



# Evaluation and Spatial Analysis of Road Accidents in Bangladesh: an Emerging and Alarming Issue

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## Abstract

Around 1.2 million people are being killed, and more than 50 million people are being injured in road accidents each year around the world. Due to Urbanization and motorization road accident has been increasing dramatically over the last few years. According to the Accident Research Institute (ARI) of BUET, on an average, 20 people are dying every day in Bangladesh. Reckless driving, overloading identified as a significant causes for road accidents. Moreover, motorbikes has a higher number of accidents in Bangladesh. The main objective is to identify the leading causes of road accidents and the spatial distribution of road accidents. The data of accidents were collected from different secondary sources for the last 50 years. Qualitative and semi quantitate methods were used to analyze the statistical data. For spatial distribution of road accidents, the kernel density estimation method is used as well as critical area index for hazardous locations. The critical area index has presented from crash rate and causality rate of the zone as a dangerous area with the score (1–10) where highs score represents the most dangerous region for road accidents. The traffic department and the Government has a crucial role to play in identifying reckless driving, speeding and overloaded vehicles, and the government and citizens have an essential role to play in ensuring road safety as well.

**Keywords** Accidents · Fatalities · Spatial · Vehicles · Economic

## Introduction

A road traffic accident is known as a global phenomenon for growing the number of people who died and seriously injured in the road all over the world. Each year around 1.2 million people have been killed, and more than 50 million people injured due to road accidents around the world [1]. But the scenario is not the same for both developing countries and developed countries. In developing countries, the number of accidents, deaths, injuries are 10–60 times higher compared with developed countries [2]. Over 80 percent of road accidents of total accidents are occurring in the developing region [3]. According to a study of WHO, death by the road accident lying ninth rank place among the total 100

different causes of death and it will move up to the sixth position by the year 2020 [4].

In the last few years, the road accident has been growing significantly. World Bank said the fatality rate around 85.6 per thousand vehicles is reasonable, but in Bangladesh, the speed is quite high and deadly [2]. According to traffic police, on average 8–10 people are dying every day, and around 84,000 road accidents occurred in the last 20 years [5]. In Bangladesh, the annual urban growth rate is 4 percent, whereas the motor vehicle growth rate is around 8 percent [6]. GDP is greatly affected by road accidents, whether it is a developed or developing country. But the economic cost of an accident is much higher in developing countries [7].

According to a study of WHO, in developing countries, this cost is around 2–3 percent of GDP [4]. The annual losses caused by road traffic accidents across the country is more than 400 billion every year [8]. According to the traffic police department in Bangladesh, reckless driving, overloading identified as a significant cause for a road accident. More than 50 percent of accidents occurred due to reckless driving and high speed [6, 9].

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Moreover, motorbike has a higher number of accidents in Bangladesh. The death rate is highest in metropolitan cities [10]. According to WHO, it is estimated at least 20 persons sustain non-fatal injuries in a road accident and facing economic and adequate medical supports [11].

The objective of the study is to identify the leading causes of accidents and the spatial distribution of crashes. Find out the present scenario and describe the safety measures is also the aim of this study. According to the requirement of United Nations Road safety 2011–2020 action plan and Sustainable Development Goals (SDGs) -2030 and its GOAL–3.6, Bangladesh must decrease the rate of the road traffic accident and injuries on the half number [12, 13]. The current situation is deadlier in comprising before. On average, 20 people are dying every day in road accidents. The purpose of this study is to describe the current scenario so that government bodies and governmental organization can take relative measure and concentrates enforcement efforts in areas characterized by high crash risks. By taking this optimization scheme and measures the government can ensure public safety effectively and efficiently.

Moreover, in the past 3 years, more than 25,000 people died, and 62,482 injured in road traffic accidents across the country [8]. But the actual statistic will be much more because the data kept only for registered cases, not that which adjusted through compromise [12]. Based on the above circumstance, road accidents are now becoming imaging, alarming issue. There are many factors related to the road accident such as drivers' behavior, road facilities conditions, weather, and many others. Another motivation of the work is to explore the accident causes, which is significantly useful to take adaptive measure and action of safety prevention for government bodies. The accident analysis an important factor for infrastructure planning, design, and decision planning. This study also could lead the planning process to find out the gap between existing condition and plan to improve the public safety.

## Literature Review

A comprehensive study [3] on road accidents described an overall scenario on road accidents tend in Bangladesh. The main objective was this study found out and visualized the road traffic accident for the last few decades. According to this study, with the growing number of motorized vehicles and road users, the number of road traffic accidents are increasing with time. In the year of 1985, the fatalities rate was 62 per ten thousand vehicles, and in the last four decades, the population has grown into double. The road accident and fatalities are increased 1.14–3.87 and 0.41–2.98 per thousand, respectively, at this time. Chowdhury [14] used

police-reported traffic accident data and deaths to show the difference between researches output the real scenario.

Another study [15] described the effects of demographical, sociological, as well as economic features in road traffic accidents in Bangladesh. Blazquez et al. [16] described the road accident is not only a crash; it has a tremendous economic burden for productivity loss in society. However, the scenario road accident is much worse in Bangladesh compared with a developed country. The study [17] examined the effect of road infrastructures on road accidents. A negative binomial model developed by [15] to reveal the impact of load length, infrastructures, socio-economic features on road traffic accidents at the local level in Bangladesh. A study [1] described the situation, issues, and challenges of road accidents in India. According to this study, the mid-age group is most vulnerable and has more fatalities and injuries by accident.

