

Application of GIS in hazardous road location (HRL) identification

H.M. Ahsan, Md. S. Newaz, A.K.M.S. Alam & M. Alam

Bangladesh University of Engineering and Technology, Dhaka 1000, Bangladesh

ABSTRACT: According to the transportation sector, 'Road Traffic Accident' is the most concerning issue in Bangladesh. Here, the road safety situation is very severe with approximately 169 fatalities per ten thousand motor vehicles, which is highest in the world. In order to decrease accident rate, traffic accident analysis should be carried out to determine which section of a road is faulty, in other words a hazardous location. This paper presents a method by which the accident-prone locations on roads, commonly termed as Hazardous Road Locations (HRL), can be identified. The methodology incorporates a model which identifies most accident occurrence locations, followed by analysis using GIS. In this study two most hazardous national highways, Dhaka to Chittagong (N1) and Dhaka to Sylhet (N2) are chosen as survey areas. Analysis has also been done for vehicle types and also for collision types. The entire map which is found by analysis has been presented in the paper. This method of identification of hazardous road locations can be used for all other national highways in Bangladesh.

1 INTRODUCTION

Bangladesh is a very densely populated low-lying country with 123 million inhabitants living in an area of 1,47,570 sq. km i.e. 833 inhabitants per sq. km. Dhaka, the capital city of Bangladesh, have a population of over 10 million with a growth rate of 8% per annum. To cater to the growing demand of road transport, the major road network (national highways, regional roads and feeder roads) increased from 14,949 km to 21,174 km in 2000. The statistics reveals that Bangladesh has one of the highest fatality rate in road accidents higher than 73 deaths per 10,000 registered motor vehicles every year. The principal contributing factors of accidents are adverse roadway roadside environment, poor detailed design of junctions and road sections, excessive speeding, overloading, dangerous overtaking, reckless driving, carelessness of road users, failure to obey mandatory traffic regulations, variety of vehicle characteristics and defects in vehicles and conflicting use of roads. There is urgent need and scope for improving the road safety situation and for that there is obviously need for much efforts and investment in safety measures to reverse the trend.

In this paper, an attempt is made to implement the GIS based accident analysis system to locate the accident prone locations on roads and thus help in identifying the required remedial measures. Specifically this involves plotting individual accident locations, identifying accident-prone areas using GIS's spatial analysis tools, and representing a diagnosis of accident characteristics by different types at these high accident locations. It is very important to determine the factors that contribute to accidents at these spots and to take action that will reduce crash frequency or severity. Here, accident data is collected from Accident Research Institute (ARI), BUET. The specific objectives of this study are to determine the HRL on N1 and N2 using GIS and to recommend some important measures for improvement of HRL.

2 HAZARDOUS ROAD LOCATION (HRL)

2.1 Definition

Most operational definitions of hazardous road locations were found in terms of the recorded number of accidents. In our country, hazardous road locations are identified as sites that have significantly more accidents and the period used to identify hazardous road locations varied between 1 to 5 years.

2.2 Methods of Identifying the HRL

2.2.1 Method 1

The minimum section length was 0.1 Km with greatest length of 0.3 Km where there were 3 or more fatal accidents in the period of five years (1999-2003), were considered as hazardous locations. This takes no account of exposure data. Under this method, a total of 310 hazardous road locations have been identified in the national highway network in Bangladesh.

2.2.2 Method 2

The minimum section length was 0.1 Km with greatest length of 0.5 Km where there were 3 or more fatal accidents in the period of five years, were considered as hazardous locations. This also takes no account of exposure data. Under this Method, a total of 346 hazardous road locations have been identified in the national highway network in Bangladesh.

2.2.3 Method 3

The minimum section length was 0.1 Km with greatest length of 0.5 Km where there were 3 or more fatal accidents in the period of five years were considered as hazardous locations. Upon further analysis, adjacent locations (within 3 km) with fairly high number of accidents and consistent geometric features were aggregated to one hazardous location. A total of 279 hazardous road locations have been identified in the national highway network in Bangladesh

In this paper method 3 has been used to identify the HRL on N1 and N2 highway.

3 ACCIDENT DATA AND ANALYSIS

3.1 HRL on N2 and N1 Highway

The route of Dhaka Sylhet National Highway (N2) is Katchpur - Bhulta - Sarai - Jagadishpur - Shaistaganj - Mirpur - Sherpur - Sylhet – Jaintapur – Jaflong and its length is 284.9 Km. The length of this Dhaka to Sylhet highway is 276 km. The route of Dhaka Chittagong National Highway (N1) is Dhaka – Katchpur – Modanpur – Mainamati – Comilla – Fani – Chittagong – Manashertek – Satkania – Ramu – Cox’s Bazar – Teknaf and its total length is 320.6 Km. The length of the highway from Dhaka to Chittagong is 264 Km.

