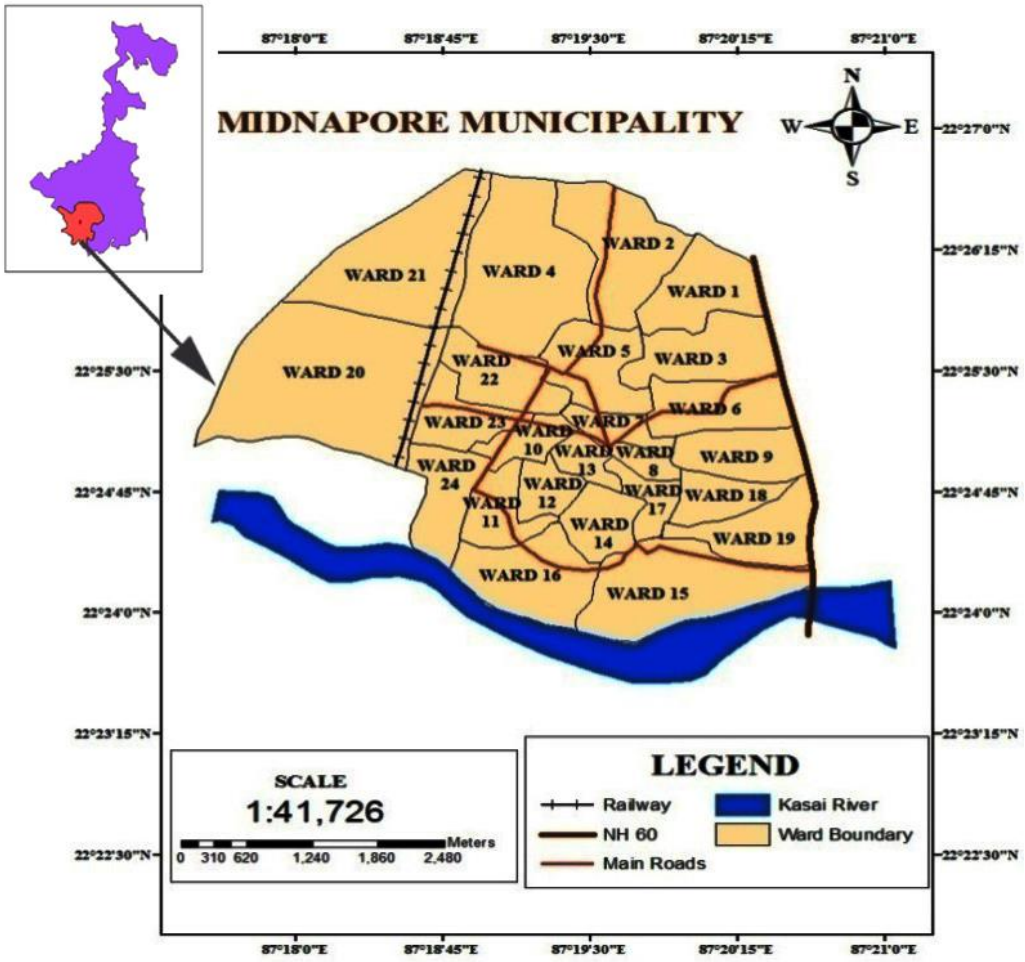


Fig. 1: *Location of the Study Area.*

AIM OF THE STUDY

To identify the volatile traffic areas where road accidents are almost regular events and assess the temporal variation of these traffic accidents and injuries in Midnapore municipality area through GIS techniques.

OBJECTIVES OF THE STUDY

- To study road network system all over
- Identify the vulnerable zones of road accident
- Find out the accident types and patterns for proper solution and management strategies of the accidents

Software Used

ERDAS IMAGINE, ARC GIS

METHODOLOGY AND DATA DESCRIPTION

The full work for identifying RTI zones is represented by the flowchart and the description given below.

Data Collection and Data Processing

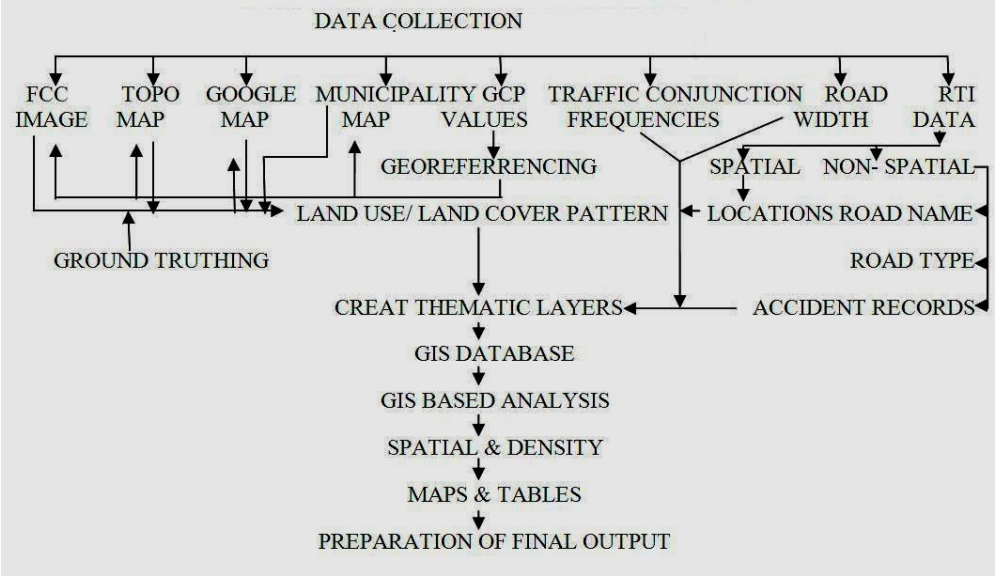
Data Collection

- Collected road accident reports from the office of SP (Superintendent of Police), Paschim Medinipur for the years 2008 up to Feb, 2012.
- Collected Survey of India topological map (73N/7) at a scale 1:50,000.
- True color map from Google Earth.
- FCC image (ETM^{+}) from GLCF.
- Municipality map.

Field Study

- Collection of GCP data
- Collection of road width
- Collection of traffic conjunction frequency data

Pre-Field Study



Post-field Study (Data Analysis)

Map Scanning

The Midnapore municipality map is scanned as the raster input.

Georeferencing

Scanned maps usually do not contain information as to where the area represented on the maps fit on the surface of the earth. To establish the relationship between an image coordinate system and a map (x, y) coordinate system, it need to align or georeference the raster data. Based on the georeferencing municipality map area of interest layer is created and then subseted the municipality area from topographic map, satellite image and true color image.

Classification

Classification is performed to the satellite image of the study area, the use of prior knowledge available from topographic, true color map and field surveys (ground truthing) while training the computer by way of assigning "training areas" about different features that are to be classified by the computer. Using their feature signatures given by the analyst, each pixel with similar characteristic signatures is grouped and assigned to respective classes. The main land use/land cover of Midnapore municipality area (Figure 2) are water body, plantation, open land, moisture land and buildup area. The area under Midnapore municipality is mainly buildup area. The middle part is very developed, but it developed in an unplanned way. Out of a total of twenty-four wards, only fifteen wards are connected by local transportation of bus and auto services. But the remaining nine wards have to depend on private cars, rickshaws, bikes and bicycles for transportation. The NH 60 passes through the eastern part of Midnapore in North-South direction. The rail line lies in North-South direction and connects not only major neighboring towns, that are, Kharagpur and Bankura, but also helps to connect the other parts of West Bengal and also all over India.

Digitization, Assigning Attributes and Use of Different Symbology

Digitizing is the process of encoding the geographic features in digital form as x, y coordinates. It was carried out to create spatial data from existing maps and documents. In the present work the georeferenced raster true color map and municipality map of Midnapore municipality are digitized using Arc GIS 9.3. This type of digitization is called "on-screen digitization". Road network of the study area is digitized as line features. Major traffic conjunction roads are also digitized as line features. Accident locations are digitized as point features [5]. Ward boundaries of the study area are digitized as polygon features. The above spatial data are organized in a geo-database and feature class.