Moreover, males has a higher rate of accident fatalities than females. Big cities have a higher rate of accidents and it nearly 50 percent rather than small cities. The road accident also influenced by weather and the rate is relatively high from December to January and May–June in a year. [10] Described road accidents and the road safety scenario, the north-east region of Bangladesh and discussed characteristics of road accidents, hazardous roads, condition of pedestrians, and safety priorities. The data collected through a questionnaire survey, expertise, and newspapers. The dangerous road has been identified by fatality index, which defined as percentages of fatalities divided by the total number of causalities through road accidents. Hossain and Khan [17] shows pedestrian are victims of a crash due to awareness and vehicle are mostly exceed its capacity. Some safety measurement and recommendation proposed by [18] as increasing awareness, government policy reform, training, footpath, and footway construction, etc.

In recent years, several tools and method have been developing for analyzing road traffic accidents. Among them, geographical information systems create its place due to its high performance of the spatial analysis. Satria [19] discussed the advantages of GIS tools for analyzing road accidents and their spatial distribution. It is possible to create visual representation with statistical analysis more accurately with GIS. Moreover, it helps the researcher as better decision-making tools in present days. The analytical tools as kernel density estimation methods (KDE) and kriging are used in a study [20] for identifying road accident hotspots.

A study conducted in the USA to identifying traffic accident hotspots. Two methods (KDE and kriging) applied according to prediction accuracy matrix. It found that the kernel density estimation method performed quite different comparing to kriging. KDE is the best fit for hot spot detection studies. Bolstad [21] said, “KDE is unique and powerful because we use the observed change in spatial

autocorrelation with distance to estimate values at our unknown locations.” Other several methods have been developed for identified traffic accidents spatial analysis. Anderson [22] also reiterated that traffic crash hot spot identification is the first primary stage for proper safety management. Ramli [23] said highway safety studies are frequently using a statistical or crash forecasting model. Traffic crash hot spots/black spots identification and clustering are widely used; these include hot zone identification through GIS-based network screening analysis [24], GIS-based assessment of spatial clustering of road accidents [25].

KDE is widely used spatial pattern and density estimation analysis method which has several advantages including determination of spread risk [26], spatial dependency [27], and arbitrary spatial unit [28]. This method easily can define a cluster which can intent there is an increased likelihood for an accident to occur based on the methods examining the effects of a spatial process. Kernel Density Estimation (KDE) generates continuous spatial intensity using a weighted distance function formally called a Gaussian kernel and distance measured with the

Euclidian measurement method. In this study the KDE is used because it easy to calculate the risk density for every crash instead of exact location of a crash [29]. An area to be considered as a risk area, it is important to show the accident rate higher than the normal threshold value [30]. The identification of most risk area is the important factor for the allocation of the resources for public safety.

There are many studies related to spatial analysis of accident using KDE [13, 27, 28, 31–36] including lixel lengths, and search bandwidths [28], NKDE [16, 37–39], K-means clustering, nearest neighbor [13, 26, 40], Full Bayes hierarchical approach [13, 41], Data-Driven Approaches [29], Monte Carlo simulations [27]. Following table describes few studies with mentioned methods (Table 1).

**Table 1** Different studies-related accident spatial analysis

Studies	Method	Description
[26]	K-means clustering KDE	Spatial patterns of injury-related road accidents Subsequently disaggregated by cell density Create a basic spatial unit of an accident hotspot
[16, 37, 39]	KDE NetKDE local Moran'I	Hot spot analysis Detection of traffic accidents Conditional permutation, Combined with a 100-m neighbor
[28]	novel network KDE lixel lengths, and search bandwidths	Estimating the density of such spatial point events Linear units of equal network length, Termed lixel (linear pixel), related network topology
[13, 40]	KDE SANET nearest neighborhood K-function	Bring out the influence of spatial factors information Examine clustering analyses Better understanding of traffic accidents patterns Deploy the clustering technique in urban roads
[42, 41]	Full Bayes hierarchical approach	Safety analysis to account for spatial correlation Spatial correlation in models of road crash frequency at the segment level
[29]	Data-Driven Approaches	Crime and traffic Safety
[38]	NKDE	High-crash-risk road segments Hotspot identification Considering the discrete nature of crash data the limited access to exact locations
[31, 31–36]	KDE	Hotspots Higher weights to the more serious accidents Temporal-spatial patterns of accident hotspots Measures the seriousness of an accident
[27]	KDE Monte Carlo simulations	Clusters of traffic accident Cluster strength and cluster stability evaluation Identification of the most important clusters within each section
[43]	Moran's I method Getis-Ord Gi* KDE	Spatial and temporal patterns of the road accidents assessment of spatio-temporal clustering

## Methodology

### Materials

This study was conducted based on secondary data sources. The information was collected from different newspapers and annual reports from the transportation authority for the last 50 years. The statistical data collected from Bangladesh Bureau of Statistics (BBS), Bangladesh Road Transport Authority (BRTA), Roads and Highway Bangladesh (RHD), Accident Research Institute (ARI), Bangladesh. In many cases, people do not register about accidents and the actual number of accidents are more comparing to registered.

### Study Area

Bangladesh is a developing country located in South Asia having a total area of 147,570 sqkm. The total population is around 165 million which is rank 12th in the world [44]. The road accident is one of the major causes of death in Bangladesh [45] (Table 2). The total length of the road in Bangladesh is around 21,000 km, which includes National Highway, Regional Highway, Zilla Roads, and others [44] (see Table 3).

## Methods

Last 10-year data are collected from different secondary sources. Qualitative and semi-quantitate methods were used to interpret the statistical data. The selected variables for analysis are road configuration, road category, factors of road accidents. The year 2000–2018 was chosen for statistical analysis. The main factors of road accidents, road safety factors, hazardous or risk factor are identified through the trend of road accidents. The analysis of the study approaches a theoretical framework to improve road safety and road accidents in Bangladesh.

