www. ebscohost. com
www.gi.sanu.ac.rs, www.doiserbia.nb.rs,
J. Geogr. Inst. Cvijic. 65(1) (91–106)

Original scientific paper

UDC: 911.3(=122)
DOI: 10.2298/IJGI1501091F

CITIZENS AT RISK FROM EARTHQUAKE HAZARD IN DHAKA CITY: SCALING RISK FACTORS FROM HOUSEHOLD TO CITY REGION LEVEL

Israt Ferdous & M. Maksudur Rahman***[1]
* Dept. of Disaster Science & Management, University of Dhaka
** Dept. of Geography and Environment, University of Dhaka

Received 25 June 2014; reviewed 21 February 2015; accepted 02 April 2015

Abstract: Dhaka city is under the looming threat of cataclysmic earthquake. However, the factors from which the citizens are at risk may not the same for its all parts. Dividing the city into three geographical scales: Old (Shankhari Bazaar), Developed (Segunbaghicha) and Newly Developing (Uttara 3rd Phase) areas, this research explores the risk factors of earthquake hazard from household to city-region level. Based on FGD at community level, in-depth interview of experts and policymakers, observation and secondary sources of data the study finds citizens of Old Dhaka are at high risk because of the obsolete and dilapidated building structures they live in whereas unauthorized high rise buildings is a massive threat for the dwellers living in developed Dhaka. The results of this research highlight that fact that enormous filling of low-lying lands enhances high earthquake risk and may cause severe liquefaction effects to the residents of newly developing areas of Dhaka. The comprehensive outcomes of this study are emphasized on raising the on-going public awareness programs, following the building codes strictly and implementing the disaster risk reduction approach into land use planning which can possibly reduce earthquake risk in Dhaka city.

Key words: Dhaka city, earthquake risk, city expansion, high-rise buildings

Introduction

Due to the concentration of both job facilities and other investments, Dhaka city has been experiencing a population growth of 6.5% each year. The city is identified as a earthquake risk prone city due to geological and geomorphological set-up, indiscriminate and unplanned construction of buildings. A study revealed that the Earthquake Vulnerability Index (EVI) of Dhaka city (1997) is 2nd among 20 vulnerable cities of the world. The factors of estimating such vulnerability where the population density, unplanned urbanization, non-compliance of building codes, narrow road network, lack of preparedness of the responding agencies and insignificant awareness among city

[1] Correspondence to: israt.dsm@du.ac.bd ; mmrahman2000bd@yahoo.com

dwellers and decision makers. In recent times, the collapse or tilting of a good number of high-rise buildings is occurring in Dhaka city due to non-engineered constructions of the buildings. Even Detailed Area Plan (Dap) of the city did not consider risk sensitive land use planning.

Since, Dhaka is subjected to potential earthquake threat coordinated attempts need to be taken for risk and crisis management of Dhaka City by GoB agencies, national and international NGOs. The main loophole in the disaster management area of the city is the lack of coordination among public and private organizations, overlapping mandates of city authorities in urban planning and lack of decision-making due to political conflict makes the complex governance structure. Moreover, the relevant agencies of the country are not yet trained for urban risk management to that of coastal and floodplain hazards. The ways how to reduce the vulnerability still an area of uncertainty in the country. The Present study has been undertaken to identify the indicators enhancing vulnerability of the community and city dwellers considering social and visual structural vulnerability factors.

Aim and Objective of the Study

The main aim of this study is to identify the indicator of earthquake vulnerability in order to determine the level of the elements at risk in three geographic locations within the Dhaka city area drawing the opinion of communities and householders through Focal Group Discussion (FGD), relevant professionals, practitioners and policymakers. The specific objectives of this study are as follows:

- To set up the vulnerability assessing indicators that govern the risk of earthquake in city and household level,
- To figure-out the contribution of each indicator in vulnerability enhancement,
- To delineate a road map identifying the potential interventions for risk management.