The precious location of an accident is a pre-requisite and leads to the identification of all hazardous locations on the road network. Here Fig. 1 & 3 shows the accident locations on N2 & N1 highway respectively from the year 2007 - 2009. And also Fig. 2 & 4 shows the location of fatal accident from the year 2007 - 2009. From above analysis, those figures shows the total and fatal accident scenario on N2 & N1 highway and from this, we found three most vulnerable road section in N2 and three most vulnerable road section in N1. The detailed accident scenario of those locations is discussed below. The segment 1, 2, 3 are at KM Post 50.0 – 53.8 (Police Line Intersection to Kararchar High School), KM Post 85.1 - 88.1 (Culvert 5/1to Beratala Market) and KM Post 92.0 – 94.1 (Ashuganj Rice Mill to BRAC office) respectively on N2. And the segment 1, 2, 3 are at KM Post 11.0 – 12.8 (Azimuddin Ahmed Petrol Pump to Kachpur Bridge), KM Post 40.0 – 43.0 (Gomoti Bridge to Daudkandi 1) and KM Post 207.1 – 210.0 (Latifia Madrasa High School to Barotakia Bazar) respectively on N1.

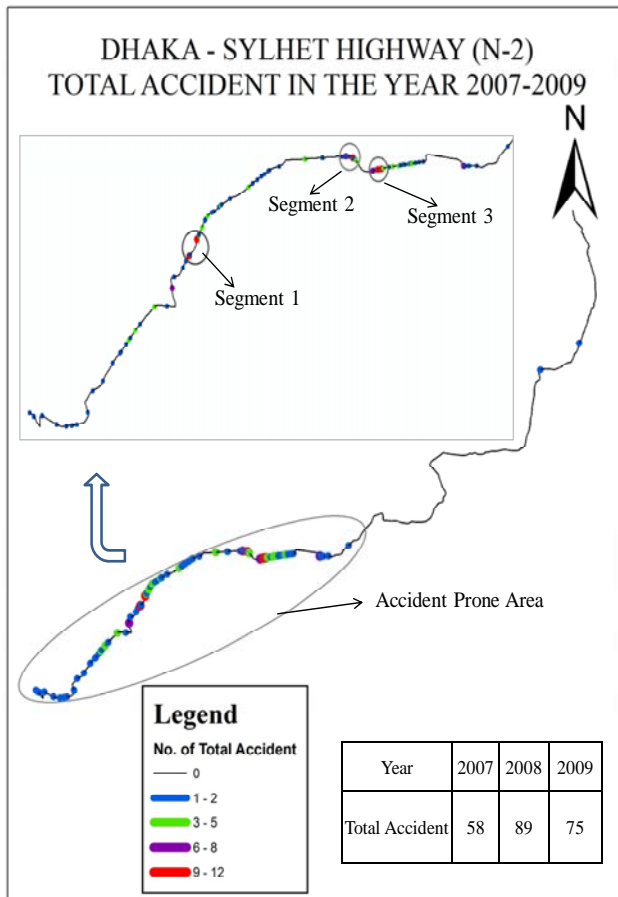