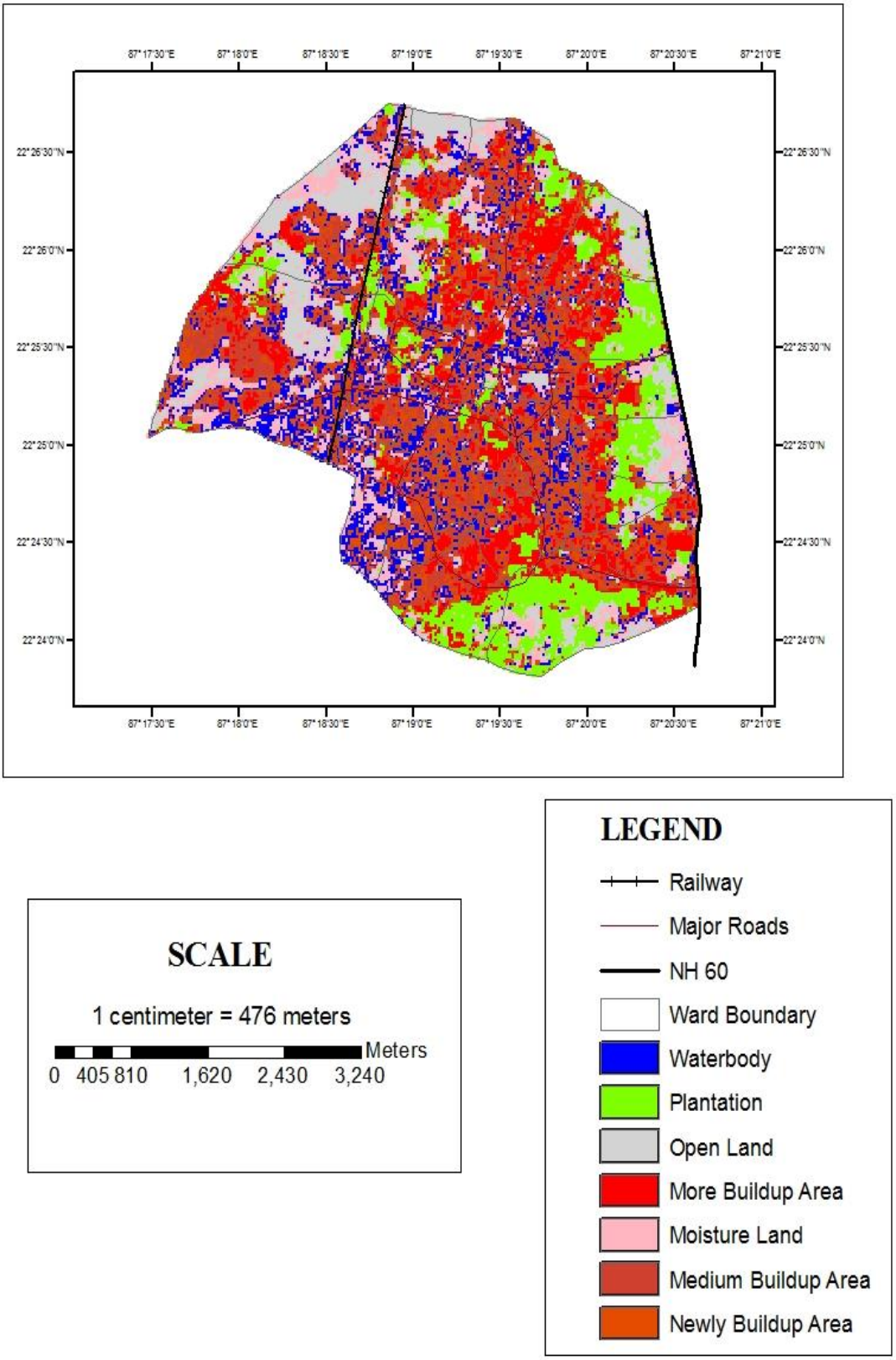


Fig. 2: *Land Use/Land Cover Classification.*

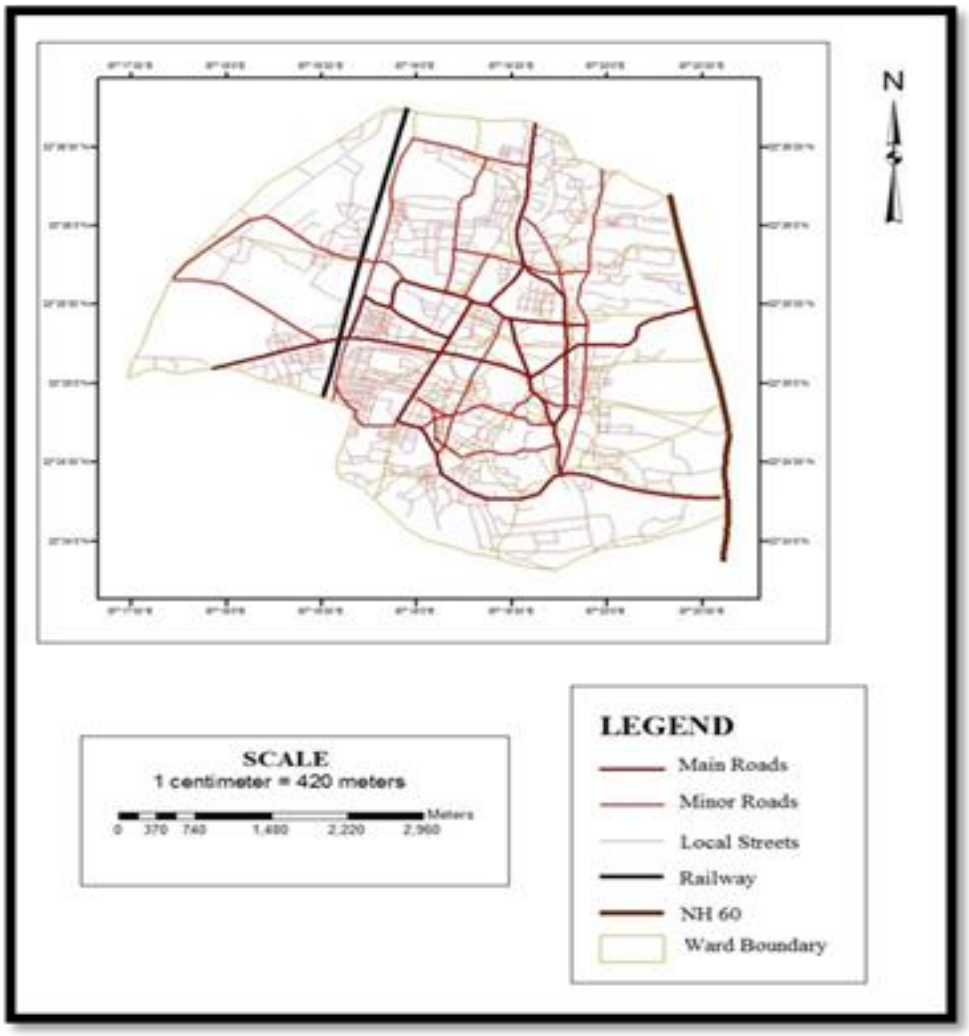


Fig. 3: *Detailed Road Network Map.*

All vector data (i.e., point, line and polygon features) will contain separate attribute tables. The accident location attribute table contains year-wise number of fatal accidents. The road network attributes table shows width-wise different roads and major traffic conjunction roads attributes. The table also contains frequencies of vehicles (up and down data of bus, auto, lorry, car, bike, rickshaw and bicycle) on working and non-working days of the study area.

By using different symbology, vector data can create a relationship or difference within two or more attributes from an attribute table. Traffic frequencies, accident rates and road types are shown by different symbologies which can give a clear idea about the created map of the study area.

In Paschim Medinipur district, Midnapore town has an important role in transportation system (Figure 3). The NH-60 passes through the eastern part of Midnapore in North-South direction. The railway line lies in North-South direction and connects not only major neighboring towns, that are, Kharagpur and Bankura, but also help to connect the other parts of West Bengal and also all over India. Out of the 24 wards, only 15 wards are connected to main roads and minor roads of Midnapore municipality area.

The main municipality roads connected are Sepoybazar, Kuikotabazar, Keranichati, and LIC more, Collectorate, Bus Stand, Rangamati, Dharma, Keranitola, Burgetown, Panchurchak, Amtala, Judgescourt, Mohonpur, Nimtala, Barobazar Hospital area, etc., and the minor municipality roads connect Ashoknagar, Policeline, Boxibazar,

Saratpally, Tantigeria, University, Station, Jal Tanki (Gate Bazar), Mirzabazar, Midnapore Jail, Ballavpur, Golapichak, etc. The pressure of traffic is more in above two types of roads, where the local streets have less pressure of traffic. Local streets are not more than 8 m in width and major parts of local streets are not concretized.