Methodology

An Attempt has been taken to figure out the indication of vulnerability earthquake based on primary and secondary information. The approach in figuring out the vulnerability indicators and extent of each indicator for risk enhancement is developed analyzing the views and reactions of the city dwellers, experts and policymakers. The information extraction has been designed in two levels - I) questionnaire survey at local community level using

the technique of Focus Group Discussion (FGD) and II) in-depth interviewing of academician, practitioners, relevant GoB professionals and policymakers. Seventy eight FGDs have been conducted both in community and household level in three study areas (Some portions of Shakhari Bazar, Segunbagicha and Uttara area representing the scenarios of old, developed and developing Dhaka). All the community groups belonging in the three studied areas have been taken into consideration during FGD to delineate the level of vulnerability due to the variety of social, economic and development trends. Table 1 represents the methods, techniques, and procedures of data collection, processing and presentations.

Table 1. Framework of methods, techniques, and procedures adopted for this study

Methods	Techniques	Procedures
Primary Field Survey	FGD with Community Groups	Strategies: Group Discussion and Personal Interview Community Groups: - Local Institutions - Local Residents and Communities - Local City Authorities - Local Business Centers Sample Procedure: Purposive
	In-depth Interview	Strategy: Face-to-Face interview Respondents: Experts, Professionals and Policymakers Sampling Procedure: Purposive
	Observation	- Participant's observation - Photographic Device
Secondary Data Collection	Relevant Literature Review	Literature from different organizations, papers, books, journals and other publications

Rationale of Selecting Three Different Study Areas

CDMP I (Comprehensive Disaster Management Program, 2009) study reveals that if an earthquake with 7.5 Richter scale is originated in Madhupur Fault, around 65 km away from Dhaka city area, the possibility of complete, moderate and extensive building collapse will be 72000. These collapses will also generate 30 million tons of debris. Since, the earthquake has not been happening in last 100 years, the awareness and preparedness in all levels of social and administrative units are relatively insignificant in order to reduce and manage the earthquake risk to an acceptable level. Hence, this study has attempted to identify and analyze the vulnerability factors with respect to social and structural aspects (observed) in three different areas considering that there might have variations in structural and non-structural vulnerabilities and soil conditions of the ground within the city area. In case of a community survey, Dhaka city has been divided into three regions (old, developed, and developing areas) which

represent three different phases of historical development of the city. The areas are:

- Shakhari Bazar from old Dhaka (Old ward number 71 and 72)
- Segunbagicha from developed Dhaka (Old ward number 56)
- Uttara from developing Dhaka (Old ward 01)

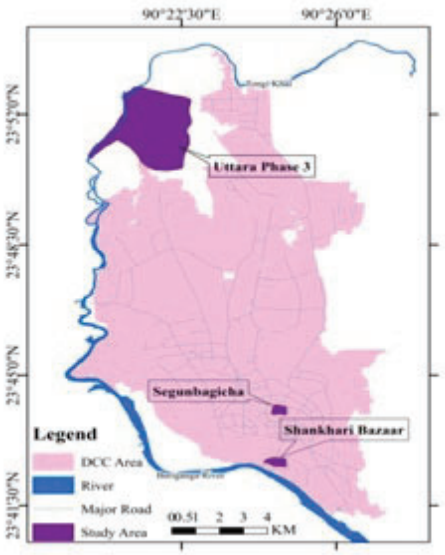

Figure 1. Location of study areas in Dhaka City

Source: Shape file collected from Comprehensive Disaster Management and Programme, 2009

Tectonic Set-up of Bangladesh

Two major active tectonic belts threaten Bangladesh for large and potentially destructive earthquakes which are the Himalayan system in the north and the Arakan subduction-collision system in the east. The Main Frontal Thrust Fault (MFT) and the Dauki Fault (DF) are the principal components of the former system and the Naga Thrust Fault (NTF), the Arakanmega Thrust (AMT) and the Chittagong-Tripura Fold Belt (CTFB) of eastern Bangladesh is a manifestation of the latter. Figure 2 (a) shows the active fault model of Bangladesh whereas Figure 2 (b) represents geodynamic model of the region. According to CDMP-I study (2009), there are three major active faults in and around Bangladesh, such as, (i) Madhupur fault, (ii) Dauki fault and (iii) Plate-boundary fault. All these faults are capable to generate earthquake in the magnitude of 7.0 or above in various recurrence periods. CDMP-I (2009)

revealed that the possible earthquake originating from the geological faults given in Figure 2 (b) has the potential to cause extensive damage in the Dhaka city area.