Fig. 1: Total accident location on Dhaka – Sylhet highway

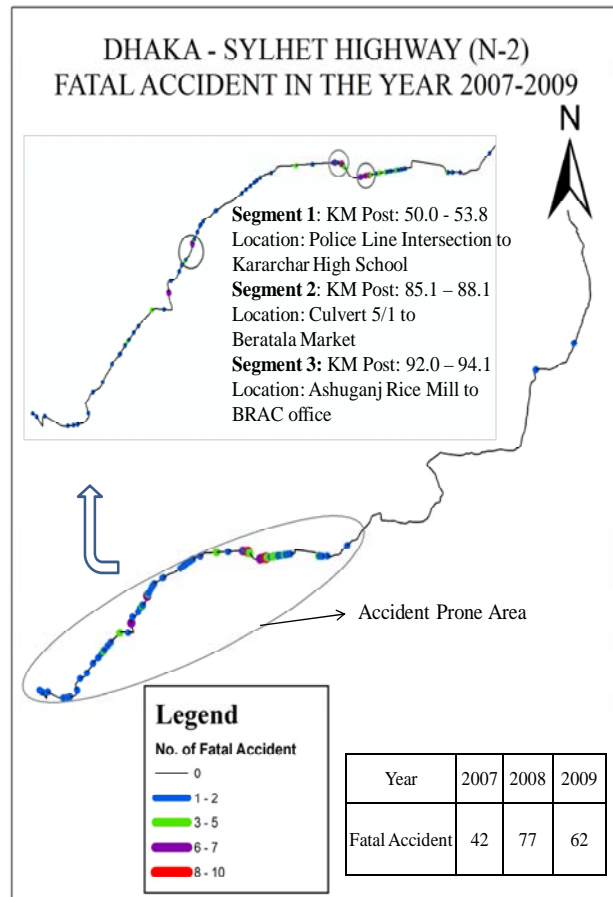


Fig. 2: Fatal accident location on Dhaka – Sylhet highway

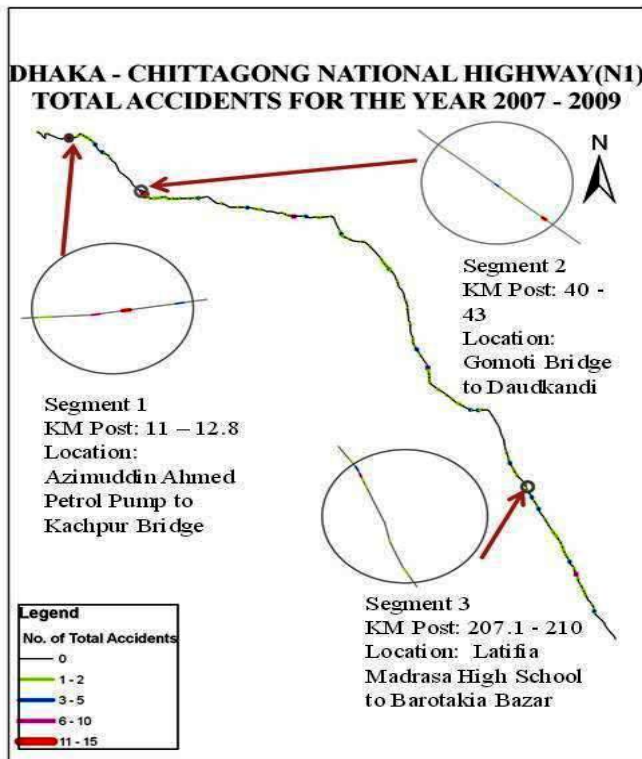


Fig. 3: Total accident location on Dhaka – Chittagong highway

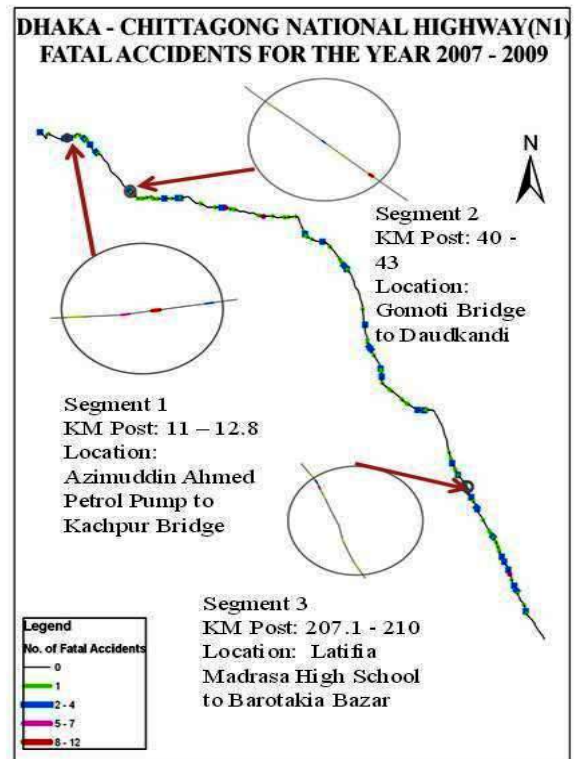


Fig. 4: Fatal accident location on Dhaka – Chittagong highway

3.1.1 Segment 1: From 50.0 km (Police Line Intersection) to 53.8 km (Kararchar Hugh School)

Table 1 indicates that the involvements of Bus (13) & Truck (7) in segment 1 are most dominating vehicles in accidents.

Table 1: Involved vehicle type at accident in segment 1

Vehicle Type								
KM Post	Bus	Truck	Micro Bus	Motor Cycle	Baby Taxi / Tempo	Pick up	Rickshaw / Push card	Other
50.0	7	2	0	1	0	1	1	0
50.2	0	1	1	0	0	0	0	0
52.8	1	0	0	0	0	0	1	0
53.0	4	2	1	1	0	0	1	1
53.7	0	2	0	1	0	1	0	1
53.8	1	0	0	0	0	0	0	0

Fig. 5 shows the comparison of total accident and fatal accident of segment 1. Table 2 shows that fatality is high at 50 km (11) and road geometry is almost straight. And table 4 locates that collision with pedestrian (12) is the most common collision at segment 1.