Table 1: *Traffic Frequency Chart of the Study Area*

S. No.	Place	Types of vehicles on non-working days													
		Bus		Auto		Lorry		Car		Bike		Rickshaw		Bi- cycle	
		U	D	U	D	U	D	U	D	U	D	U	D	U	D
1	Keranichati–LIC	40	23	46	46	35	43	57	48	159	157	14	13	192	159
2	Fakirkua–LIC	0	0	55	63	21	16	31	27	319	333	128	143	522	515
3	Amtala–Judgescourt	56	60	19	17	26	16	121	98	365	365	8	5	265	281
4	Keranitola–Dharma	0	16	35	36	36	41	69	94	240	241	29	25	290	265
5	Keranitola–Station	5	4	3	1	36	31	67	63	391	309	113	99	377	377
6	Keranitola–LIC	57	63	56	49	21	10	55	57	249	252	58	64	219	221
7	Battala–LIC	16	4	32	33	10	8	60	61	367	385	88	123	350	347
8	Keranitola–Judgescourt	38	38	38	55	26	21	91	91	358	568	77	67	486	396
	Place	Types of vehicles on working days													
		Bus		Auto		Lorry		Car		Bike		Rickshaw		Bicycle	
		U	D	U	D	U	D	U	D	U	D	U	D	U	D
1	Keranichati–LIC	36	27	66	52	62	56	62	88	220	207	28	21	195	156
2	Fakirkua–LIC	2	4	75	71	24	29	48	47	310	345	149	150	735	978
3	Amtala–Judgescourt	54	51	31	25	42	57	116	115	402	395	5	6	209	192
4	Keranitola–Dharma	0	16	54	47	21	32	109	115	333	319	26	29	493	283
5	Keranitola–Station	2	5	13	12	24	32	128	122	315	363	155	170	357	391
6	Keranitola–LIC	38	47	55	52	16	18	74	76	197	213	70	82	161	250
7	Battala–LIC	8	13	41	35	14	15	45	38	302	338	51	54	267	283
8	Keranitola–Judgescourt	42	47	24	20	28	23	121	59	556	553	60	48	254	326

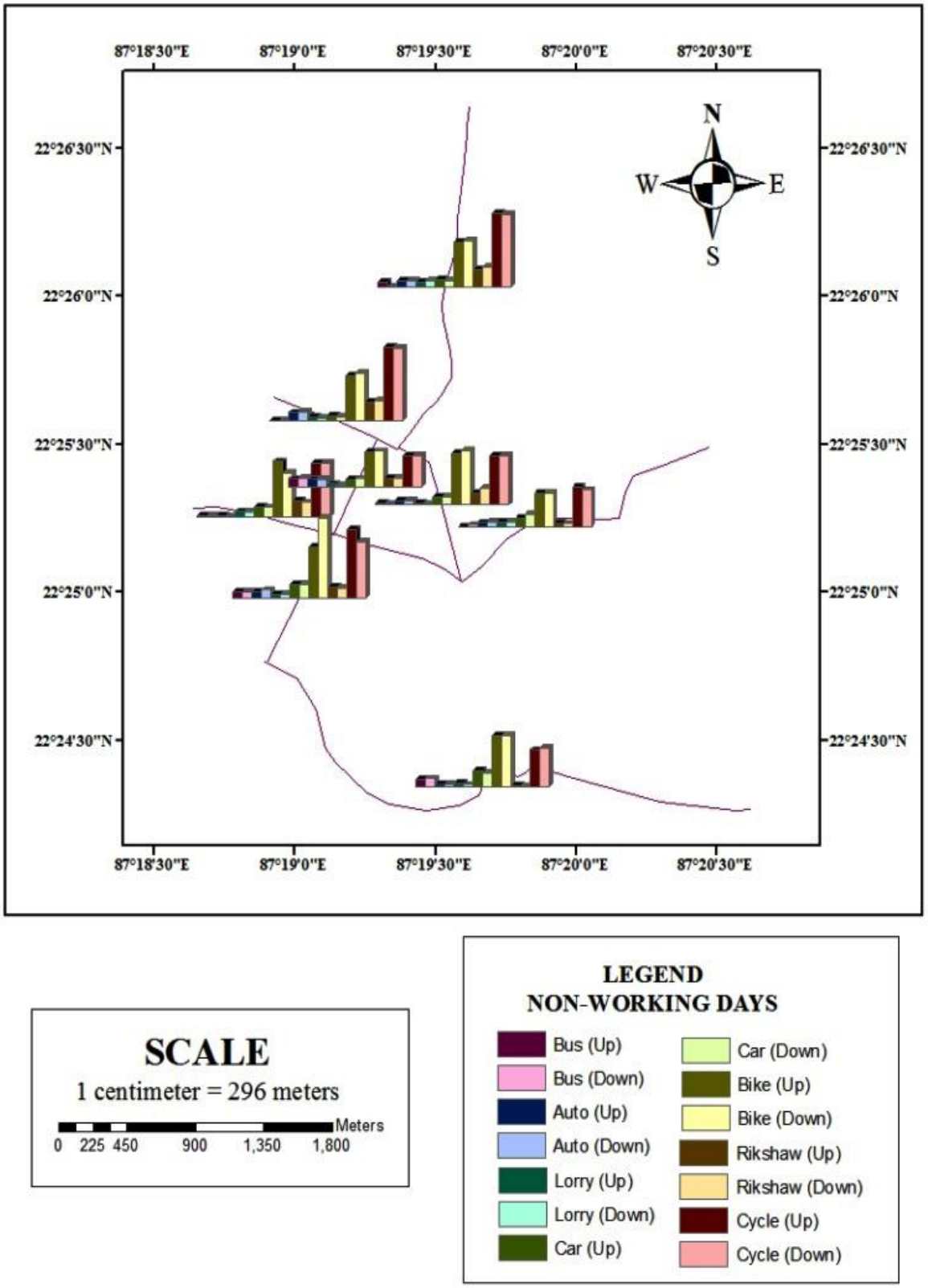


Fig. 4: *Frequency of Vehicles on Non-working Days.*

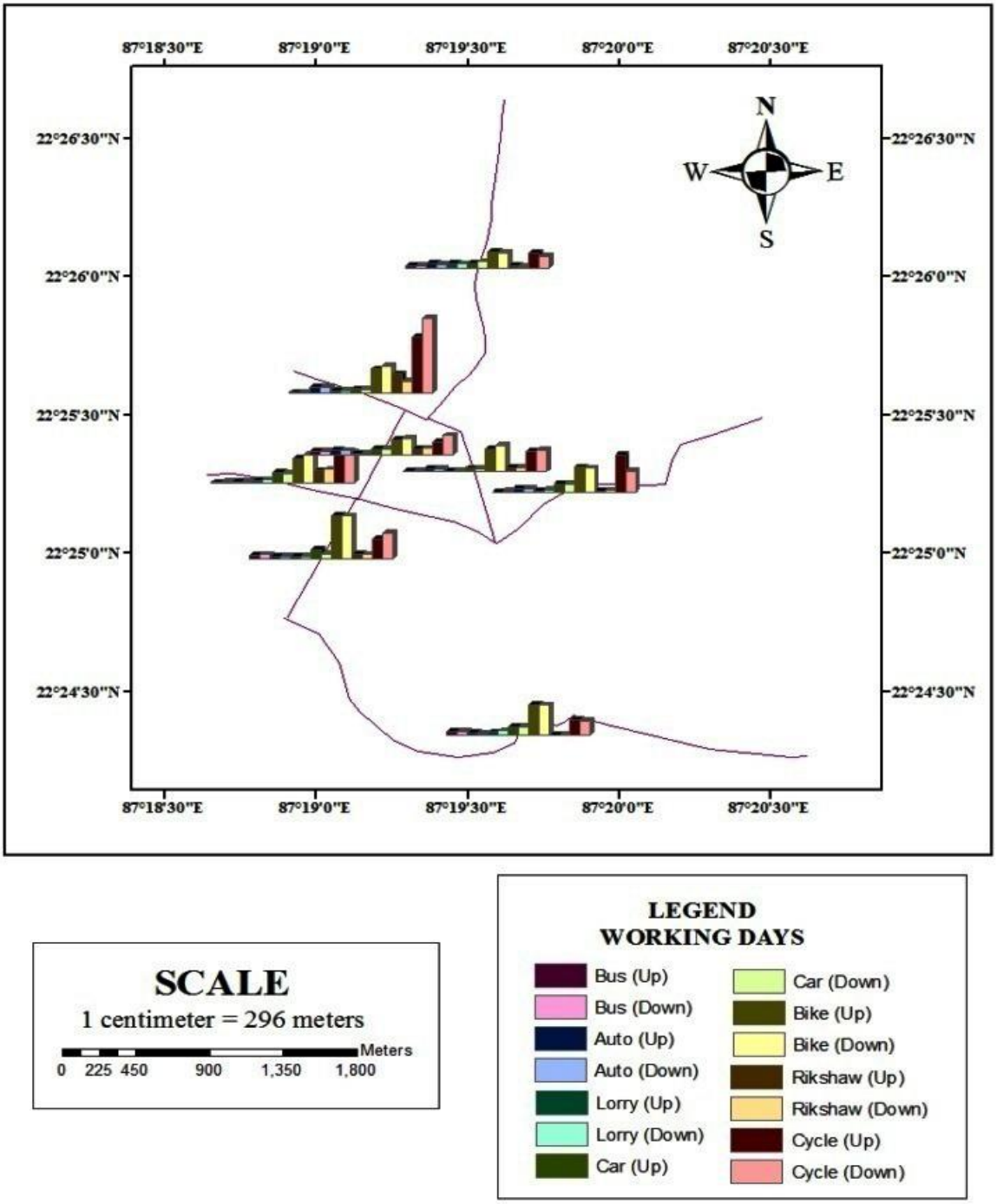


Fig. 5: *Frequency of Vehicles on Working Days.*

Based on the frequency of vehicles on map (Figures 4, 5 and Table 1), seven types of vehicles show up in eight major traffic conjunctions on their up and down movement (1. Keranichati–LIC, 2. Fakirkua–LIC, 3. Amtala–Judgescourt, 4. Keranitola–Dharma, 5. Keranitola–Station, 6. Keranitola–LIC, 7. Battala–LIC, 8. Keranitola–Judgescourt). The flow of bicycles and bikes is high in all of the eight major traffic junctions. But the flow of buses is comparatively less in Fakirkua–Bus stand, Keranitola–Dharma and Keranitola–Station roads. It may be due to more frequency of autos and rickshaws on these roads. Frequencies of vehicles are different in working and non-working days; except some individual cases, frequencies of vehicles are more on working days than on non-working days.