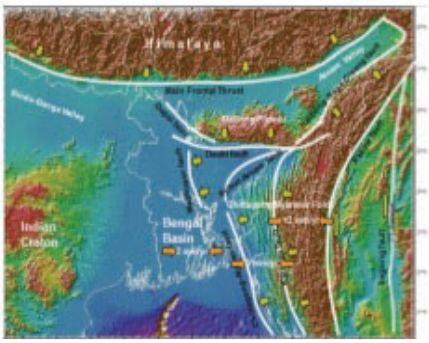

Figure 2 (a). Active Fault Model of Bangladesh (CDMP-1, 2009)

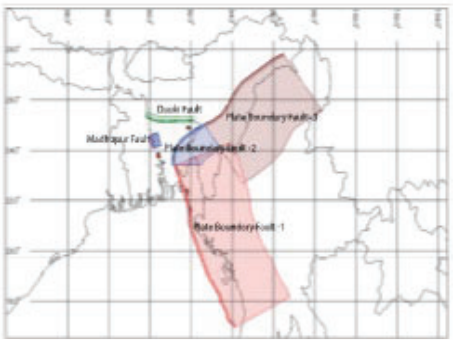

Figure 2 (b). Geodynamic Model of Bangladesh (Akhtar, 2012)

Indicators of Vulnerability Assessment

Vulnerability and risk carry potential meaning in order to determine the damage and loss caused by a disastrous event. Vulnerability is defined as the degree of loss to a given element or set of elements resulting from the occurrence of a natural phenomenon of a given magnitude. United Nations International Strategy for Disaster Reduction (UNISDR, 2009) defined vulnerability as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. In other word, risk is the chances of an occurrence of a hazard and its impact on the exposed communities or assets. The level of risk depends upon the nature of hazards, vulnerability of the elements at risk and level of the capacity of the households and communities which enable them to cope with, withstand, prepare for, prevent, mitigate, or quickly recover from a disaster. Yodmani (2001) presented a disaster risk formula as below:

$$\textit{Disaster RISK} = \textit{Hazard} * \textit{Vulnerability} / \textit{Capacity} \quad (1)$$

Vulnerability is usually governed by two conditions, such as, structural and non-structural. Structural vulnerability is related to construction (structural design, location of houses on an unstable slope, soft soil and fill land) of the infrastructure. Nonstructural vulnerabilities have the social (disorganized or fragmented society, lack of education, bad leadership); economical (fragile livelihoods, no credit and saving facilities) and individual (lack of skills or

knowledge with regard to preparedness; lacking opportunity due to gender; being old or very young) aspects. As mentioned in methodology, this study is built on questionnaire survey, expert opinion and visual observation of structure; hence indicators of vulnerability that considered in this study to determine the level of risk are (i) social and (ii) observed/visual structural conditions.

Social Vulnerability Conditions

Based on the expert opinions, five indicators have been identified to understand the conditions of social vulnerability of the citizen at risk. These indicators are (i) socio-economic conditions (ii) building uses (iii) availability of contact numbers of fire station at household level (iv) awareness and preparedness of earthquakes during the occurrence of the event (v) building ownership. The description and analysis of the social vulnerability indicators are given below.

Socio-economic Conditions of the Citizen at Risk

Education, financial ability and job pattern somehow govern the vulnerability of community and householder. The survey reveals that 19% respondents of Shakhari Bazar completed secondary education and graduation. Whereas, 48% respondents of Segunabagicha and 41% respondents of Uttara completed their post-graduation but 8% respondents of Shakhari Bazar completed the degree mentioned**.** By occupation, the family head involved in business are 69%, 24% and 20% respectively in Shakhari Bazar, Uttara and Segunbagicha. About 80% and 76% respondents are service holders in Segunbagicha and Uttara respectively. Economic point of view, residence in Uttara and Segunbagicha are relatively well-up to that of Shakhari Bazar. This statistic reveals that in terms of education, financial ability and job pattern, the vulnerability of the community as well as householders is higher in Shakhari Bazar to that of Uttara and Segunbagicha. In this context, the status of Uttara and Segunbagicha is almost same.

