

Implication of GIS Technology in Accident Research in Bangladesh

Dilip Goswami*
Dr. Md. Manjur Morshed**
Md. Sazedul Hasan*

Abstract

Road accident is a major cause of loss of lives and economy of Bangladesh. National highways of Bangladesh have been a virtual death trap. However, accidents are concentrated on a few locations, which means, improvement of the scenario is possible through accident counterstrike measures. This paper has used Hazardous Location Index analysis to identify accident-prone areas of Joydebpur-Jamuna Bridge National Highway (NH405). In doing so, it has identified that about 11.50% accidents occurred in only 2.63% of the total length of the highway (highly accident-prone), whereas 12.41% length of the highway is accident-prone location. About 15.04% length of the highway needs counterstrike measures against accidents through road safety programs.

Introduction

Traffic accident is a major manmade disaster in Bangladesh. Bangladesh police reports about 4500 road accidents each year. Contrary to the Bangladesh police, World Bank (WB) reports about 12,000 deaths by road accident every year, which means, roads in Bangladesh are virtually death traps (Mahmud et al, 2011). About 1,064 road fatalities occur per 100,000 motor vehicles in Bangladesh (Rahman et al, 2006). The annual cost of road accidents and injuries varies between 1.8 to 2.8 % of national GDP in Bangladesh (Hoque et al, 2009).

About 42% of fatal road accidents occur on national highways, and most of the accidents are concentrated at a very few locations. Almost 43% of highway accidents are concentrated on only 5% of total length of highways (Mahmud et al, 2011). Such abnormal high road accidents concentrated locations are called 'Hazardous Road Location (HRL)' or 'Black Spots' (Rahman et al, 2006). Therefore, accident rate reduction is the most important measure for highway safety. The objective of the research is to identify and to explore the hazardous road locations and its environmental, operational and behavioral deficiencies in Joydebpur-Jamuna Bridge highway. This highway corridor plays an important role in national development of Bangladesh. About 313 traffic crashes occurred on the corridor in last five year with significant toll on human lives and economic resources.

This study used a combined field survey and Geographic Information System (GIS) technique to identify hazardous road locations graphically. GIS is a very popular tool for

* Research Assistant, Department of Urban and Regional Planning, Khulna University of Engineering & Technology (KUET), Khulna.

** Assistant Professor, Department of Urban and Regional Planning, Khulna University of Engineering & Technology (KUET), Khulna. E-mail: manjurmorshedkhan@gmail.com

accident analysis. GIS technique emphasizing on accident frequency, accident rate, accident severity, rate quality control methods, and also, combination of these methods is used to identify hazardous locations where accident concentration is abnormally high (Utainarumol & Stammer, 1999). With this background, rest of the paper is organized as follows. Second section of the paper is the methods for identifying hazardous road locations. Third section describes the data collections and analysis methods which is followed by analysis in the fourth section. Finally, some concluding remarks are in the fifth section of this paper.

Identification of Hazardous Road Location

There are four major methods to identify Hazardous Road Location: (i) Accident Frequency Method; (ii) Accident Rate Method; (iii) Rate Quality Control Method; (iv) Accident Severity Method. Hazardous Location Index is the combination of these four methods (Utainarumol & Stammer, 1999). The methods are described sequentially in the following.

Accident Frequency Method (Fa):

The accident frequency method is used to explore the number of accidents within various road segments.

Fa=Number of crashes in each 200 m roadway segment over a period of 5 years.

Accident Rate Method (Ra):

The accident rate method consists of simply dividing the accident frequency at a location by the vehicle exposure to determine the number of accidents per million vehicle-km of travel at highway segments.

$$Ra = A * 1,000,000 / (365 * T * V * L)$$

Where,

Ra= accident rate for highway segment (in accidents per million vehicle km),

A = number of accidents for given analysis period,

T = time of analysis period (in years or fraction of years),

V = average annual daily traffic (AADT) during study period, and

L=length of highway segment (in km)

Rate Quality Control Method (Rq):

The rate quality control method is used in Poisson distribution to determine the significant of the accident rate at each location. For each location, a critical rate;

$$Rq = Ra + K (Ra/E)^{.5} + 1 / (2E)$$

Where:

Rq = critical accident rate for highway segment (accidents per million vehicle km),

Ra = average accident rate for all highway segments of similar characteristics or on similar road types,

E = (365*T*V*L)/1,000,000 million vehicle-km of travel on the highway segment during the study period.

K = a probability factor determined by the desired level of significance for the equation. The value of K corresponding to 99% confidence level is 2.327.