Table 2: *Road Traffic Injuries Chart of the Study Area.*

Places	Year					Places	Year				
	2008	2009	2010	2011	2012		2008	2009	2010	2011	2012
Abash	-	-	1	1	-	Narayan Bridge	1	-	-	-	-
Amtalaghat	-	-	-	1	-	Natun bazar Town	1	-	-	-	-
Ashokenagar	-	-	1	1	-	Near Aliganj Bus Stop	-	-	1	-	-
Bakulkunja, Mirzabazar	-	-	-	1	-	Near Birla Cotton Mill	-	-	-	1	-
Battolachak	-	-	1	3	-	Near Central Lodge	-	-	-	1	-
Birendusetu Bridge	1	-	-	-	-	Near Midnapore Jail	-	-	-	-	1
Central Bus Stand	-	-	-	-	1	Near Natun Basti	-	-	-	-	1
Collectorate	-	-	-	1	1	Near Nirmal Hriday Ashram	-	-	1	-	-
Colonelgola	1	1	-	2	1	Near Palko Automobile	-	-	-	1	-
Dewanbabarchak	-	-	-	1	-	Near RKM School	-	-	1	-	-
Dharma	5	3	2	4	-	NH-60 near Binapani Hotel	-	-	1	-	-
Fakirkuya	-	-	-	1	-	Nh-60 Dharma	1	3	-	1	1
FCI Godown	-	-	1	-	-	Nh-60 Giridharichak	1	-	1	-	-
Places	**Year**					**Places**	**Year**				
	2008	**2009**	**2010**	**2011**	**2012**		**2008**	**2009**	**2010**	**2011**	**2012**
Gandhighat More	1	1	-	1	-	NH-60 Hosnabad	-	1	-	1	-
Giridhari Chak	-	-	1	-	-	NH-60 in front of Weigh Bridge	-	1	-	-	-
Golkua Chak	-	1	2	1	-	NH-60 Mantu Hotel	-	1	-	-	-
Homeopathy College Compound	-	-	1	-	-	NH-60 Mohonpur Bridge	1	1	-	-	-
Hosnabad	-	2	1	3	1	NH-60 Parul Petrol Pump	1	-	-	2	-
Hospital Road	-	-	1	-	-	Nilu Bagan	-	-	-	1	-
Jagannath Mandir	3	3	3	1	-	Nimtala Chak	-	-	1	-	-
Judgecourt Road	-	1	1	1	-	Pitch Road	-	2	-	-	-
Kashai Bridge	-	-	1	-	-	Rabindranagar	-	-	-	-	1
Keranichati	-	1	-	-	-	Rangamati	-	-	-	1	1
Keranitola	2	2	-	4	-	Rangamati Fly Over	-	-	1	1	1
Khudiram More	2	1	-	-	-	Rangamati ITI College	-	-	-	-	1
Kolonelgola	-	-	1	-	-	School Bazar Chak	-	-	1	-	-
Kuikota	1	1	1	-	-	Sepoybazar	5	2	1	3	1
LIC More	-	1	-	-	-	Talkui	-	1	-	-	-
Midnapore College Gate	-	-	1	-	-	Tantigeria	1	-	1	-	-
Mohanpur Bridge	-	-	2	1	-	Zilla Parisad Main Gate	-	-	1	-	-
Najarganj	-	-	-	1	-	Total Accidents	28	30	33	42	12

Nowadays the rate of road traffic injuries (RTIs) increases in town areas (Figures 6 and 7) according to the RTI data during the year of 2008 to up to Feb 2012. The road accidents occurred mainly in main roads and at traffic conjunction in a high traffic pressure area. Some of the accidents occurred in the conjunction of main roads and NH 60. Rest of the accidents occurred in local streets near major roads; accidents occurred at one time and somewhere in other areas they occurred at multiple times. The accident locations classified in five classes based on number of accidents are shown in Figure 10. Green color indicates single number of accidents which occurred in Amtalaghat, Mirzabazar, Bus Stand, Fakirkuya, Hospital Road, Keranichati, Colonelgola, LIC More, Natun Bazaar, Nimtalachak, Rabindranagar, etc., areas; yellow indicates two to four numbers of accidents which occurred in Abash, Ashoknagar, Battalachak, Collectorate, Golkuachak, Judgecourt, Khudiram More, Kuikota, Tantigaria, Rangamatietc areas; blue indicates five to seven numbers of accidents which occurred in Colonelgola, Hosnabad on NH 60 and Dharma on NH 60; pink indicates eight to ten numbers of accidents which occurred in Jagannath Mandir, Keranichati; and red indicates highest number of accidents which occurred in Sepoybazar (12) and Dharma (14).