Building Uses

Unauthorized uses of the buildings enhanced the vulnerability. In Shakhari Bazar, there are mix uses of buildings with residential, commercial, administrative and service activities. Mix uses of the buildings in Shakhari Bazar (ground floor is used for the storage of various materials or shopping and the upper floors are for residing) consists of 90%. Only 10% building is used for residential purpose. In most cases, in the ground floor, flammable materials like cloths, fiber and plastic equipment's are found to be conserved. In Segunbagicha and Uttara, predominantly most of the buildings have residential uses and multi-

purpose buildings are almost absent. The survey showed that in Segunbagicha 70% buildings are residential, 26% building for commercial purpose and 4% use for others, whereas 95% building is residential and 5% buildings are mixed uses in Uttara. Multipurpose uses of the buildings and the presence of flammable substances, the vulnerability of Shakhari Bazar is higher to that Segunbagicha and Uttara areas. On the other hands, Uttara area is less vulnerable than Segunbagicha in context of multipurpose uses of the building.

Availability of Contact Number for Fire Station at Household Level

Fire Service and Civil Defense (FSCD) is the first responder during any disaster. Theoretically, city dwellers should have the contact number of nearest fire station. In Segunbagicha, most of the respondents (83%) are conscious about fire hazards and they have a contact number of nearest fire station at home to their locality whereas 60% people have that contact number in Uttara. On the other hand, 58% respondents of Shakhari Bazar don't have the contact number. Considering the non-availability of FSCD contact number, Shakhari Bazar is more vulnerable than Segunbagicha and Uttara areas. Residents of Segunbachia area are more aware to get the service of FSCD during emergency. Figure 3 below represents the availability of contact number of the nearest fire station in household level of investigated area.

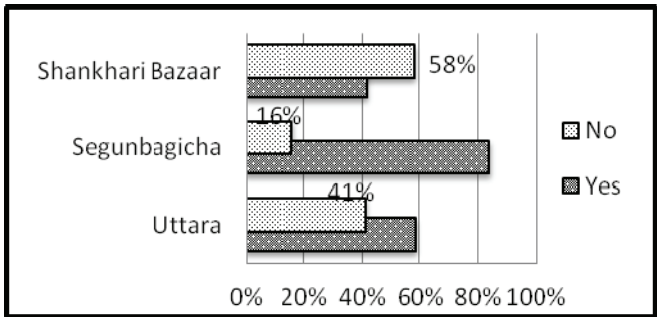

Figure 3. Contact number of nearest fire station at household level of surveyed locality

Awareness and Preparedness of Earthquake during the Occurrence of Event

Awareness and subsequent preparedness in community and household level reduce the primary, secondary hazard of earthquake as well as injury, casualty and property damage. The field survey showed that most of the people of Segunbagicha and Uttara area are aware of the possible earthquake threat of Dhaka City. But dwellers in Shakhari Bazar are more concerned on water logging, fire hazard, drainage problem rather than an earthquake during the

surveyed period, responders have been asked how they will respond during the occurrence of an earthquake. Particular queries were: (i) if they would take Drop-Cover-Hold position under or near a sturdy desk or a table. (ii) If they would use the elevators or stairs, (iii) if they would jump from the upper floor of the building, (iv) how they would handle gas and electricity system. Survey data shows that 64% and 65% respondents in Segunbagicha and Uttara area respectively, are educated on the preparedness of the above queries. In Shakhari Bazar 83% resident are not familiar on the above mentioned preparedness during earthquake. About 41% and, 48% respondent of Uttara and Segunbagicha are educated on earthquake mock drills regarding how to response during the period of emergency. Whereas, 8% respondents are educated on said mock drills in Shankhari Bazar area. Survey results reveal that citizens of Segunbagicha and Uttara area are more educated on the emergency response of earthquake with respect to Shakhari Bazar.

Building Ownership

Most of the surveyed buildings are private ownership in Uttara. On the other hand, private ownership belongs to 84% and 83% in Segunbagicha and Shakhari Bazar respectively. Another type of property ownership also exists in Shakhari Bazar known as ‘vested property or enemy property’ constitutes 11%. The interview reveals those private owners are not concerned with the re-strengthening techniques of the building.