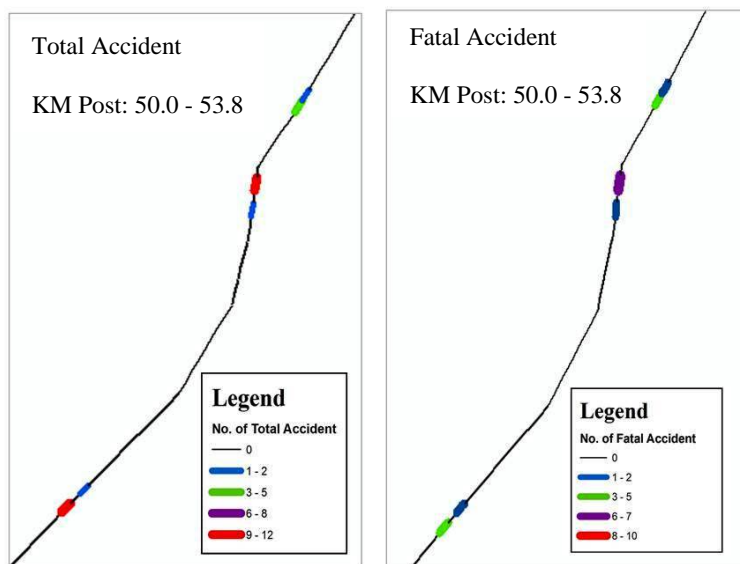


Fig. 5: No. of total and fatal accident at KM Post 50.0 – 53.8

Table 2: No. of fatality at accident in segment 1

No. of Fatality			
KM Post	2007	2008	2009
50.0	5	4	2
50.2	0	4	0
52.8	0	0	1
53.0	3	3	4
53.7	1	4	0
53.8	0	0	2

Table 3: Road geometry at segment 1

Road Geometry	
KM Post	Road Geometry Type
50.0	Straight
50.2	Straight
52.8	Straight
53.0	Straight & Slope
53.7	Straight
53.8	Straight

Table 4: Collision type of accident in segment 1

Collision Type							
KM Post	Head on	Rear End	Side Sway	Over turn	Parking Vehicle	Hit Pedestrian	Others
50.0	0	1	1	0	1	6	1
50.2	0	0	0	0	1	0	0
52.8	0	1	0	0	0	0	0
53.0	1	1	1	0	0	5	1
53.7	0	2	0	0	0	1	0
53.8	0	0	0	1	0	0	0

3.1.2 Segment 2: From 85.1 km (Culvert 5/1) to 88.1 km (Beratala Market)

Fig. 6 & 7 shows the total accident and fatal accident of segment 2 respectively.

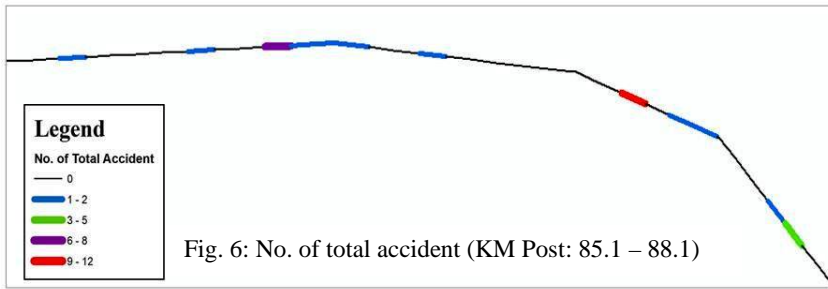


Fig. 6: No. of total accident (KM Post: 85.1 – 88.1)

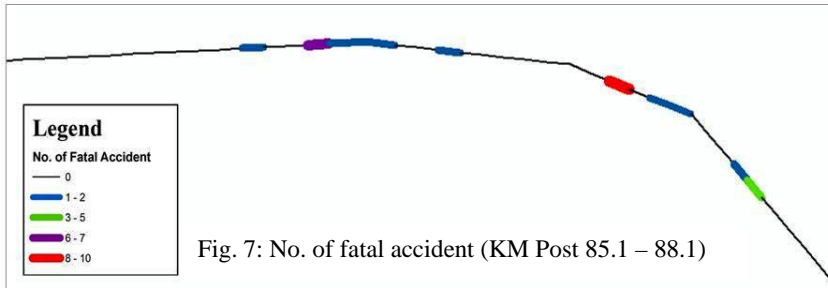


Fig. 7: No. of fatal accident (KM Post 85.1 – 88.1)

Table 5: No. of fatality at accident in segment 2

No. of Fatality			
KM Post	2007	2008	2009
85.1	0	0	0
85.6	0	0	2
85.9	4	6	0
86.0	3	0	0
86.1	0	1	0
86.2	1	0	1
86.5	1	0	0
87.3	4	5	3
87.5	0	0	1
87.6	0	0	4
88.0	0	0	3
88.1	1	2	0

Table 6 & 7 it's indicate that number of hit pedestrians (21) is very high and head on (3) and rear end (9) are also significant. Table 8 shows bus (13) & truck (9) involvement in the accident is very high.