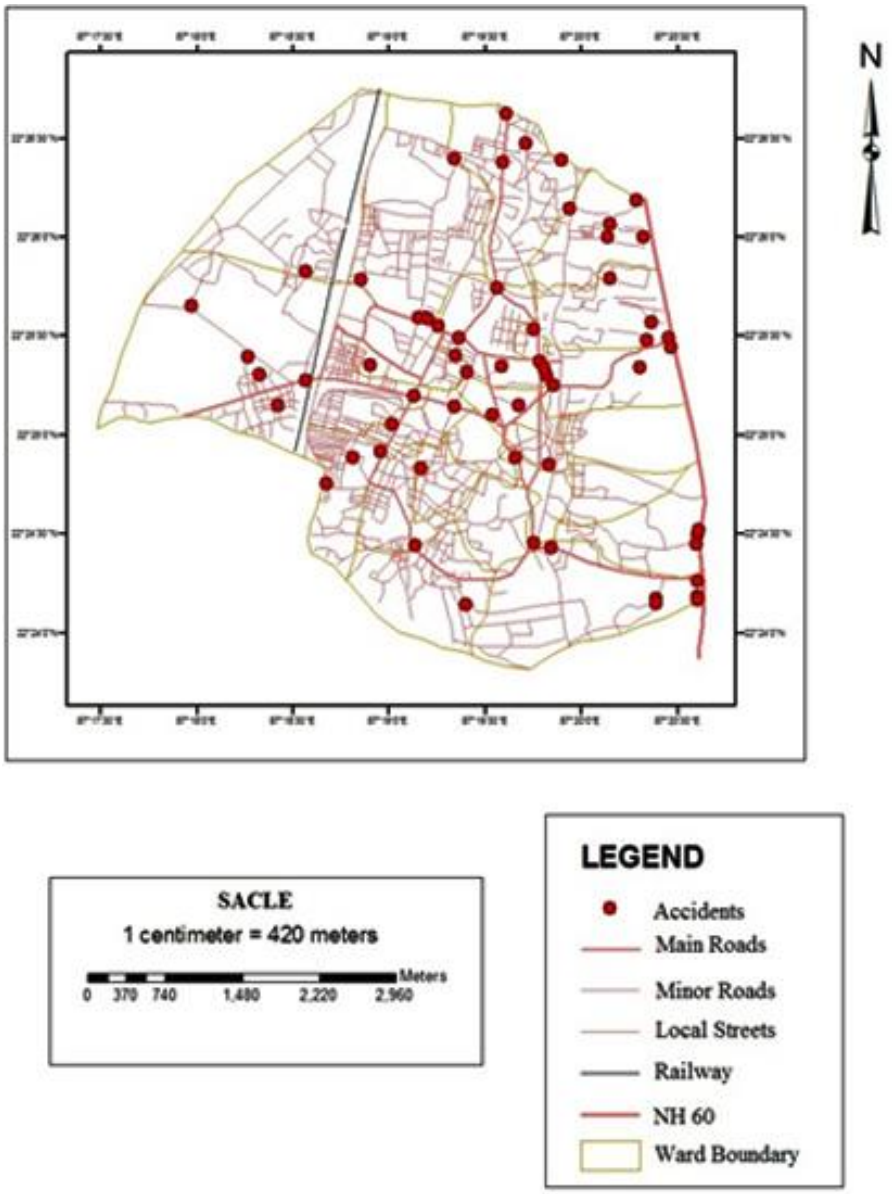


Fig. 6: *Road Traffic Injuries.*

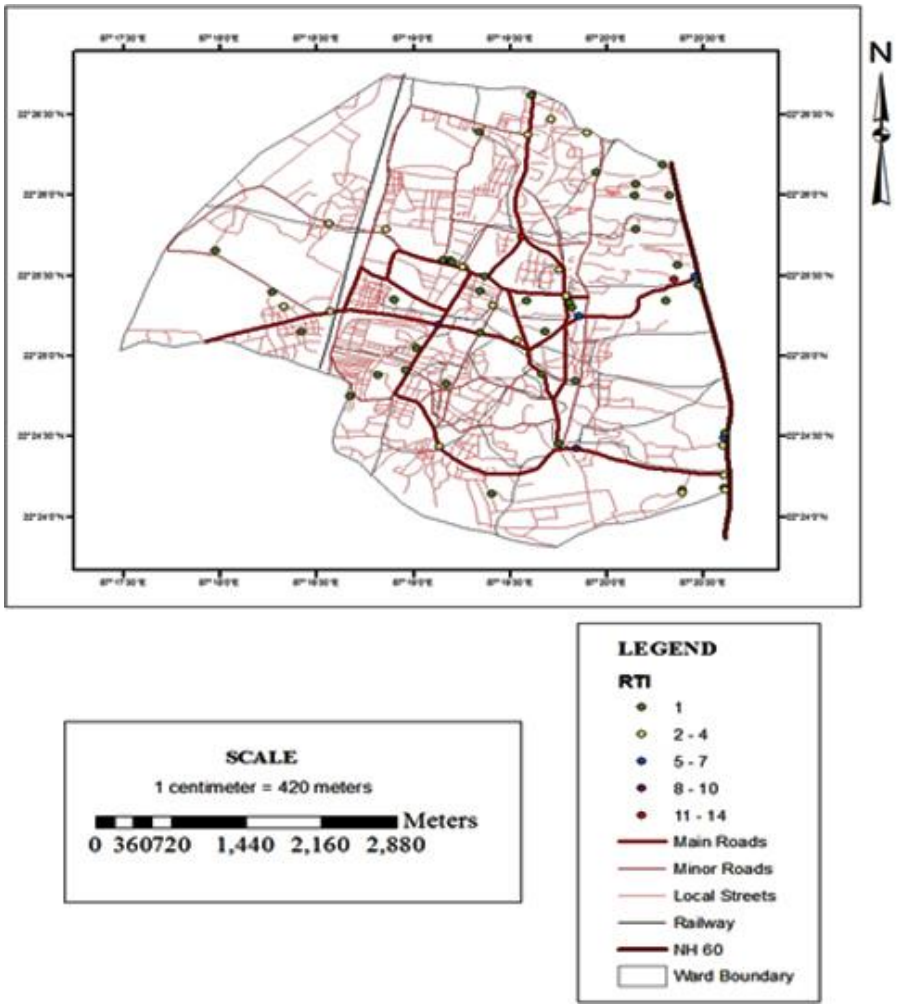


Fig. 7: *Road Traffic Injuries Rate Map.*

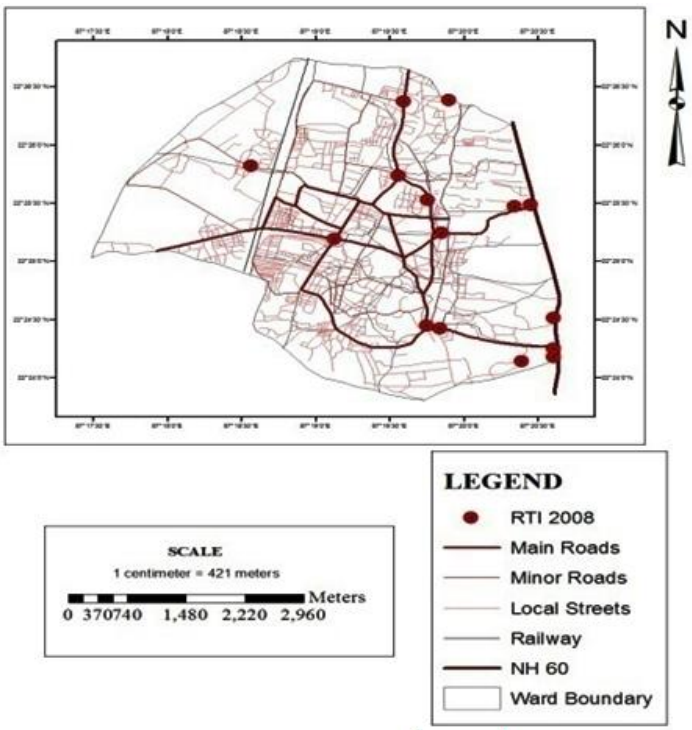


Fig. 8: *RTI Location Map (2008).*

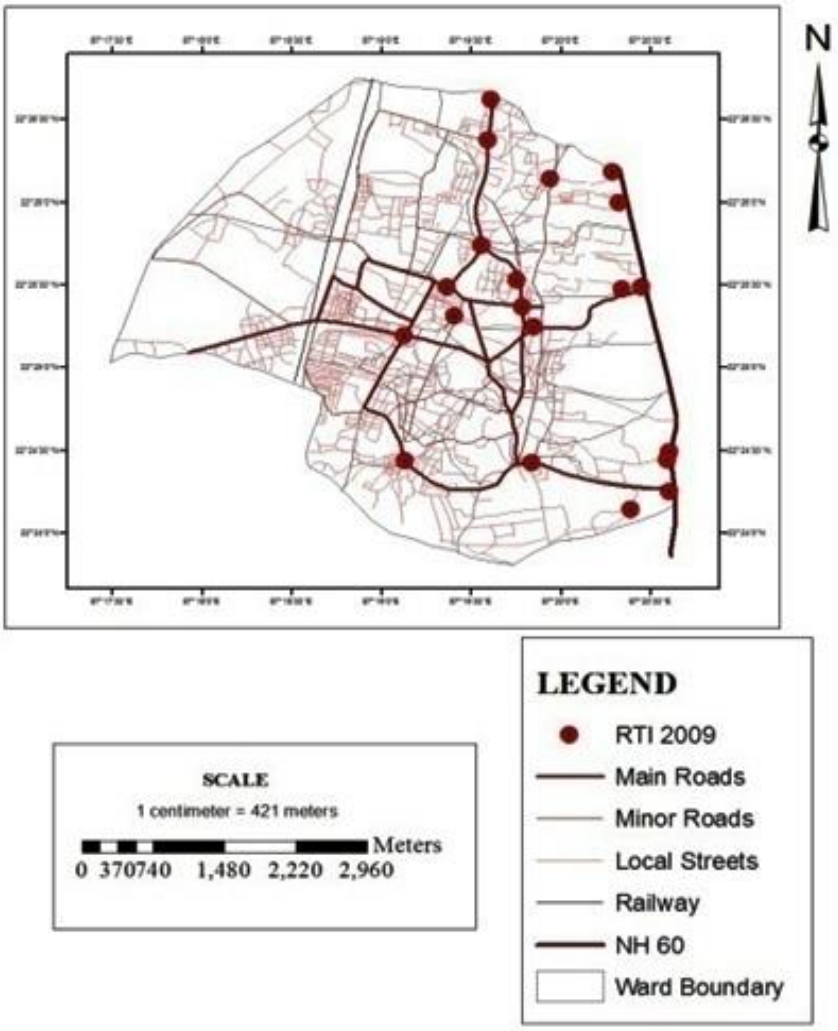


Fig. 9: *RTI Location Map (2009).*

It is always observed that somewhere accident occurred at one time and somewhere in another area it occurred at multiple times. The accident locations are classified in five classes based on number of accidents (Figure 10).

Green color indicates single number of accident which occurred in Amtalaghat, Mirzabazar, Bus Stand, Fakirkuya, Hospital Road, Keranichati, Colonelgola, LIC More, Natun Bazaar, Nimtalachak, Rabindranagar, etc., areas; yellow indicates two to four numbers of accidents which occurred in Abash, Ashoknagar, Battalachak, Collectorate, Golkuachak, Judgecourt, Khudiram More, Kuikota, Tantigaria, Rangamatietc areas; blue indicates five to seven numbers of accidents which occurred in Colonelgola, Hosnabad on NH 60 and Dharma on NH 60; Pink indicates eight to ten numbers of accidents which occurred in Jagannath Mandir, Keranichati; and red indicates highest numbers of accidents which occurred in Sepoybazar (12) and Dharma (14).

Nowadays the rate of road traffic injuries (RTIs) increases in town areas (Figures 6 and 7) according to the RTI data during the year 2008 up to Feb 2012. The road accidents occurred mainly in main roads and at traffic conjunctions in a high-traffic-pressure areas. Some of the accidents occurred in the conjunction of main roads and NH 60. Rest of the accidents occurred in local streets near major roads.