To find out the spatial distribution of road accidents, the kernel density estimation (KDE) method was used. KDE method is most commonly used and well-known spatial techniques which are used to identification of hotspots studies. The method is describing as the kernel function which denotes overlapping density surface. For a given cell, it is estimating the summary by an overlapping discrete point with density surface, and this process repeated for all reference’s grids [20, 24]. The kernel function denotes a symmetrical mathematical equation as:

$$f(x, y) = \sum_{i=1}^n \frac{1}{n \times 2 \times \pi h^2} \times W_i \times K\left(\frac{d_i}{h}\right)$$

where,  $f$  is the density function,

**Table 2** The total number of different types of vehicles

		2013–14	2014–15	2015–16	2016–2017
Length of total roads	Km	21,365	21,365	21,365	21,576
Bus	‘000’ no	2778	29,350	31,873	35,106
Micro bus	‘000’ no	66,076	70,052	74,689	79,545
Truck	‘000’ no	87,479	93,781	99,482	107,043
Motor car/taxi/jeep	‘000’ no	35,862	36,070	36,126	36,152
Auto rickshaw	‘000’ no	155,509	171,460	184,635	192,945
Tractor/trailor	‘000’ no	25,430	26,704	28,344	30,469
Rickshaw	‘000’ no	813	814	815	815
Pushcart	‘000’ no	36	35	35	36

Sources: [45]

**Table 3** Total Length of different types of road

Sl	Types of road	Number of roads	Length	Remarks
1	National highway	96	3826.78	8 lane National highway–17.50 km 6 lane National highway–20.60 km 8 lane National highway–470.51 km
2	Regional highway	126	447.045	Width–5.50 and 7.30 m
3	Zilla road	654	13,274.87	Width–3.70 and 5.50 m
		876	21,576.00	

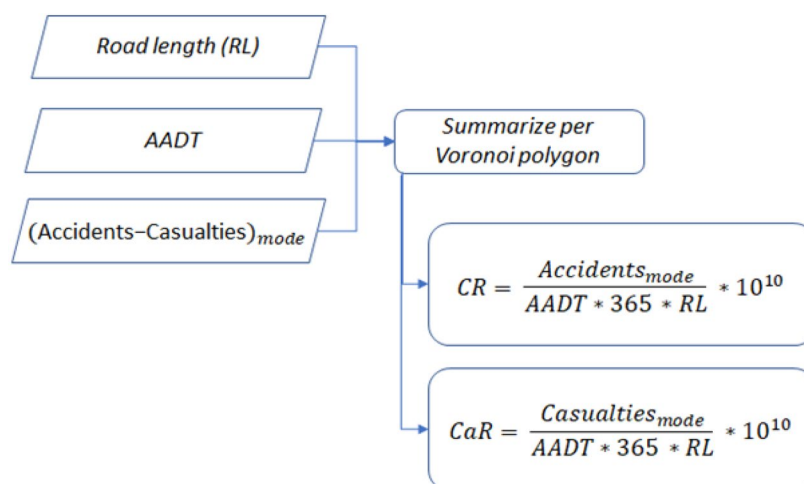
Sources: [45]

$n$  is times of observation,  
 $h$  is length,  
 $k$  is the function of the kernel,  
 $W_i$  is the intensity.  
 $D_i$  is the distance between the locations.

The kernel function has a different form like usual, quartic and triangular. Among them, the normal is [22] used in crime mapping, ArcGIS used the quadratic function (Prasanna Kumar et al. [25]). The general overview of density estimation methods represents coded raster data. The main parameters that affect kernel function are bandwidth and cell size [20]. Large cell size has short computational time, and meanwhile, small size increases processing time.

The crash rate index is an exposure measure that results in identifying the zones where the probability of having an accident is higher. This indicator is based on AADT, road length and the total number of accidents per zone. The calculation procedure consists in taking the total number of accidents in each analysis unit (AU) and divide it into the exposure factors (traffic and road length), finally to create a consistent and readable number, the AADT is multiplied by 365 to convert the AADT to an annually traffic and multiply the result by  $10^{10}$  the measuring unit are accidents/car/m\* $10^{10}$ .

The casualty rate is an approach to obtain the critical zones based not only in the total number of accidents but in the number of casualties. Therefore, the main improvement of this method is to change the accident variable from the total number of accidents to the total number of casualties instead. The calculation procedure is like the CR, with the difference that now, the equation uses the total number of casualties instead of the number of accidents. The calculation procedure for CR and CaR are shown in the figure below,



Hazardous locations or regions have been identified by critical area index [10, 24, 46] which is defined as a weighted factor of accident density, crash rate and causality rate in the study area. The critical index shows the hazardous location very well. With critical index it is possible to understand which location are more risky, which location or area should give more preference in term of safety and infrastructure planning. The Critical area index has presented with the score (1 to 10) where high score represents the most critical area for accident and low score represents a less rate due to road accidents. ArcGIS statistical analysis was used to calculate and identify the critical area index and hazardous area.

## Analysis and Discussion

### The Accident Trend in Bangladesh

Road traffic accidents are common phenomena in daily life in Bangladesh. More than 10,000 accidents have occurred in the last 3 years, moreover, around 25,000 people died on these road accidents [8]. This number of accidents and fatalities represents general information about the present condition of road safety. Following figures and tables will describe visually, the road accidents and safety scenario in the country.