Table 6: Collision type of accident in segment 2

Collision Type						
KM Post	Head on	Rear End	Over turn	Parking Vehicle	Hit Pedestrian	Others
85.1	0	0	0	0	0	1
85.6	1	0	0	0	1	0
85.9	1	3	1	0	3	0
86.0	0	1	1	0	1	0
86.1	0	0	0	0	1	0
86.2	0	0	1	0	1	0
86.5	0	1	0	0	0	0
87.3	0	3	0	0	8	0
87.5	0	0	0	0	1	0
87.6	1	1	0	0	0	0
88.0	0	0	0	0	2	0
88.1	0	0	0	0	3	0

Table 7: Road geometry at segment 2

Road Geometry	
KM Post	Road Geometry Type
85.1	Straight
85.6	Straight
85.9	Straight & Crest
86.0	Straight
86.1	Straight
86.2	Straight
86.5	Straight
87.3	Straight
87.5	Straight
87.6	Straight
88.0	Straight
88.1	Straight

Table 8: Involved vehicle type at accident in segment 2

Vehicle Type						
KM Post	Bus	Truck	Micro Bus	Car	Motor Cycle	Baby Taxi / Tempo
85.1	0	0	0	0	0	1
85.6	1	1	0	0	0	1
85.9	1	2	4	2	0	0
86.0	2	1	0	0	0	0
86.1	1	0	0	0	0	0
86.2	1	1	0	0	0	0
86.5	1	0	0	0	0	0
87.3	3	3	0	2	1	0
87.5	0	1	0	0	0	0
87.6	1	0	1	0	0	2

3.1.3 Segment 3: From 92.1 km (Ashuganj Rice Mill) to 94.1 km (BRAC office)

Fig. 8 & 9 shows the total accident and fatal accident of segment 3 respectively.

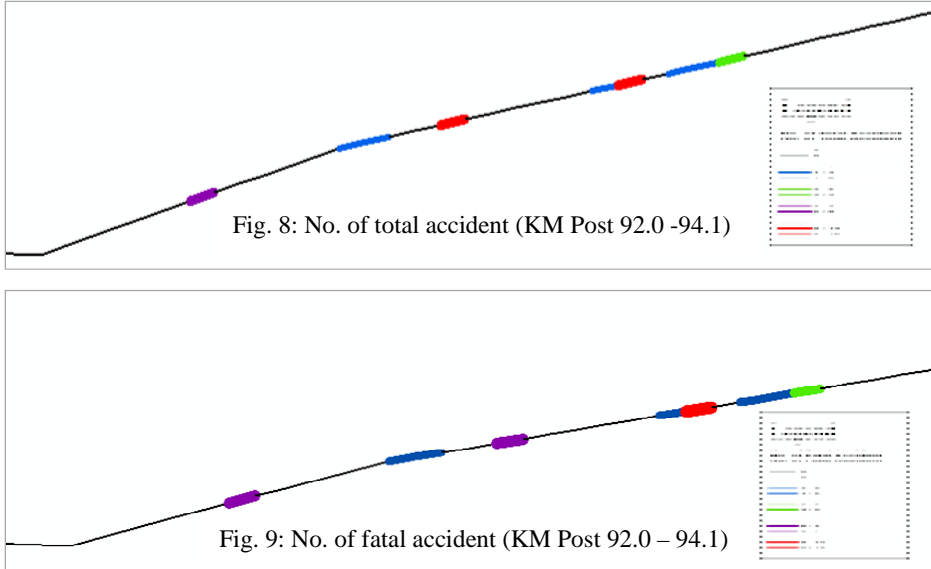


Table 9: No. of fatality at accident in segment 3

KM Post	No. of Fatality		
	2007	2008	2009
92.0	4	5	1
92.6	0	0	2
92.7	0	0	3
93.0	9	4	1
93.6	0	0	2
93.7	2	20	3
93.9	0	1	0
94.0	0	5	0
94.1	0	5	0

From Table 9 & 10, we find that fatality is high at 92.0 (10), 93.0 (14) & 94.1 (25) km and road geometry is almost straight. Table 11 & 12 indicates that number of hit pedestrians (14) is very high and rear end (10) is also significant. Bus and Truck involvements in the accident are very high.