Accident Severity Method (SI)

The accident severity method is used to identify locations based on the number of severe accidents at each location. Accident severity is defined as a fatal accident, personal injury accident, or property damage only (PDO) accident. Weighting scale for SI:

$$SI = (45F + 4.5 PI + PDO) / \text{Total Accidents}$$

Where,

SI = Severity index,

F = Number of fatal accidents during study period,

PI = Number of personal injury accidents during study period,

PDO = Number of property damage only (PDO) accident

Total = Total number of all types of accidents of the segment.

Hazardous Index

This analysis model is very important for comprehensive safety program. This model takes an attempt to develop a discriminant model to find out the highway segment, which is safe or not safe.

In this model the highway corridor is divided into 200m segments. Hazardous index is calculated for each segment of highway to define which section is safe or not safe based on rank. Hazardous index is calculated by following way:

$$\text{Hazardous index, HI} = (Fa + Ra + Rq + SI) / 4$$

Where,

Fa = rank of location by accident frequency method,

Ra = rank of location by accident rate method,

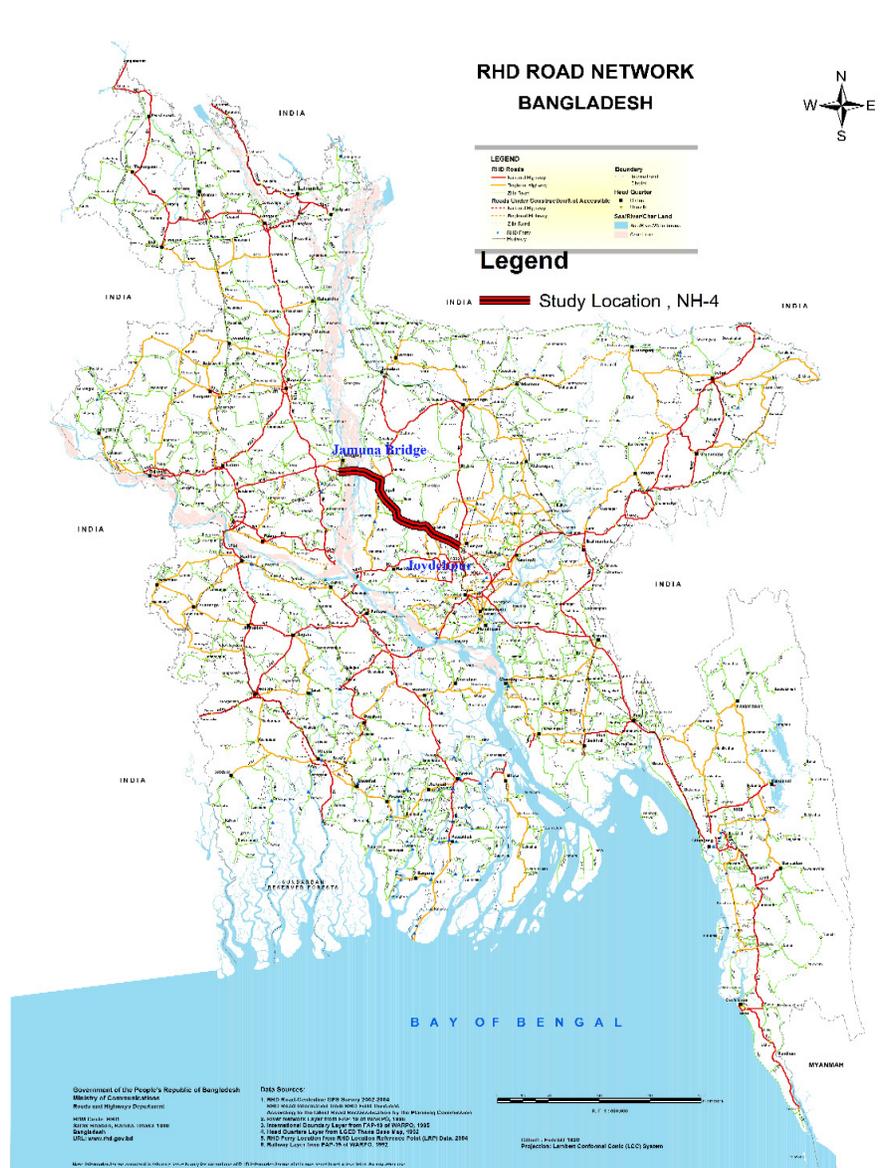
Rq = rank of location by rate quality control method and

SI = rank of location by accident severity method.