The number of accidents has been dynamically changing over the year for the last four decades. For the last few years, it has been increasing at an alarming rate. In the last 3 year, around 19,000 accidents occurred within the country. Accidents have increased from 114 in 1972 to 4989 in 2017, nearly 5 times higher than before. In 1997, the previous highest number of accidents were collected and that was 5448 but in 2015 the counted number of accidents was

6581, which is the height number of accidents. The fatalities have increased from 187 in 1972 to 16,193 in 2017 and the rate is almost 90 times higher than previous accidents. The highest fatalities counted in 2015 and the number was 21,855. The increasing number of accidents and fatalities are varying for the last few years, and especially, in the last 4 years, the increasing rate of accidents and fatalities are much higher than any time. The increasing number of accidents and fatalities are as high as 78.91% in 1989 and 190.2% in 1972, respectively.

### The Road Accident Scenario in the Metropolitan City

The number of road accidents is quite higher in metropolitan cities in Bangladesh (Mannan and Karim [47]) [47, 48]. Fatality risk in metropolitan cities on average 75% which is higher than all average [49]. There are 11 metropolitan cities in Bangladesh, among them, Dhaka and Chittagong are the 2 most populated cities. Dhaka and Chittagong have around 17 million and 4 million habitats, respectively [44]. The rate of accident is also quite high in these two cities. In 2018 more than 2000 accident occurred in Dhaka metropolitan. Most of the accidents were occurred by private cars and mini buses and pedestrians were victims in all those cases (serious injury-33.9%, simple injury-8%) [6]. Earlier studies of [18] of road accidents in Dhaka, vehicles are responsible for pedestrian fatalities for around 79 percent, where trucks are for 37%, buses are for 20% and mini buses are 22% responsible for accidents [10]. In Chittagong, the rate is quite lower compared to Dhaka city [50, 51]. About 865 accidents occurred in last year (2018) where 25 people died [20]. Simple injuries were almost 65% and pedestrians were involved in accidents in 51% cases. Involved vehicles are buses, mini buses and human haler where the percentage of involvement in accidents in 39%, 26%, and 23%, respectively [12].

### The main factor of Road Accidents

There are many causes of a road accident. The major causes are: overtaking another vehicles, high speeds, competition between vehicles, overloaded vehicles by passengers or goods, break down and the failure of control of vehicles, hit down to first moving vehicles, the rail crossing, the backward movement of standing vehicles, during turning, suddenly stopped vehicles, to give side opposite direction vehicles, pedestrian road crossing, mental or physical disable drivers, tiredness of the driver, and collision with passengers. Other important causes of road accidents are to save pedestrians the driver falls in an accident. Fallen from bikes, defective vehicles, hit into pedestrians, elevation difference between shoulder and carriageway, taking a turn in high speed, sleeping of the driver, illness of drivers, driving

in rough weather, drying of straw on road, erosion of road pavements, etc. Reckless driving and excessive speed of vehicles incommensurate with road conditions were generally assigned as reasons for 90 percent of the incidents. According to a study [52] in 1997 of road accidents, heavy truck, buses, and mini buses are the major contributor to a road traffic accident. On average, 79 percent accidents occurred by these heavy vehicles.

### The major Factor Contributing to Accidents

In Bangladesh, total registered vehicles are about 3 million, among them, 44.9% are private car [12, 13]. Most of the accident occurred by bus which contributes 38 percent of the total accidents while trucks contribute 28%, cars involved with 17%, the three-wheeler is about 12% and motorcycle contribute around 5% [7]. Most of the drivers of Bangladesh mainly public transport and car are the ages of less than 30 or equal to 30 years. According to this statistic, most of the drivers are young with uprising energy. They drive vehicles like do not care mentality and conduct road accidents. The working hour of a driver is a very crucial factor for conducting accidents. Long working time makes them exhaust in driving. About 52 percent drivers drive 8 h or less in a day and 12 percent drives more than 12 h in a day [7]. They try to work more time to make more profits and drives fast and crazy mentality and occur road accidents.

Almost all accidents occur at peak hour. Between 10 am and 2 pm (peak hour), the rate of accidents is quite higher than between 6 and 10 pm (off-peak hour) [3]. During off-peak, most of the pedestrians, animals, private or local vehicles are not common in the road and that reduce the risk of occurring accidents. About 46% of male persons are involved in accidents in the age of 25 to 35 and most victims of accidents are young. Female is less involvement in accidents rather than male persons and the rate is about 27% in the age of 35 to 40 while about 21% of female persons fallen in accidents in age above 55 years [10]. About 52.30% children, who are in below 10 years and 31.70% are between 10 and 15 years whose are affected in road accidents are elementary students and do not have any knowledge of the traffic rules and regulation. Pedestrian is the dominant accident type both in the rural and urban area. About 29.9% accidents occur through runoff, rear, and head are 17.25%, 12.9%, and 13.9%, respectively [8]. According to this information, pedestrians are most victims during accidents while at the unaware crossing of the road. Different types of accident are hit pedestrian, park vehicle, hit object, overturn, sideswipe, ninety-degree, animal, head-on, rear-end, others. Most of the accident occurs during the rainy season and winter season. About 40% accidents occur in the rainy season. During rainy season roads become slippery, as results, drivers lose the controls. In winter, it is very dangerous to