Table 10: Collision type of accident in segment 3

KM Post	Collision Type						
	Head on	Rear End	Side Sway	Over turn	Object on Road	Parking Vehicle	Hit Pedestrian
92.0	0	1	1	0	1	0	4
92.6	0	0	0	0	0	0	1
92.7	0	1	0	0	0	0	0
93.0	0	5	0	2	1	1	2
93.6	0	0	1	0	0	0	0
93.7	2	3	0	2	0	0	4
93.9	0	0	0	0	0	0	1
94.0	1	0	0	0	0	0	1
94.1	1	0	0	1	0	0	1

Table 11: Involved vehicle type at accident in segment 3

KM Post	Vehicle Type						
	Bus	Truck	Micro Bus	Car	Motor Cycle	Baby Taxi / Tempo	Pick up
92.0	0	2	2	1	0	0	0
92.6	1	0	0	0	0	0	0
92.7	1	0	0	0	1	0	0
93.0	3	3	1	0	0	1	1
93.6	1	0	0	0	0	1	0
93.7	1	6	1	0	2	5	1
93.9	1	0	0	0	2	1	0
94.0	1	0	0	0	1	0	0
94.1	1	2	0	0	0	1	0

Table 12: Road geometry at segment 3

KM Post	Road Geometry
	Type
92.0	Straight & Crest
92.6	Straight
92.7	Straight
93.0	Straight & Curve
93.6	Straight
93.7	Straight
93.9	Straight
94.0	Straight
94.1	Straight

3.2 HRL on N1 Highway

3.2.1 Segment 1: From 11.0 km (Azimuddin Ahmed Petrol Pump) to 12.8 km (Kachpur Bridge)

Figure 10 and figure 11 show total and fatal accidents in segment 1 of Dhaka – Chittagong Highway (N1) respectively. On segment 1, from 11.0 km to 12.8 km, total number of accidents is 30 and the number of fatal accidents is 24. So, the fatal accidents are 80 percent of the total accidents. Table 13, shows that in year 2008, at km post 12.1, total number of death is 13, which is a significant one. Table 14 shows that most of the accidents occurs in straight portion of road. Table 15 shows that pedestrian collision is maximum among the causalities. Table 16 shows that involvement of Bus is the highest.

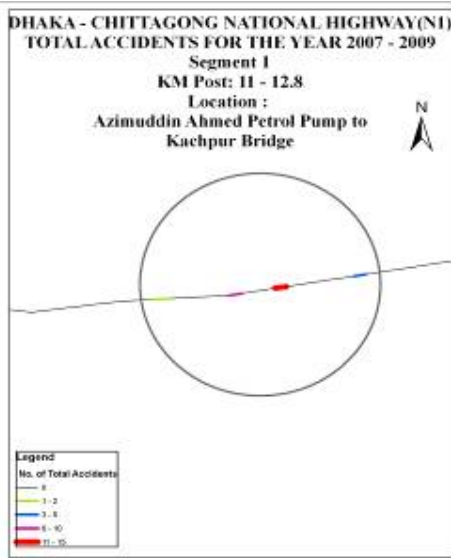


Fig 10: Total Accidents in Segment 1

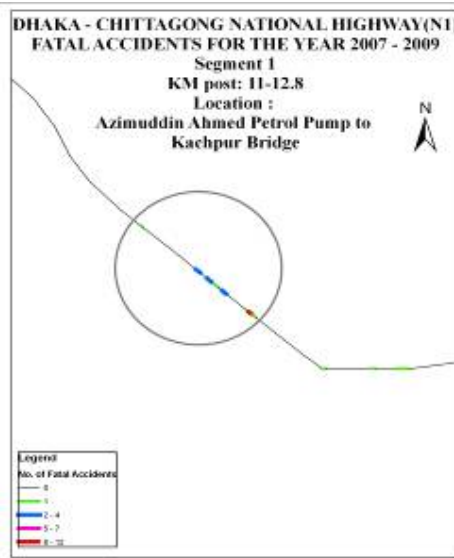


Fig 11: Fatal Accidents in Segment 1

Table 13: Total Number of Deaths in Segment

KM Post	2007	2008	2009
11.0	2	1	0
11.7	1	3	3
12.1	1	13	1
12.8	0	1	1

Table 14: Road Geometry in Segment 1

KM Post	Road Geometry Type
11.0	Straight
11.7	Straight
12.1	Straight
12.8	Straight

Table 15: Collision Type in Segment 1

KM Post	Head on	Rear End	Side Sway	Over turn	Object 2	Parking Vehicle	Hit Pedestrian
11.0	0	0	0	1	0	0	2
11.7	0	2	0	1	0	0	4
12.1	1	2	0	0	0	2	9
12.8	1	1	0	0	0	0	2

Table 16: Vehicle type in segment 1

KM Post	Vehicle Type							
	Bus	Truck	Micro Bus	Motor Cycle	Baby Taxi / Tempo	Pick up	Rickshaw / Push card	Car
11.0	2	0	0	0	0	0	0	0
11.7	2	0	0	0	0	0	0	1
12.1	7	2	2	0	0	0	0	2
12.8	1	1	0	1	0	0	0	0

3.2.2 Segment 2: From 40.0 km (Gomoti Bridge) to 43.0 km (Daudkandi)

Figure 12 and 13 show total and fatal accidents in segment 2 of Dhaka – Chittagong Highway (N1) respectively. It is also found that fatal accidents are 93 percent of the total accidents. Table 17 shows that in the year 2009, significant number of death is 12 on km post 42.9. From Table 18, it is found that in segment 2, most accidents occur in straight portion of road. Table 19 shows that pedestrian collision is maximum among the casualties. Table 20 shows that buses and trucks are the vehicle types involved in most of the accidents.