Structural Vulnerability of the Investigated Area

The vulnerability of the building is largely governed by soft storey, heavy overhang, short column and pounding effect. Soft story buildings are characterized by having open space in ground floor. Heavy overhang indicates inclusion of extra-mass in the building in the form of a balcony, terrace, horizontal extension of the building, etc. A short column is a structural member that is shorter than other components in the same building. Pounding effect define the possibility of collision between adjacent buildings during ground motion. City dwellers are not much educated to understand these vulnerability factors. During the field survey, simplified questionnaire has been designed for the city respondents following the suggestions of experts to figure-out the vulnerability of the surveyed buildings. These are: (i) ground shaking experience with respect to the height of the buildings (ii) building fabrics and intriguer (iii) type of settlement and a number of building storey (iv) age of building (v) pounding effect (vi) alternative stairway of buildings (vii) alternative accessibility to road and open spaces.

Ground Shaking Experience

Usually residence of high rise buildings (Building Construction Regulation, 2012) experienced strong shaking during earthquake. 45% respondents opined that they felt moderate to violent shaking in Segunbagicha (intensity corresponds to V-VI in Modified Mercalli scale) in high rise building. On the other hand, 42% respondents experienced moderate to violent shaking in Shankhari Bazar to that of Segunbagicha where the building height is around 2-4 storey. Noted that most of the buildings are 5 or 6 storey in Uttara, as a result when earthquake occurs 42% respondents feel moderate shaking (intensity correspond to IV-V). Survey analysis reveals that the response with regard to ground shaking is almost same in three areas of investigations irrespective of height constraint. Though the building height in Shankhari Bazar is low to that of Segunbagicha and Uttara, but the intensity of ground shaking is almost same in three different areas. Figure 4 below shows the people's reactions during earthquake.

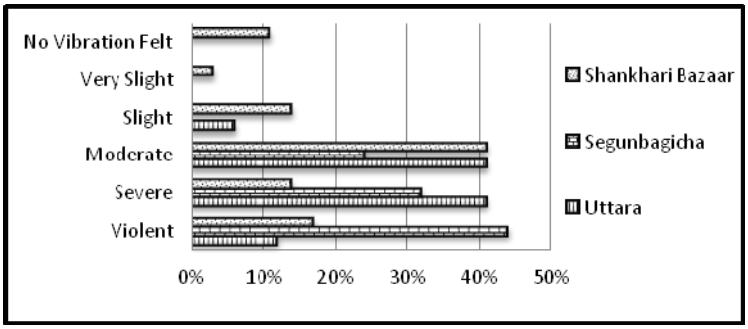

Figure 4. Ground shaking experienced at household level in the surveyed areas of Dhaka

Source: Community Survey, July-August 2012

Building Fabrics and Intriguer

Non-engineered buildings are always vulnerable for earthquake. Patterns and types of the building also influence the damage of the building. In Segunbagicha and Uttara 88% buildings made by competent engineer whereas only 8% buildings designed by engineer in Shankhari Bazar. On the other hand, 42% respondents of Shankhari Bazaar did not know whether their buildings designed and constructed by involving competent engineers/architects. This statistic reveals that buildings are potentially vulnerable to earthquake risk in Shankhari Bazaar to that of Uttara and Segunbagicha. Figure 5 below represents the involvement of competent engineers in building design and construction.

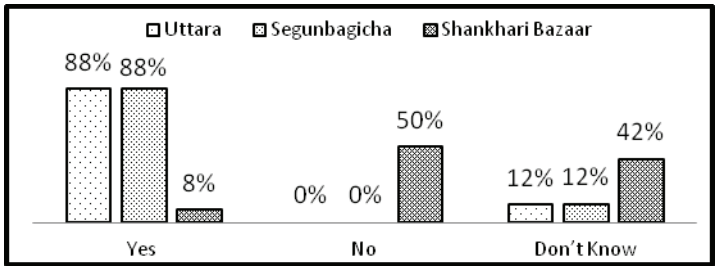

Figure 5. Buildings designed by competent architect/engineer in the Surveyed Areas in Dhaka

Source: Community Survey, July-August 2012

Type of Settlement and Number of Building Storey

Above six storey building is defined as high rise in BNBC (1993). The trends of making high rise buildings are mostly seen in developed and developing Dhaka. The Survey reveals that 96% and 41% are reinforced high rise concrete buildings in Segunbagicha and Uttara area as of BNBC (1993). Some (6%) semi-pucca structures are also seen in Uttara. In Shankhari Bazar, 80% are masonry buildings. Though mostly engineered construction is going on, but table 3 below shows progressive vertical expansion in Uttara and Segunbagicha, which could be vulnerable to earthquake because most of the owners of the buildings generally don't aware of Bangladesh National Building Code (BNBC), but concerned developers urge that they follow BNBC. Experts mention that most of the developers don't follow minimum standard of building code during construction.