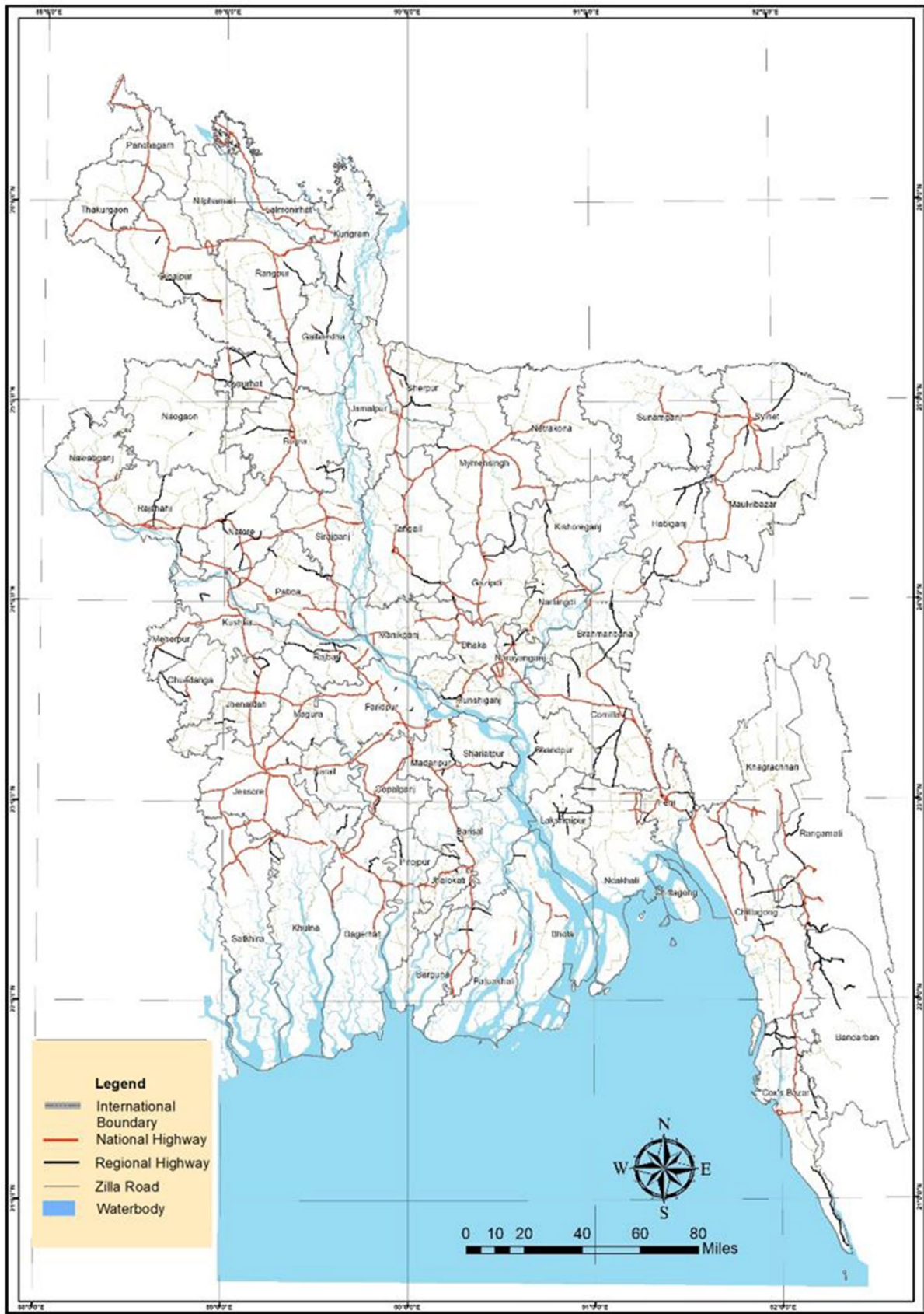


Fig. 1 Study area map (Sources: [12])

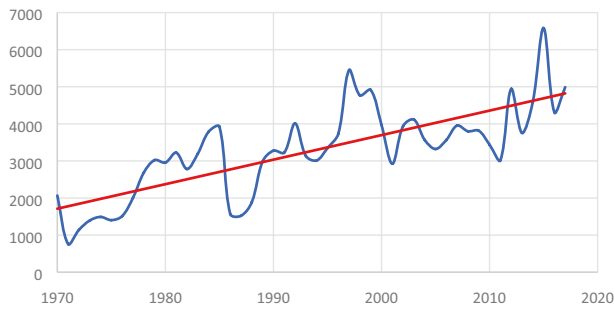


Fig. 2 The accidents trend for the last 50 years (Sources: [12])

drive in fog and mist and its increase the accidents by about 20%. The fog reduces visibility of driver struggle to see with any clarity. Drivers are drives at inconsistant speed and they found the insufficient following distance, as result, involves with an accident [12] (Figs. 1, 2).

At the last, road accident occurs mainly in highway, cities, intersection. About 47% accidents occur due to high speed in highway and about 48% due to careless driving in cities as well. Around 75% drivers do not wear seat belts and another 7% are drunk due to alcohol. Sometimes accidents occur due to poor surface condition (3%), surface type (1.5%), road geometry (2%), weather condition (3.1%), maneuvering characteristic, etc. [15].

The Fig. 3 shows the correlation between accidents, fatalities, causality and registered vehicles over the past 50 years. The correlation indicates the accidents rate is increasing over time. The correlation between fatalities and year is 0.91, which indicates there is a high relation between this as the

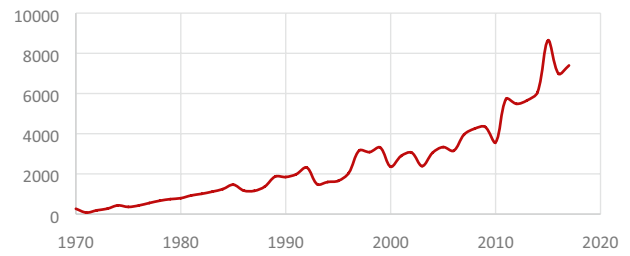


Fig. 4 The fatalities trend for the last 50 years (Sources: [12])

number of fatalities are also increasing over the years. The number of injuries including the total causality is highly correlated with the registered vehicles. This figure concludes that accidents, fatalities, causality are correlated with each other (Fig. 4).