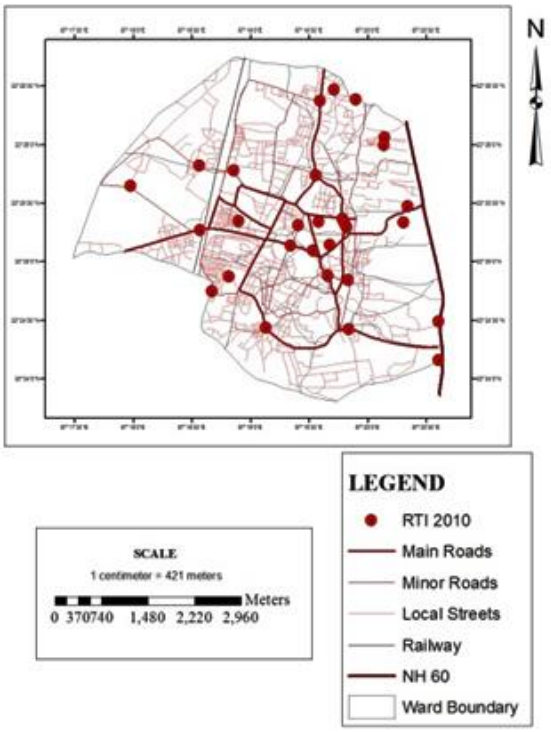


Fig. 10: *RTI Location Map.*

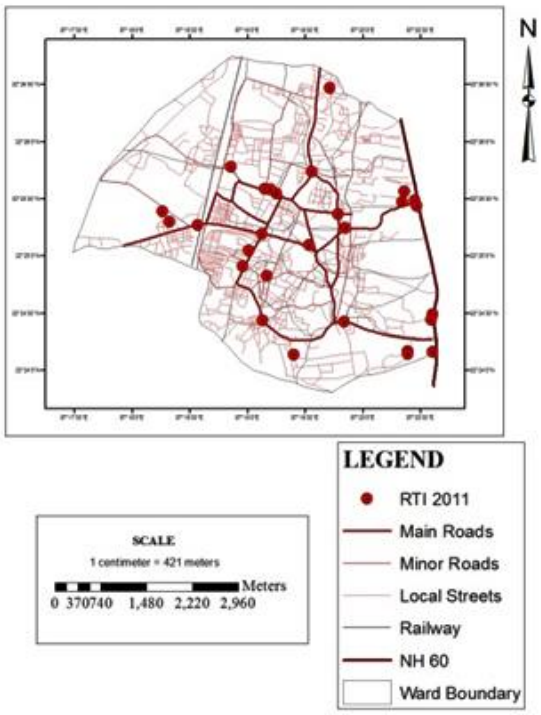


Fig. 11: *RTI Location Map.*

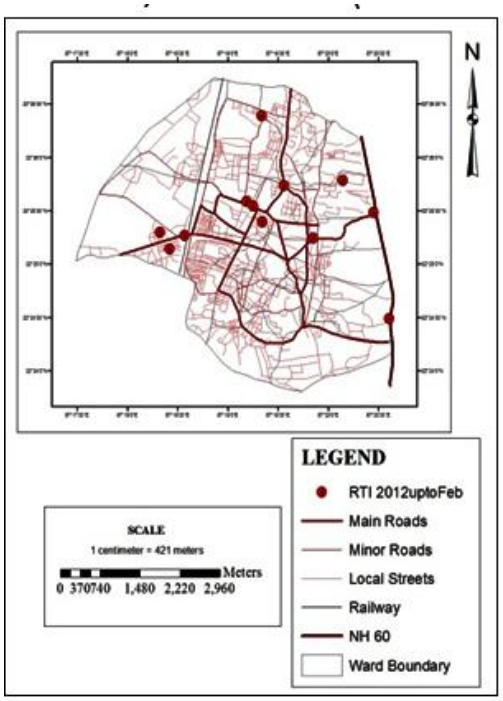


Fig. 12: *RTI Location Map up to Feb.*

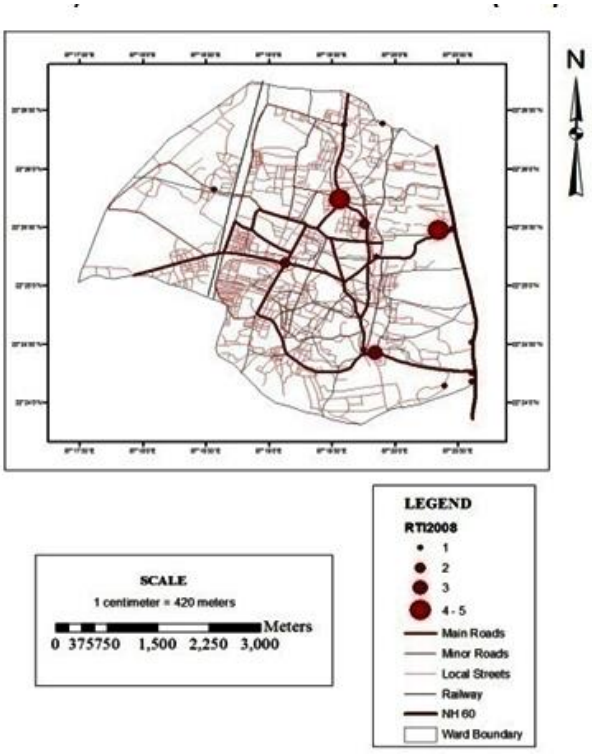


Fig. 13: *Road Traffic Injuries Rate Map (2008)*

The RTI location of five years is indicated with five different colors (Figures 8–12 and Table 2). In 2008, road accidents occurred in 15 places (i.e., Colonelgola, Dharma, Jagannath Mandir, Keranotola, Khudiram More, Kuikota, Sepoybazar, etc.) whereas road accidents occurred in 20 places in 2009 (Colonelgola, Dharma, Golkuachak, Judgescourt, Jagannath Mandir, Keranitala, Kuikota, etc.). But road accidents occurred in

29 places (Abash, Dharma, Golkuachak, Kuikota, Tantigaria, Sepoybazar, Nimtalachak, etc.) in 2010. Again, road accidents occurred in 28 places in 2011 (Abash, Ashoknagar, Battalarchak, Dharma, Keranitala, Sepoybazar, Rangamati, etc.) and just within two months in 2012, road accidents occurred in 12 places (Bus Stand, Collectorate, Colonelgola, Dharma, Sepoybazar, Natunbasti, Rangamati, Rabindranagar, etc.) in Midnapore municipality area.

So it can be inferred that road accident-prone locations increase every year. But in Jagannath Mandir, Dharma and Sepoybazar accidents occurred in last four years and Sepoybazar is the only place of Midnapore municipality area, where accidents occurred every year (2008–2012 up to Feb.). So, Sepoybazar is a very-high accident-prone area in Midnapore municipality. By the analysis of five RTI rate maps, i.e., Figures 13–17, it is clear that road accident rates are different in different locations in each year. It represents different classes of graduated shapes. In the year 2008, four classes are used. First class showing single accident which includes 10 places, i.e., Kolonelgola, Kuikota, Natun Bazar, etc., second class showing double accidents which includes Keranitala and Khudiram More; third class showing three accidents which include only Jagannath Mandir area and the final class showing four or five numbers of accidents in Dharma and Sepoybazar area.

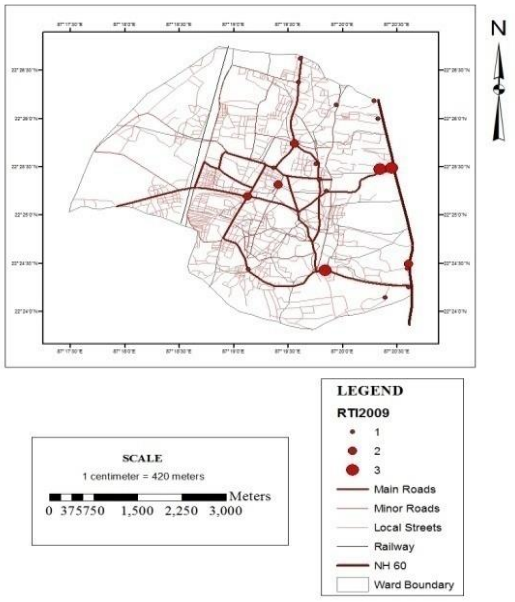


Fig. 14: *Road Traffic Injuries Rate Map (2009).*

In the year 2009, three classes are used. First class showing single accident which includes 13 places, i.e., Kolonelgola, Kuikota, LIC More, etc., second class showing double accidents which includes four places, i.e., Keranitala, Sepoybazar, etc., and the final class showing three accidents which include three places, i.e., NH-60 near Dharma and Jagannath Mandir area. Three classes are used in year 2010 – first class showing single accident which includes 24 places (Abash, Kuikota, Sepoybazar, etc.); second class showing double accidents which includes Mohonpur Bridge, Golkuachak and Dharma and the final class showing three accidents which include only Jagannath Mandir area.

In year 2011, four classes are used – first class showing single accident which includes 22 places (Collectorate, Kuikota, Rangamati, etc.); second class showing double accidents which includes only Kolonalgola; third class showing three accidents which includes Hosnabad near NH-60, Battaltchak and Sepoybazar and the final class showing four accidents in Dharma and Keranitala area. In year 2012 within two months, 12 accidents occurred in 12 different locations (Bus Stand, Colonelgola, Collectorate, Sepoybazar, etc.) in Midnapore municipality area. So, the rate of accidents was high in Dharma, Keranitola, Jagannath Mandir, Sepoybazar and NH-60 near Dharma area.

The number of total road accidents in the years 2008, 2009, 2010 and 2011 are 28, 30, 33 and 42 respectively. So, the rate of road accidents has a positive increasing trend. The bar of the year 2012 represent only 12 road accidents; but this is only first two months accident data. So, it is possible to increase number of accidents and has a chance to cross highest number (of accident of year 2011) at the end of the year.