Materials

Study Area

Joydebpur-Jamuna Bridge highway move through Gazipur and Tangail district of Bangladesh. This corridor plays an important role in Bangladesh roadway transportation. This corridor connects Dhaka with the northwest and southwest parts of the Bangladesh. Daily traffic volume of the highway corridor varies from 10000 to 12000, occasionally it is more than 24000 vehicles, e.g., Eid. The highway corridor is the part of Bangladesh national highway four (N405), which is about 84 km. It is also the part of the Asian highway network. Ribbon development is built along side of the corridor from Joydevpur chowrasta to Mirzapur, Tangail.



Source: Roads and Highways Department, Bangladesh.

Fig. 1: Road Map of Study Area (Not to scale)

Data Collection

The ultimate success of a road safety program on the availability of comprehensive and integrated databases about accidents, traffic and highway elements, which is very limited in Bangladesh. Data related to road accident program is acquired from both primary and secondary sources. The Accident Report Form (ARF) was first introduced in around 1995 in Bangladesh by the help of World Bank (Ahsan, 2011). Accident report form contains 69 accident related information which recorded for every reported accident. Five years

accident data from July 2009 to June 2014 is collected for purpose of study from the office of superintendent of police of Tangail and Gazipur district. Annual average daily traffic (AADT) is the average number of vehicles passed through a point or section of a road per day over a period of one year. Annual average daily traffic (AADT) data of Joydebpur to Jamuna Bridge highway corridor is collected from Roads and Highways Department of Bangladesh.

Road crash locations are marked by highway police in Accident Report Form (ARF). Often the exact crash locations are not matched with the written location. Exact crash location is important to find the epidemiological nature of road crashes of those accident-prone location (Raman & Newaz 2013). Ground control Points (GCP) of accident locations were found out through GPS and Google Earth Software. Distance of road crash point from the nearby well known locations or features is calculated from the satellite map. Secondary information about road accidents was collected from the Bangladesh Bureau of statistics and Accident Research Institutes (ARI), BUET.

Analysis and Findings

Location and Contributory Factor of Accident

About 72% accident occurs in the rural part of highway and 28% accident occurs in the urban segment of the highway. Also most of the accident victims are pedestrians.

Road crash in the study site is mainly occurred due to rough driving. Careless driving constitute about 62% of the total accidents. Speeding was the second highest cause of accident, about 19.8% road crashes occurred due to bad overtaking tendency. Other major causes of road accidents are bad driver signal, weather, drunk driving, driver fatigue, bad road geometry, etc.

Environmental, Operational and Behavioral Reasons of Road Accident

Most of the accident occurs in general section of the highway, which constitute 257 (about 82.1%) road crashes. Bridge section of highway constitute 8.31% road crashes, built-up area along the side of highway 6.07%, and culvert section 1.92% and speed-breaker 1.6%.

Good road surface constitute the most number of accident (90.73%), where driver would like to drive in high speed. Similarly, careless driving at high speed is the main cause of accident. Dry surface condition constitutes 87.22% accident and wet condition constitutes 11.50% accident. Majority of the road crashes are occurred in straight highway section, which constitute 83.5% accident. Curve segment of highway constitute 11.8% accident, slope areas 2.56% and slope and curve 0.32%. Majority of the road crashes are occurred during the daytime, about 55.27%, dawn and dusk 19.49% and night-time 17.25%. Majority of the road crashes occurred in non-junction segments of the highway, about 53.63% of total crashes. About 27.8% accident concentrated on other type of junctions, which are not pointed out in Accident Report Form (ARF). About 7.98% crashes concentrated in T-junction type segment of the highway. Crashes are comparatively less in intersection, rail crossing, roundabout and staggered section of the highway.

Hazardous Road Location Analysis

Three or more accidents concentrated in 200m of highway segments are considered as hazardous road locations. This allows for detail analysis of small parts of the highways. About 11.50% accidents occurred in only 2.63% of the total length of the highway, whereas, 44.73% occurred in 15.04% of the highway length.

Table 4.2: Number of Hazardous Location in Different Segment

Segment Length(KM)	Location Name	Accident Frequency
16.6-16.8	Chandra	3
40.4-40.6	Dholla bus stand	3
46.8-47.0	Natiapara Bazar	5
51.0-51.2	Gollah four brothers petrol pump	3
69.8-70.0	Elenga Bus Station	3
70.4-70.6	Echapur	3
71.0-71.2	Rajbari	3
72.6-72.8	Chorbabla BBA-E 4 No Bridge	4
75.4-75.6	Northside of analiabari	3
82.8-83.0	Ibrahimabad Rail Station Infront	3
83.0-83.2	Southern west side of east rail station	3