### The Fatalities Analysis

The developing countries like Bangladesh are now experiencing a lot of human miseries and losses in human life and national properties, due to a serious road safety crisis. Over 45% of cases were disabled, 25.4% turned handicraft, 21.8% suffered from mental stress and shock [7].

Road accidents and its fatalities are now growing public concern worldwide. Road accident is the leading causes of death by injuries and ninth leading causes of all death. Accident due to the motor vehicles is taking an increasingly larger share in the sum of fatal accidents. In developed countries, the proportion of deaths from this cause is n general between 25–40% of that attributable to an

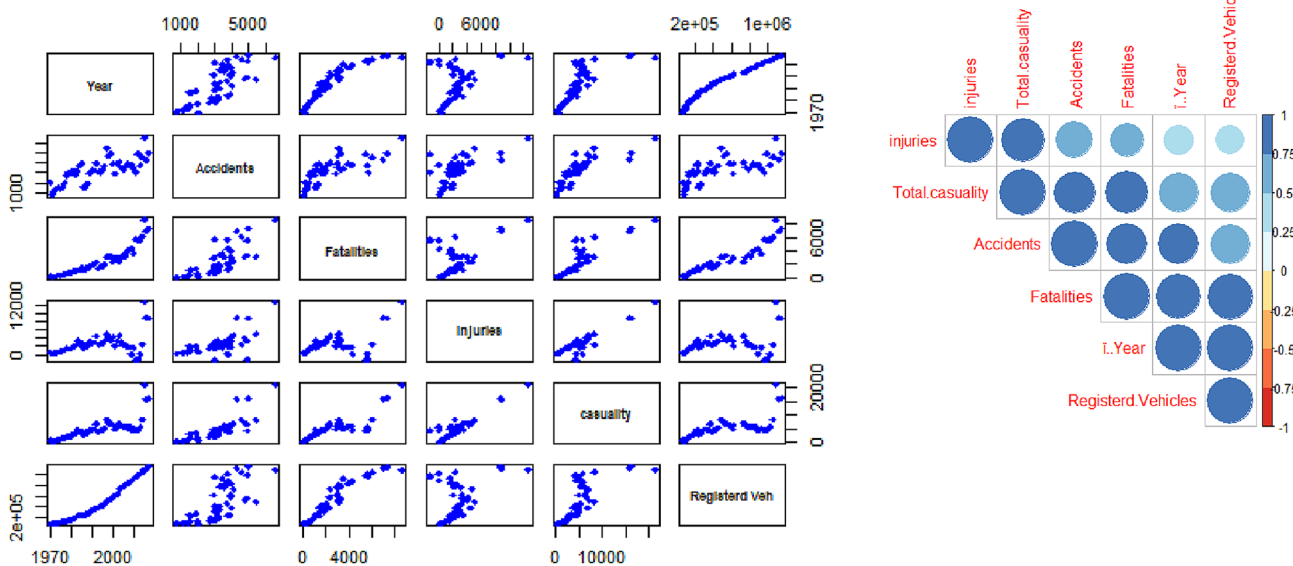


Fig. 3 The correlation between accidents, fatalities, and causality

accident from all causes, but in developing countries that only 10–20%. Worldwide every year almost 1.3 million people are killed on the road [7] and another 20–50 million are injured. It is interesting to note that over 90 percent of this road accidents death are occurred in low and middle-income countries and among them 48 percent of registered vehicles. The age of casualty mostly between 25 and 40 years is accounting 64.6 percent [7]. Children, pedestrians, cyclist, old people are more vulnerable to road user. Around 88% if 1.2 million of death from road accidents occur in developing countries where children and young people are most affected. If the present trend continues road accident deaths will increase to 2.4 million a year by 2030 with more than 90 percent of them in the developing country [11].

**Socio-Economic Effect**

Road accident has the most devastating impact on society and the economy. Public property damaged, the owner loses vehicles, and treatment costs are high. The cost and paralyzed person become a burden for the family. However, sometimes, they lose only earning person in the family. Road accident has no positive effect. Injured persons are always facing hardship during their normal lives. Moreover, this affects societies, communities, as well as country and over-world. Table 4 shows the direct and indirect cost of road accident injuries.

**Spatial distribution of Accidents**

Spatial distribution of road accident is described by kernel density estimation method (KDE), and it is most commonly used and well-known spatial techniques. In this study, KDE was used to identifying the area or region where most accidents occurred for the last 3 years. Around 3000 accident location point is used to identify the accident area. The light color shows the low number of road accidents whereas deep color describes the high accidents rate. The bandwidth was used as 50 km for this analysis. Most of the accident occurred for last few years in highway and city areas. High

speed is the main causes of road accidents in highways and reckless driving in city areas as well.

Figure 5 describes the spatial distribution of road accidents for the last 3 years. The map was created with kernel function a log transformation of accident data. There is a liner relation between road accidents and spatial areas. In a crowded area, the highway has very high accident rates and pedestrians are the main victims in most of the accidents. For the strategic safety plan, it is an important element to analyze accidents location and their spatial relation. Geographic information system (GIS) has used to identify this spatial relation. Therefore, we have tried to include the last 3 years accident data and there is any spatial pattern among those accident locations. According to normalized fatalities rate, we found that most of the traffic accidents are apparently clustered and self-centered based on some city areas and highways.