Table 2: Number of building storied in surveyed areas of Dhaka city

Location	Number of Building Storey				
	1 to 5	6 to 10	11 to 15	16 to 20	21 +
Uttara	59%	41%	0%	0%	0%
Segunbagicha	4%	36%	36%	20%	4%
Shankhari Bazaar	78%	22%	0%	0%	0%

Source: Community Survey, July-August 2012

Age of Building

Age of the building is also an indicator that makes the structure vulnerable. There are prominent variations find in building ages among three studied areas. Structures in Shankhari Bazar are mostly centuries old where 50% buildings are found above 51 years of old and 5% are almost 350 years. In Segunbagicha and Uttara, the age of the most of the building is less than 10 years. Figure 6 illustrates the variation of building ages in three investigated areas.

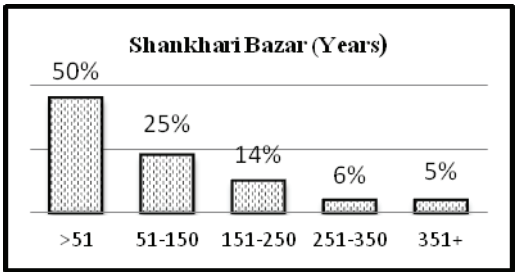

Figure 6. Age of Building in Segunabgicha, Uttara and Shankhari Bazar

Source: Community Survey, July-August 2012

Pounding Effect

Seismic pounding is defined as the collision of adjacent buildings during earthquakes. The main cause of seismic pounding is insufficient separation between the buildings. In Dhaka city, Shankhari Bazar is one of the densely populated areas and it is very much congested. Almost 80% buildings don't have any gap between them. Whereas, in Segunbagicha and Uttara area, 92% and 100% buildings have such gap respectively that could reduce the possibility of a pounding effect to an extent, but need more investigation.

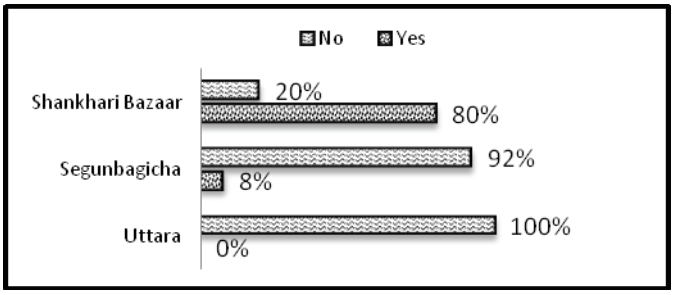

Figure 7. Gap between buildings that may cause a pounding effect in the surveyed areas

Source: Community Survey, July-August 2012

Alternative Stairway in Buildings

During earthquake induced fire hazard alternative stairway is the safest option to exit the building. In Shankhari Bazar, 86% respondents don't have alternative stairway. In Segunbagicha, almost 88% apartment buildings have alternative stairway (Figure 8). In some cases, these alternative stairways are used for different purposes such as the place of store room of the apartments (Figure 8). The survey reveals that some of the people don't know how to use the

alternative stairway to exit and some are totally unknown. In some cases, though alternate stairways exist, but are not enough spacious to get off all residents quickly during earthquake. About 61% of the building stairways in Shankhari Bazar are very narrow and inaccessible.