The pie graph (Figure 19) shows percentage (%) of total road accidents; for year 2008, 2009, 2010 and 2011 these are 19.31, 20.69, 22.76 and 28.96% respectively. From the chart, year-wise RTI increasing rate can be identified. From year 2008 and 2009 it is + 1.38%; for years 2009 and 2010 it is + 2.07%; whereas in the years 2010 and 2011 it is + 6.20%.

So, the trend of year-wise road accidents is positive and it increases faster than in the previous year. Within two months of 2012, 8.28% of road accidents occurred. So, it has possibility to positive relation in percent of accidents in the years 2011, 2012 and at the end of the year 2012.

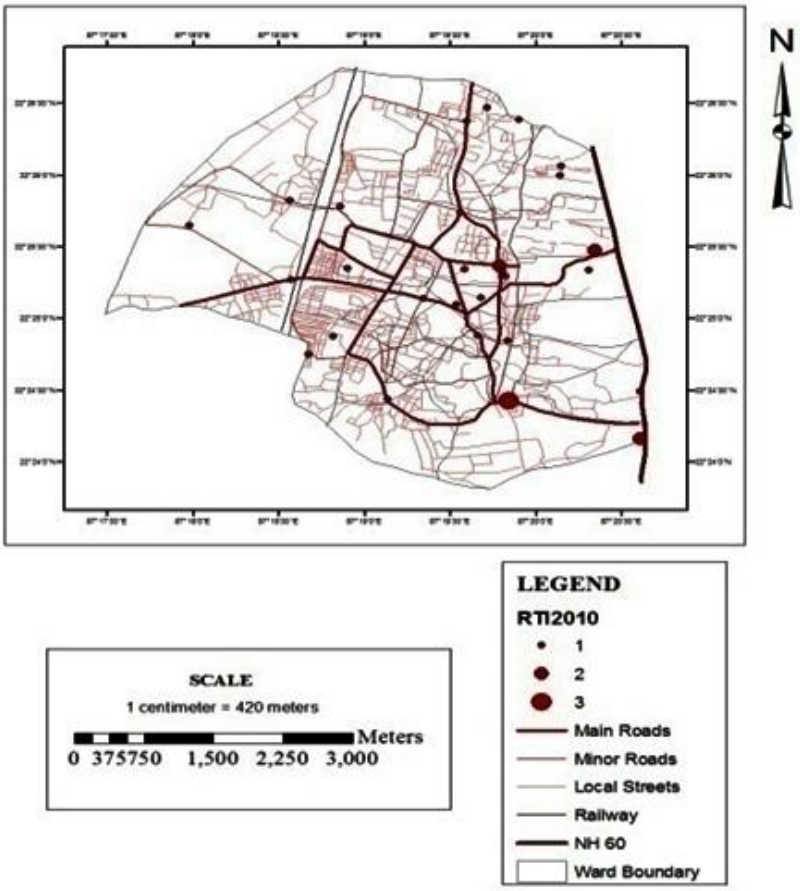


Fig. 15: *Road Traffic Injuries Rate Map (2010).*

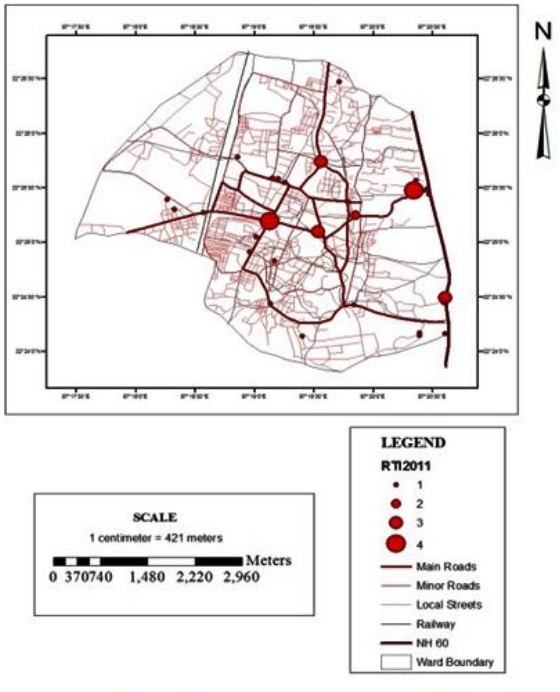


Fig. 16: *Road Traffic Injuries Rate Map (2011).*

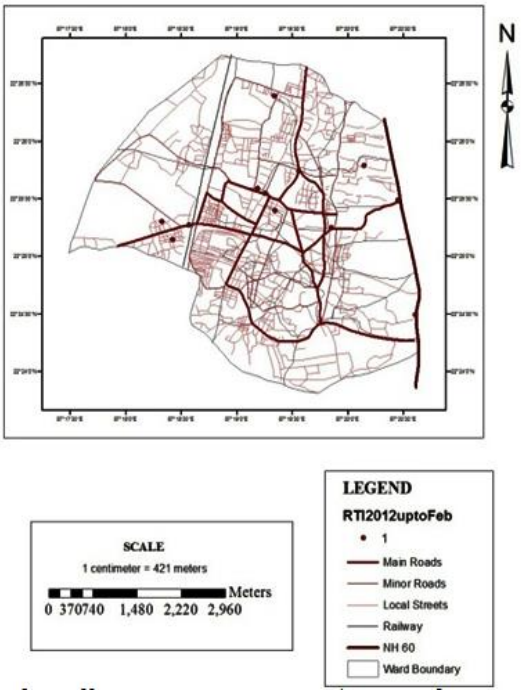


Fig. 17: *Road Traffic Injuries Rate Map (up to Feb 2012).*

Death Rate and Injuries Rate Analysis

This data is processed to extract indicators and to associate results to the nearest road segments by calculating aggregate statistics as indicated in the preceding years. The attributes of interest where the number of deaths and the number of injured persons in the accidents is attached. Two indicators are calculated from the "A" number of accidents, which are associated to a specific road segment by the above-illustrated nearest-neighbor procedures.

The death rate (DR): DR = (D/A)*100 …
where, D is the number of deaths, A is the number of accidents.
Injury rate (IR): IR = (I/A)*100 …
where, I is the number of injured persons, A is the number of accidents.

Table 3: *Road Accident and Death Data of The Study Area.*

Year	A (total accidents)	D (total deaths)	I (total injuries)	DR ( )	IR ( )
2008	28	11	49	39.29	175.00
2009	30	10	29	33.33	96.67
2010	33	14	37	42.42	112.12
2011	42	13	109	30.95	259.52
2012 up to Feb.	12	1	12	8.33	100.00

The accident and death rate can be seen by the analysis of graph and table (FIG-20 & TABLE-III). From the graph it can be clear that rate of accident is much more than rate of deaths in every year. But rate of injuries and rate of death has different trends.

Rate of death lies in between 30 and 45 (year 2008 to 2011) and it is the highest in the year 2010. Within two months of year 2012, the rate of death is 8.33. Rate of accident lies between 95 and 260 (year 2008 to 2011). Accident rate is highest in year 2011 (259.52) and it has an increasing trend. Within two months of 2012, the rate of injuries is 100.