**Identification of the Hazardous District**

Hazardous region or districts are identified by critical area index which is the combination of accident density, crash rate, and causality. The critical area index has presented with the score (1 to 10) where highs score represents the most hazardous region for road accidents (see Fig. 6). This is done by two steps, firstly, crash rate and causality was calculated according to accident data for last 3 years, and secondly, these had to combine with spatial location information and created a scoring for hazardous locations. Deep color and high score show the critical density of fatal traffic accidents and most hazardous area. Low fatal density and low hazardous areas are represented by the low score as the light color. According to Fig. 6, some areas are not identified as fatality prone area those are the area seems to be critical areas of interest and those areas might be subsequent errors.

**Conclusion**

The road traffic accident can be defining an alarming issue by considering the present fatality scenario. The scenario is getting worse day by day. Most of the developing country is facing this problem. Bangladesh has the worst situation for the last few years. Excessive speed, reckless driving, and overload of vehicles are responsible for an accident in about 90 percent cases. The fatalities have occurred in most of the accidents. Most of the accidents occurred in city areas and highways. The cost of a road accident is quite high to survive for low- and middle-income group. The study concludes that most of the road accidents victims are the member of a family or an earning member of the family and affect the driving force of the country as well as the national economy. Few safety measure are describing below based on this study:

**Table 4** The total direct and indirect cost due to the injuries

Sl	Total direct cost	Percentage of people	Total indirect cost	Percentage of people
1	< 1000	45.5	< 2000	1.8
2	1000–4000	29.1	2000–4000	20.0
3	4000–8000	12.7	4000–8000	21.8
4	8000–10,000	1.8	8000–10,000	10.9
5	> 10,000	10.9	> 10,000	45.5

Sources: [48]