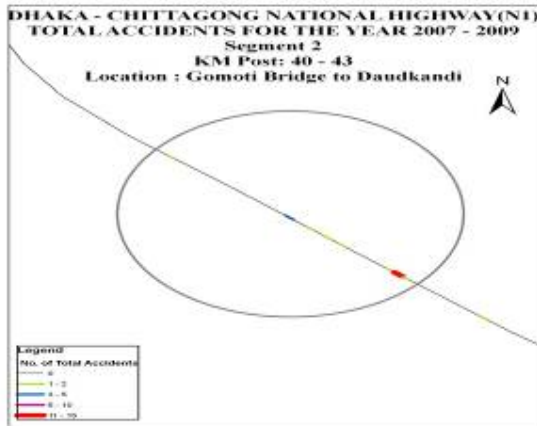


Fig 12: Total Accidents on Segment 2

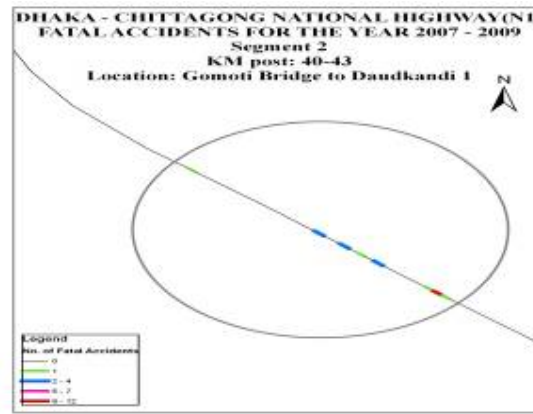


Fig 13: Fatal Accidents on Segment 2

Table 17: Number of Death on segment 2

KM Post	2007	2008	2009
40.0	1	0	0
41.5	0	4	0
41.8	3	0	0
42.0	0	1	0
42.2	0	0	2
42.8	0	0	1
42.9	0	3	12
43.0	2	0	0

Table 18: Road Geometry of accident spots on segment

KM Post	Road Geometry Type
40.0	Straight
41.5	Straight & Slope
41.8	Straight
42.0	Straight
42.2	Straight
42.8	Straight
42.9	Straight
43.0	Curve

Table 19: Collision Types of Accidents on segment

KM Post	Head on	Rear End	Over turn	Parking Vehicle	Hit Pedestrian	Others	Side Sway
40.0	0	0	0	0	1	0	0
41.5	0	0	0	0	4	0	0
41.8	1	0	0	0	0	0	0
42.0	0	0	0	0	1	0	0
42.2	0	0	0	0	2	0	0
42.8	0	0	1	0	0	0	0
42.9	3	0	0	0	0	1	1
43.0	1	0	0	0	0	0	0

Table 20: Vehicle Types of Accidents on segment 2

KM Post	Bus	Truck	Micro Bus	Motor Cycle	Baby Taxi / Tempo	Pick up	Rickshaw / Push card	Car
40.0	1	0	0	0	0	0	0	0
41.5	1	0	0	0	0	0	0	0
41.8	1	0	0	0	0	0	0	1
42.0	0	1	0	0	0	0	0	0
42.2	2	0	0	0	0	0	0	0
42.8	1	0	0	0	0	0	0	0
42.9	7	7	0	2	0	0	0	0
43.0	2	0	0	0	0	0	0	0

3.2.3 Segment 3: From 207.1 km (Latifia High School to 210.0 km (Barotakia Bazar)

Figure 14 & 15 show total and fatal accidents in segment 3. The total number of accidents in segment 3, from 207.1 km to 210 km, is 24 and fatal accidents is 20. Table 21 shows that most fatality occurs on the 207.4 km post in the year 2008. Table 22 shows that hit pedestrian is the main collision type. Table 23 shows that road geometry on the accident locations are straight and table 24 shows that buses, trucks and cars are involved in mostly in accidents.

