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Identification of Inaccessible Roads and Vulnerable Settlements in Dhaka City Using ArcGIS Tools

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ABSTRACT

Dhaka, the capital, is a highly populated city in Bangladesh. Indiscriminate and unplanned urbanization, with narrow road networks, has made the city more vulnerable and risk-prone for any disaster. This study focuses on the identification of inaccessible roads and vulnerable areas of Dhaka city for improving search and rescue operations, response initiatives, and debris management. For the study purposes, four different locations of Dhaka city have been selected to analyze the accessibility of emergency vehicle and equipment for rescue operations. The narrowest roads and vulnerable areas including individual houses have been identified using ArcGIS. The analysis reveals that a maximum of 60% houses of old Dhaka has been found vulnerable whereas in Uttara there are 2.4% vulnerable houses. In addition, the traffic volume analysis is performed for the most vulnerable area in terms of narrow roads. Thus, vulnerable houses have been identified on the basis of maximum congestion in a scenario of no disaster to access basic facilities like hospital and fire stations.

KEYWORDS

ArcGIS, Emergency Facility, Inaccessible Road, Traffic Congestion Road Width, Vulnerable Buildings

INTRODUCTION

Bangladesh is the eighth largest country in the world by population (Rahman & Rabbani 2007). Dhaka, the capital city of Bangladesh, is one of the most overcrowded cities in the world with a population of 162.9 million having only very basic emergency service capabilities (Islam et al. 2017). Due to the high concentration of job, education, and medical facilities as well as for other major investments, especially for Ready-made Garments Factory, Dhaka city has been experiencing a population growth of 6.5% each year (Ferdous & Rahman 2013). The city is also identified as potential risky area for frequently occurring earthquake due to geographical and geomorphological formation. As such, Dhaka has become highly vulnerable for earthquake due to indiscriminate and unplanned construction of buildings and other massive infrastructures. According to earlier observation, some buildings in the old Dhaka have been collapsed even without any earthquake, so it is obvious that there will be a huge damage and casualties during onset of an earthquake even of moderate magnitude. In fact, every year, there are many building collapse incidences have been occurring in and around Dhaka city without

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any disaster resulting in huge number of deaths and injuries. For example, five storied building in old Dhaka (2004); nine storied factory building in Savar, Dhaka area (2005) have been collapsed due to faulty construction, which takes several days for search and rescue operation and debris removal due to narrow road network for accessing the building (Rahman et al. 2015). Apart from that, in 2013, there was a massive 'Rana Plaza' building collapsed in Savar, which is considered one of the severe most man-made disaster killing 1127 people (Barua & Ansary, 2017) due to the lack of timely commencing of rescue operation. Comprehensive Disaster Management Program (CDMP), a UNDP funded project estimated that around 78,323 buildings will be destroyed completely in Dhaka city with an economic loss of US $1075 million if a 7-magnitude earthquake is occurred (Sultana et al. 2013). So, it is quite evident that in case of any disaster like Nimtoli fire incident and Rana Plaza, the effect and damages corresponding to these events will be terrific (Rahman et al. 2015).

The risk in urban center is complex due to unplanned urbanization and development in high risk zone areas. So, their aftermaths demand a prompt response from decision makers and the population, through the proper management of the emergency situations (Waugh & Streib 2006). In emergency situations, the key concern is to access rapidly to the places of damages and casualties. Timely intervention within the first two hours is critical to route the vehicles and equipment for saving the wounded people (Kaplan 1996). Therefore, the determination of the safest and speediest access routes for specific rescue interventions proves to be crucial during crisis. Scenario based impact assessment is a vital disaster management technique to devise risk reduction options for the vulnerable communities (Blaikie et al. 2005). Road inaccessibility is a major issue for taking much time to mobilize the rescue vehicles and equipment. Hence, it is necessary to identify the narrow road segments in an area.

Geographic Information Systems (GIS) may be particularly useful to locate the narrow road sections and at-risk areas very quickly. Urban vulnerability analysis using spatio-temporal information is increasingly being used by urban planners and policy makers to anticipate and mitigate catastrophic disasters. Over the past two and half decades, the use of GIS has become instrumental in addressing urban vulnerabilities at the local, national, and international levels (Alexander & Smith 1993; Rashed & Weeks 2002; Wu & Webster 2000). Using GIS, a decision-making tool to analyze the landscape and topography, researchers have identified numerous urban vulnerabilities resulting from a lack of emergency vehicle access routes and inadequate open spaces. In light of the foregoing, this paper does geospatial analysis for urban setting including spatial arrangement of road networks and vehicle densities at different time periods to identify the vulnerable zones for different study areas in Dhaka city.

Rigorous literature review is required for this kind of research using state-of-the-art GIS technology in urban context considering huge buildings and road network. Although, there are some related works that have been done on a smaller scale, extensive research is rare specially using GIS tool. Some researchers have used simulation methods to view the roles of these ensembles in urban amenities (Torrens 2006) while other researchers have taken a theoretical approach to define vulnerability, damage or injury because of biophysical factors. Rasheed and Weeks (2003) relate urban vulnerabilities to natural hazards such as earthquakes, and to human behavioral adaptations; and argue that urban vulnerabilities become intertwined with socioeconomic systems. Various layers such as houses, critical facilities, industrial sectors, and others can be overlaid together for visualization and subsequent spatial analysis (Richardson 1994). Researchers often apply multi-criteria approaches using spatial objects to examine the quality of life, urban conditions and aesthetic structures, because these "urban ensembles" represent dynamic phenomena involving people not only as users but also as victims, contributors, and modifiers (Alexander 2000; Burton et al. 1978; Koninger & Bartel 1998; Mileti 1999; Menoni, 2001). GIS technologies have proven its ability to be helpful tools to identify vulnerable and/or non-vulnerable ensembles across urban landscapes. Alexander and Smith (1993) used GIS to locate areas within seismic zones and analyzed the degrees of urban vulnerability they posed. Rashed and Weeks (2002) explained how a society might be subjected to various hazards because of its own actions, such as construction of unaesthetic and congested structures like