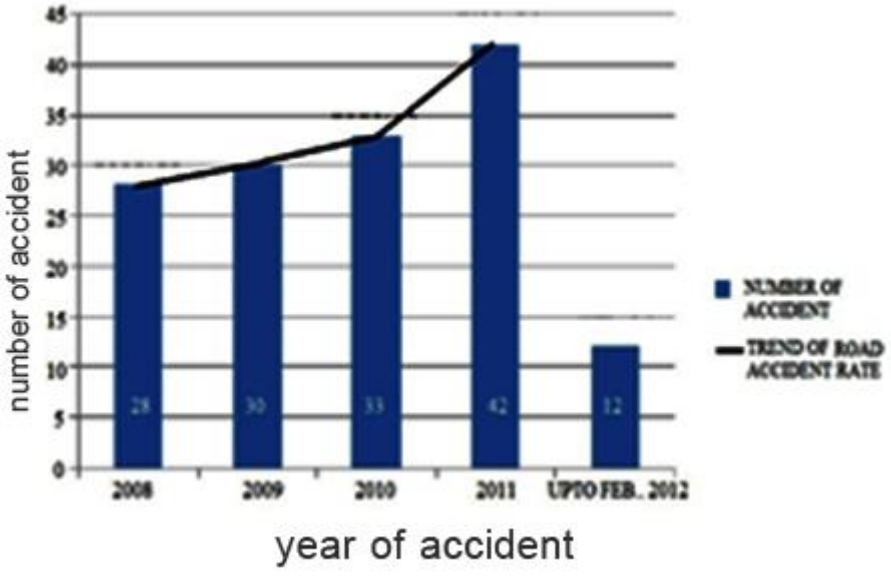


Fig. 18: *Number of Road Accidents (Year-wise).*

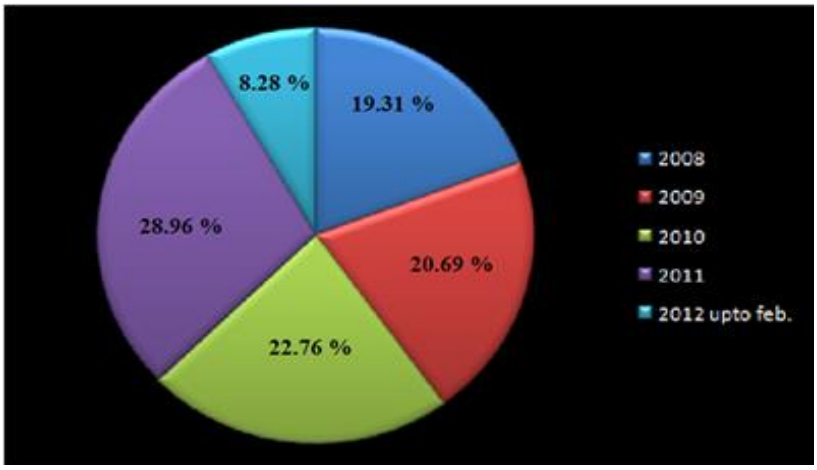


Fig. 19: *Percentage of Road Accidents.*

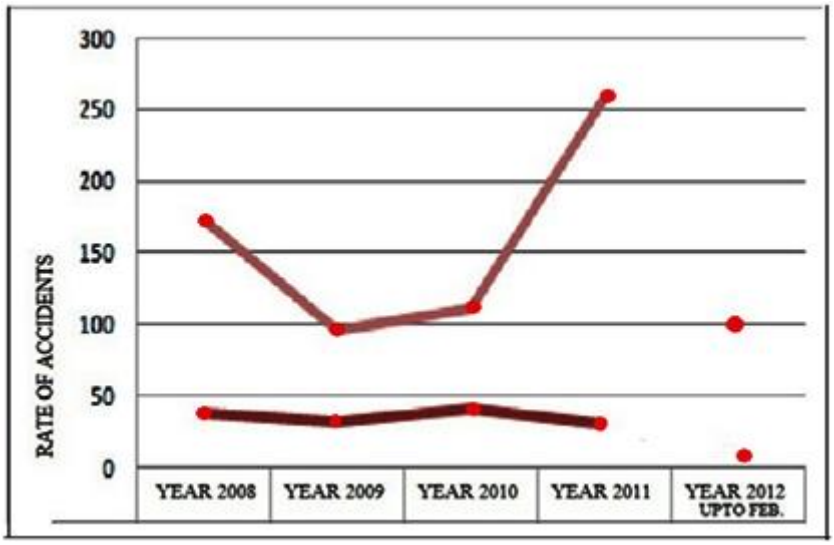


Fig. 20: *Rate of Death and Injuries (Year-wise).*

Overlay Analysis

All vector layers are converted to raster ("Feature to Raster" tool from Arc GIS 9.3) with attribute tables and then overlay ("Weighted Overlay" tool from Arc GIS 9.3) with LU/LC map. Then accident density map (Figure 22) is prepared using models in Arc GIS 9.3.

Two classes of accident-prone zones are identified through the overlay analysis (Figure 21) using road widths and accident values of different locations over land use/land cover map. The red indicates less accident-prone zones and black indicates high accident-prone zones. From the map, 10 major and seven minor accident-prone zones are observed. The major accident-prone zone concentrated to center and minor accident-prone zones are distributed near border of the Midnapore municipality area.

Density Analysis

Kernel-density method is applied in identifying accident prone locations by 'Density Tool' in Arc GIS 9.3 [6].

By applying Kernel-density method (it calculates points or lines that fall within the search size are summed and then divided by lying near the center of a raster cell's search size are weighted more heavily than those lying near the edge) in identifying accident-prone locations in Midnapore municipality area (Figure 22), three accidents prone zone are observed. This result shows highest concentration of a particular type of accidents and is useful for looking at patterns rather than at locations of individual features.

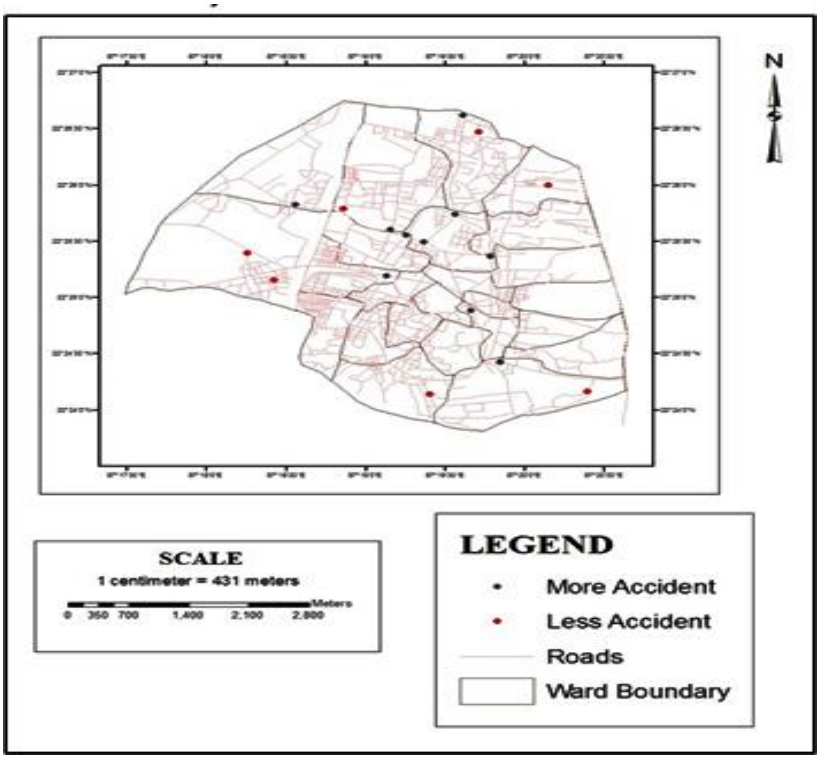


Fig. 21: *Overlay Analysis.*

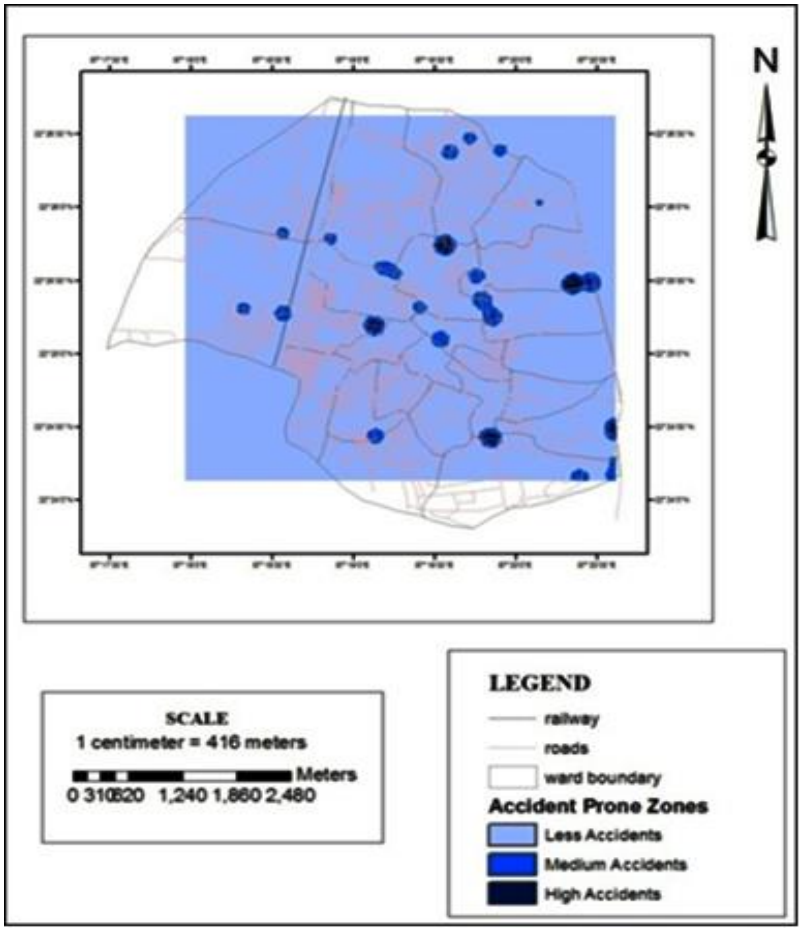


Fig. 22: *Accident Density Map.*

CONCLUSIONS

Decreasing of RTIs (road traffic injuries) depends largely on optimum spatial interaction through easy and accessible transportation mode.

This result shows highest concentration of a particular type of accidents and is useful for looking at patterns rather than at locations of individual features. This work give an insight into the present scenario of the traffic conditions, road width, land use/land cover of the area and shows the most accident-prone roads. In future, accidents can be reduced by eliminating unsafe conditions and reducing unsafe acts. This work will give an insight into the traffic scenario and will give planners and traffic authorities some breathing space when considering long term objectives and likely solutions of the problem.

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