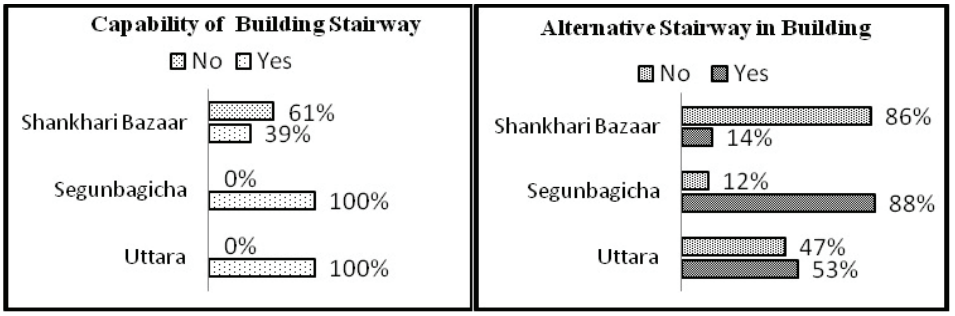

Figure 8: Alternative stairways and capability of building stairways

Source: Community Survey, July-August 2012

Alternative Accessibility to Road

Every locality must have alternative access roads and available transport facilities for residents. If their own roads collapsed during hazard, people can use these alternative ways. Almost the respondents of Segunbagicha and Uttara stated that they have alternative access ways to use for daily purpose and during the disasters as well (Table 3). However, in Shankhari Bazar where narrow access roads are routine hazards for the local people, which would be defined major risk factor during the disastrous events.

Table 3: Alternative access road in the surveyed locality

Location	Alternative Access Road in Locality	
	Yes (%)	No (%)
Shankhari Bazaar	6	94
Segunbagicha	100	0
Uttara	100	0

Source: Community Survey, July-August 2012

In Shankhari Bazaar, 56% respondents stated that roads are very narrow and congested here, which is inaccessible to pass in for rescue vehicles. On the other hand, Segunbagicha and Uttara areas have enough space to give access of heavy and light vehicles for rescue purposes.

Soil Type and Related Structural Vulnerability

Dhaka city has been expanding haphazardly without considering disaster risk management issue. Specially, most of the low lying areas adjacent to the urban centers are being filled which are most vulnerable for earthquake hazard like liquefaction. Moreover, Uttara 3rd phase, which is now filled with sand (Figure 9) for an expansion of planned residential area is the combination of floodplain and marshy land (Figure 10). Thickness of the filling range could be 70-150 feet in Uttara 3rd phase area. Survey data shows that 76% respondents' buildings stand on soft ground at Uttara 3rd phase area, whereas in Shankhari Bazaar 75% respondents live on solid land. Besides, box culverts are observed in some of the places of Segunbagicha as those places were previously canals. Some respondents said that their buildings are constructed in Segunbagicha with heavy pilling. Though the construction of the buildings are relatively good in Uttara area, but soft and thick infill soil enhances the vulnerability of the buildings.

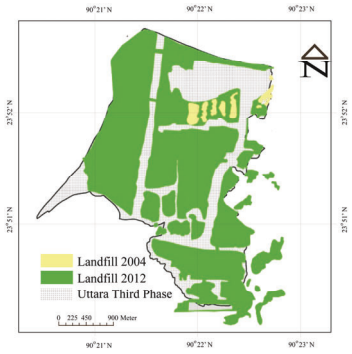

Figure 9: Landfill area in Uttara 3rd Phase

Source: Community Survey, July-August 2012

Development of Road Map for Earthquake Risk Reduction Interventions

Considering the possible earthquake threat and social as well as the structural vulnerability of the study areas as well as the opinion of the experts, the necessary interventions for earthquake risk reduction are given in Table 4. The interventions are categorized into two groups, for developed and developing Dhaka (one cluster) and old Dhaka (another cluster).

Marshy Land Fill Process

Figure 10. Marshy land and Fill Procedure in Uttara 3rd phase

Source: Community Survey, July-August 2012

Table 4: Road Map of Possible Interventions for Earthquake Vulnerability

Category of study are for selecting interventions	Possible interventions	Time-frame (Initiated within 6 months=short term, 6 months-2 years= Intermediate and Above 2 years= Long term)	Possible agency to carry out	Comments
Developed and Developing Dhaka	Training on BNBC for the engineers	Short term	Public works Department	Expert opinion
	Training for masons and bar binders	Short term	Ministry of Housing and Public Works	Expert opinion
	Extensive awareness development through mock drills and SMS	Short term	Fire service and Civil Defence (FSCD), School Curriculum and Text Board (NCTV), Mobile Company	Responders opinion
	Household vulnerability reduction through TV, ICT materials, Local cable operators	Short term	Department of Disaster Management, Ministry of Information	Responders opinion
	Development of sustainability plan for the volunteers trained and procure light equipment for the volunteers use	Short term	Fire Service and Civil Defence, Department of Disaster Management	Expert opinion
	Preparing road for possible evacuation	Intermediate	City corporation and roads and high ways	Responders opinion
	Preparation of open space to use during disaster time	Intermediate	City corporation and Department of Disaster Management	Expert opinion
	Clearance certificate of each building	Intermediate	RAJUK and City Corporation	Expert opinion