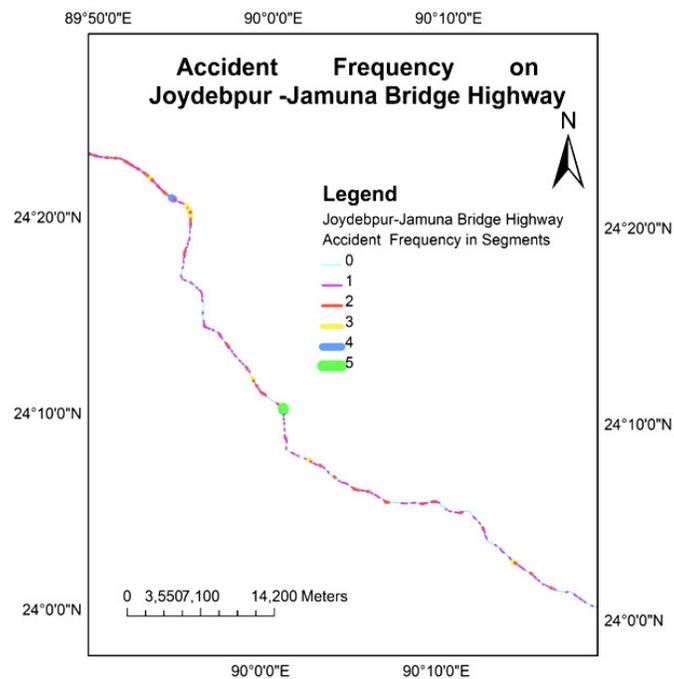


Fig. 2: Number of Accidents on Joydebpur-Jamuna Bridge National Highway

Hazardous Index Analysis

Hazardous Index Analysis is conducted on accident cases. Data set is divided into 4 group on the basis of AADT value of the highway corridor. The data and indices are in the appendix.

Hazardous Index (HI) of each segment of the highway determine the accident condition of the segment. Highway segments are differentiated as safe or not safe based on the HI value. 2.63% length of the highway is highly accident-prone whereas 12.41% length of the highway is accident-prone location. About 15.04% length of the highway needs counterstrike measures against accidents through road safety programs. Except highly accident-prone and accident-prone locations, other 84.96% location is safe for journey.

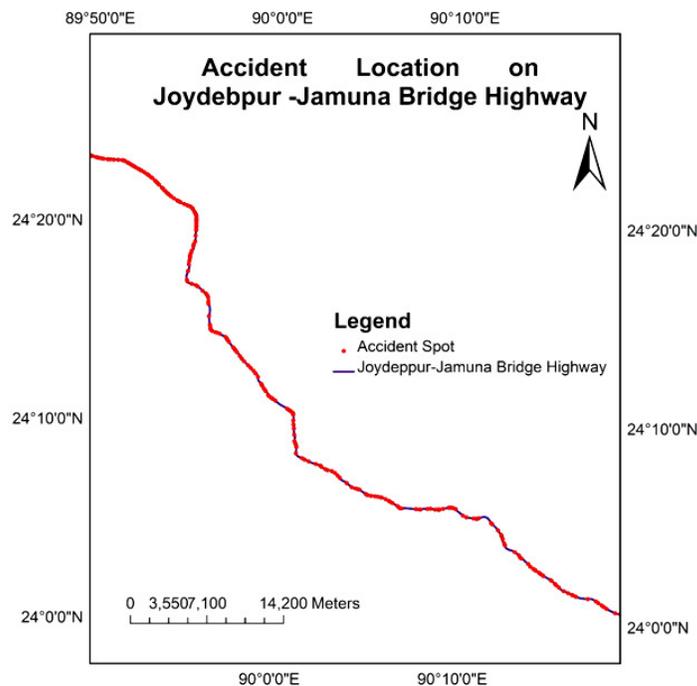


Fig. 4: Accident Locations on Joydebpur-Jamuna Bridge National Highway

Conclusion

This paper has used Hazardous Location Index analysis to identify accident-prone areas of Joydebpur-Jamuna Bridge National Highway (NH405). Using GIS techniques, it has identified the areas that require immediate environmental and operational measures to reduce accident rate in the study sites. In doing so, it has identified that about 11.50% accidents occurred in only 2.63% of the total length of the highway (highly accident-prone), whereas 12.41% length of the highway is accident-prone location. Overall 44.73% accidents occurred in 15.04% of the highway length. Therefore, About 15.04% length of the highway needs counterstrike measures against accidents through road safety programs. Except highly accident-prone and accident-prone locations, other 84.96% of the highway is safe for journey.

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