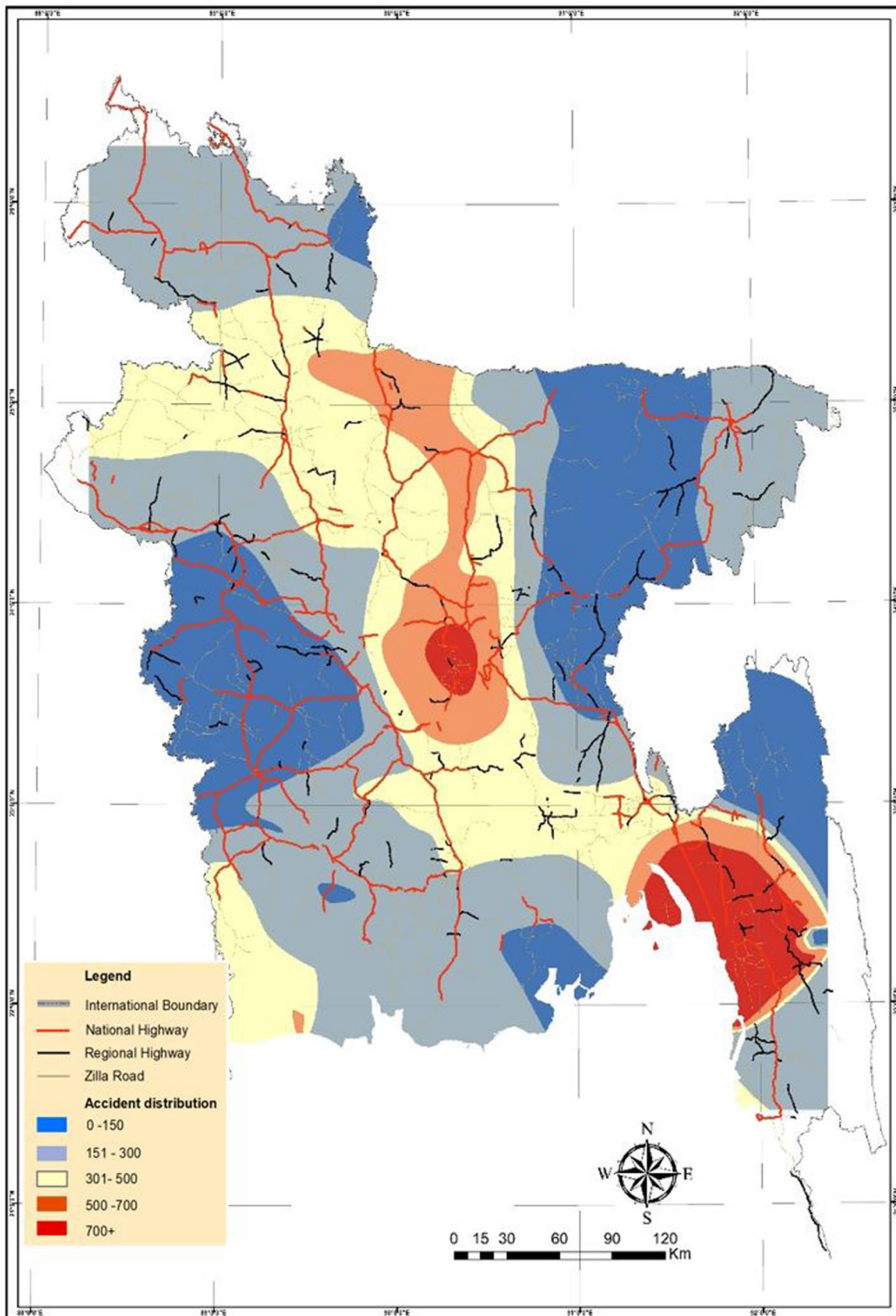


Fig. 5 Spatial distribution of accidents

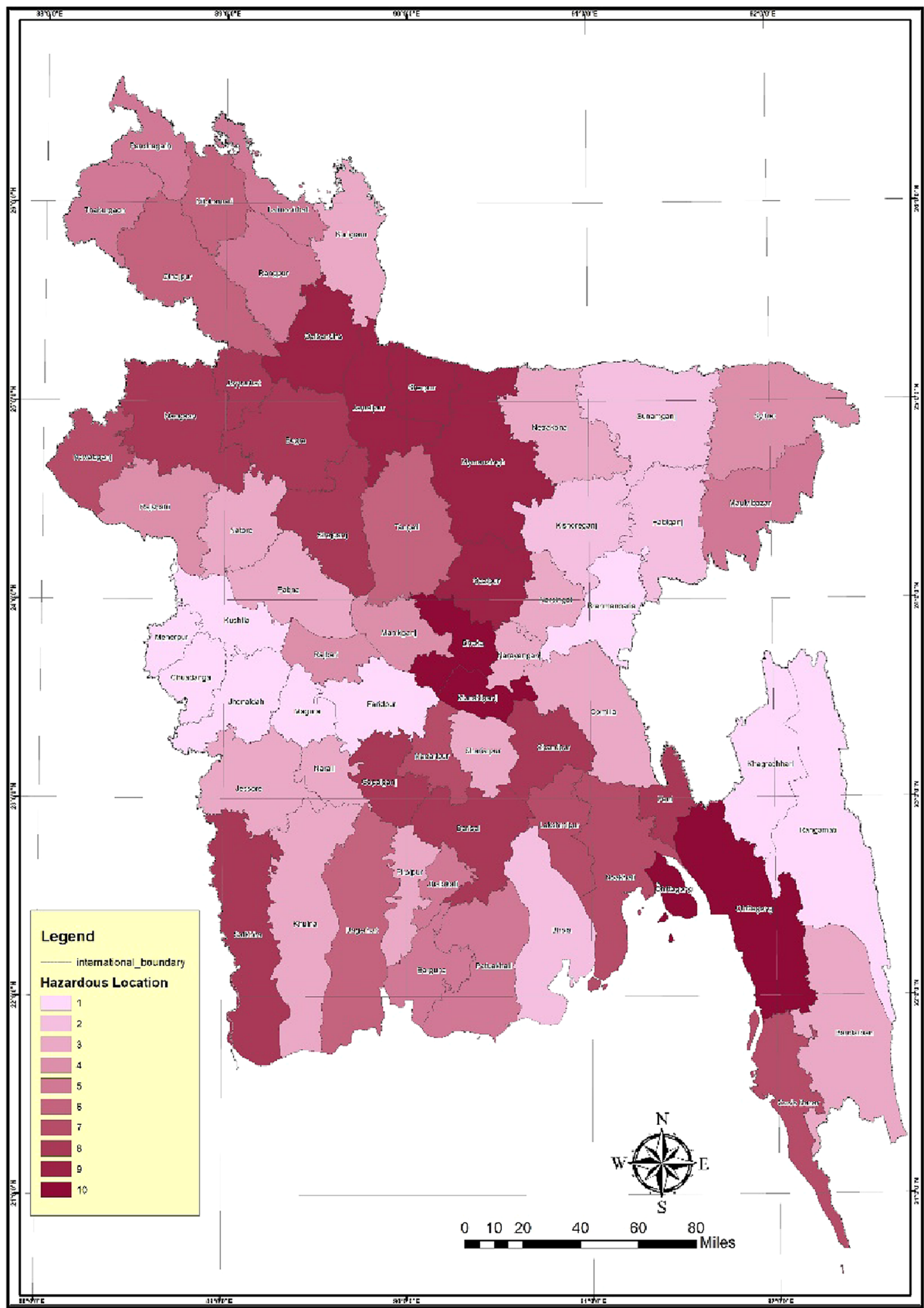


Fig. 6 The hazardous region of accidents

- Integration of stakeholders in the planning process:

Authority must ensure community participation during the plan preparation so that they are aware of the needs of the users and incorporate those ideas in different stage of planning. There should be an open platform for the mass people where they can share their ideas and express their views without any hesitation with the presence of all stakeholders during all stage of plan preparation.

- Community-based awareness program:

Central Government with the help of Municipalities should initiate some awareness program, training, in every ward to make people aware of the traffic rules and regulation, individual role in road safety, advising people how can participate to make a safe environment for their children. This will make mass people much conscious and accountable for their responsibilities. There can be some initiatives in the form of training, workshop at kindergarten level so that the children get familiar with the traffic rules from their childhood which will be much more effective.

- Initiating adaptive traffic signaling system:

At present, most of the road intersection is regulated in a very traditional way. In every intersection, there are some designated traffic police that is responsible for maintaining traffic through manually closes one side of the road then open other one and so on. But during peak hours it is challenging to manage the dense flow of the traffic. Therefore, there are not any pedestrian signal in any of the roads thus as a result while pedestrians and high-speed vehicles try to cross the intersection at the same time finally ended in severe road accidents.

- Investment in transportation research:

Although the modern world is making progress in the automation sector of the transport industry, Bangladesh is still far behind. Only one institute is working for road safety in Bangladesh which is also not even much active. The government should focus and make investment in research of Intelligent Transport System (ITS) which can play a vital role to make the road networks much more convenient, secure, integrated and astute.

- Strict enforcement of law:

The government must be very strict in terms of violating traffic rules and regulations whether it is pedestrian or vehicles. There should be zero tolerance for reckless driving, over speeding, drunk driving. All kinds of unfit vehicles

must be removed from the road. The frequency of the operation of the mobile court should be increased. All types of law and order personnel that are involved in traffic management must have to carry out their responsibilities from their own position for ensuring road safety.

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