	with regard to compliance of BNBC			
	Availability of Soil characterization map reflecting ground shaking	Intermediate	Geological Survey of Bangladesh, Department of Disaster Management	Expert opinion
	Risk sensitive landuse planning and implementation	Long term	Urban Development Directorate and RAJUK	Expert opinion
Old Dhaka representing historical development	All above mention interventions should also be applicable for Old Dhaka. Some new interventions need to be address for old Dhaka.			
	Introduction of Urban regeneration	Long term	RAJUK, City Corporation	Expert opinion
	Retrofitting of the heritage buildings	Long term	RAJUK, City Corporation	Expert opinion
	Detail technical assessment of Old buildings and conducting necessary actions for making them resilient	Long term	RAJUK, City Corporation	Expert opinion

Conclusion

The objectives of this study is to set up the vulnerability assessing indicators that govern the risk of an earthquake in the city and household level as well as to figure out the contribution of each indicator in vulnerability enhancement. Based on the analysis of vulnerability indicators, this study also delineates a road map identifying the potential interventions for risk management. This study has been conducted in three study areas, namely; Shankhari Bazar of old Dhaka, and Segunbagicha as well as Uttara is reflecting developed and developing Dhaka respectively. Three different study areas represent three phases of development from historic to recent days. In order to figure out the objectives of this study Focal Group Discussion (FGD) has been conducted with seventy eight community groups. Based on the expert opinions, five indicators have been identified to understand the social vulnerability of the citizen at risk. These indicators are (i) socio-economic conditions (ii) building uses (iii) availability of contact numbers of fire stations at household level (iv) awareness and preparedness of earthquakes during the occurrence of the event (v) building ownership. During the field survey, simplified questionnaire has been designed for the city respondents following the suggestions of experts to figure-out the structural vulnerability of the surveyed buildings. These are: (i) ground shaking experience with respect to the height of the buildings (ii) a building fabrics and

intriguer (iii) type of settlement and a number of building storey (iv) age of building (iv) pounding effect (v) alternative stairway of buildings (vi) alternative accessibility to road and open spaces and (vii) Soil type and related structural vulnerability.

Analysis of the social and visual structural vulnerability reveals that the infrastructure in Shankhari Bazar area is more vulnerable to that of Segunbagicha and Uttara 3rd phase areas. Though the buildings of Uttara and Segunbagicha areas are younger as well as most them they belong to reinforced concrete buildings to that of older masonry buildings of Shankhari Bazar, but the intensity of ground shaking appears similar in all three areas of investigations. Considering the possible earthquake threat and social as well as the structural vulnerability of the study areas as well as the opinion of the experts, a road map has been proposed with potential areas of interventions to reduce the risk of earthquakes. Road map also identifies the potential agency responsible to carry-out the implementation of interventions within a certain time frame.

Acknowledgement
During my paper work, with immense gratitude I acknowledge the help of my supervisor, one of the professors of Department of Civil Engineering, Bangladesh University of Engineering and Technology, Chief town planner of Dhaka City Corporation, my younger brother, some of my friends and fellows of the University of Dhaka for their thoughtful guidance, critical comments, support and inspiration.

References

Bangladesh National Building Code (1993). Building and Housing Research Institute, Dhaka

CDMP-I (2009). *Seismic Risk Assessment of Dhaka*, Chittagong and Sylhet City Corporation area

CDMP-I (2009). *Time-predictable fault modeling for Seismic Hazard and Vulnerability Assessment of Dhaka*, Chittagong and Sylhet City Corporation Area.

Davidson, R. A., & Shah, H. C. (1997). An *Urban Earthquake Disaster Risk Index*, Department of Civil and Environmental Engineering, Stanford University

UNISDR (2009). UNISDR terminology on disaster risk reduction. UNISDR, Geneva. Retrived from http://www.unisdr.org/we/inform/publicaitons/7817.

Yodmani, S. (2001). Disaster risk management and vulnerability reduction: protecting the poor. In: *Paper presented at the Asia and Pacific Forum on Poverty*. Organized by the Asian Development Bank