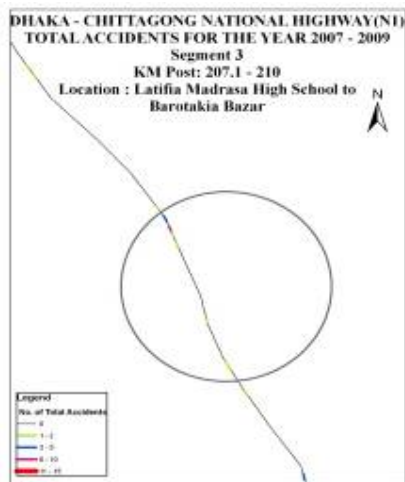


Fig 14: Total Accidents on Segment 3

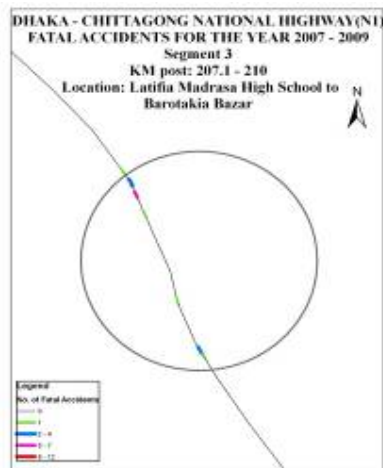


Fig 15: Fatal Accidents on Segment 3

Table 21: Total Deaths on Segment 3

KM Post	2007	2008	2009
207.1	2	0	0
207.3	0	0	0
207.4	2	5	0
207.5	1	0	0
207.6	1	0	0
209.1	0	1	0
209.9	0	2	1
210.0	2	1	2

Table 22: Collision Type of Accidents on Segment 3

KM Post	Head on	Rear End	Side Sway	Over turn	Object 1	Parking Vehicle	Hit Pedestrian
207.1	2	0	0	0	1	0	0
207.3	0	0	0	0	0	0	0
207.4	0	0	0	0	0	1	1
207.5	0	0	0	0	0	0	1
207.6	0	0	0	0	0	0	1
209.1	0	0	0	0	0	0	1
209.9	0	0	1	1	0	0	1
210.0	1	0	0	0	1	0	1

Table 23: Road Geometry of Accident locations on Segment 3

KM Post	Road Geometry Type
207.1	Straight
207.3	Straight
207.4	Straight
207.5	Not found
207.6	Straight
209.1	Straight
209.9	Straight
210.0	Not found

Table 24: Collision Type of Accidents on Segment 3

KM Post	Bus	Truck	Micro Bus	Motor Cycle	Baby Taxi / Tempo	Pick up	Rickshaw / Push card	Car
207.1	2	1	0	0	2	0	0	0
207.3	1	0	0	0	0	0	0	0
207.4	3	0	0	0	2	0	0	0
207.5	1	0	0	0	0	0	0	0
207.6	1	0	0	0	0	0	0	0
209.1	1	0	0	0	0	0	0	0
209.9	0	1	0	0	0	0	0	2
210.0	2	0	1	0	0	0	0	1

4 CONCLUSIONS AND RECOMMENDATION

This paper has highlighted the characteristics of the link-accident of two major highway of Bangladesh. In this study, the accident rates and fatal accident rates of those road obtained by GIS. In the period of 2007 – 2009, about 45 – 50 percent of reported accidents (KM post known) occurred in only 5 percent length of N1 and N2 highways, which clearly demonstrate that accidents are amenable to targeted and site specific

treatments. Six specific sections of these two national highways worthy of being treated as hazardous locations have been identified. In recent years, both the Dhaka – Chittagong and Dhaka – Sylhet highways have become very busy roads. As Chittagong is the business capital of Bangladesh. Sylhet is one of the most important city and tourist spots, a large number of vehicles passes through these roads everyday and as a result traffic jam occurs very frequently on these roads. On the basis of the results and findings, the necessary remedial measures should be provided to make the operation of these two most important and widely used national highways (N1 and N2) of Bangladesh safe and efficient. Some potential measures are as follows:

The high rate of fatal accidents in both N1 & N2 is a cause of alarm in road safety. Recently some initiatives and measures have been taking by the government. However, significant result has not been achieved so far. To improve the situation some measures should be taken like this;

- Pedestrian is the most vulnerable group at all segments in both N1 and N2. So, pedestrian facility such as pedestrian briar, overpass, underpass, zebra crossing, pedestrian signal etc should be increased. Also focus on speed reduction near schools, bazar and residential should be considered.
- Head on and Rear end collisions are the dominating collision types at all the segments of both the highways. Undivided highway, reckless overtaking are the main causes of head on collision. So divided highway and special overtaking sections should provided. Speed variation is the main cause of rear end collision. So exclusive lane for NMV may reduce rare end collision.
- Appropriate signs, road markings, fencing, guardrails, junction modifications, and improvements to visibility should be considered as remedial measure.
- Dangerous and inappropriate operation of heavy vehicles (buses and trucks) such as reckless overtaking, overloading and braking/stopping on roads and road sides are particularly a serious problem in all those segments. So, adequate enforcement should also be considered.

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