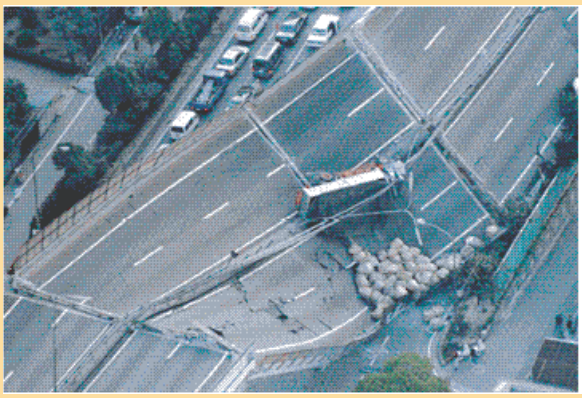
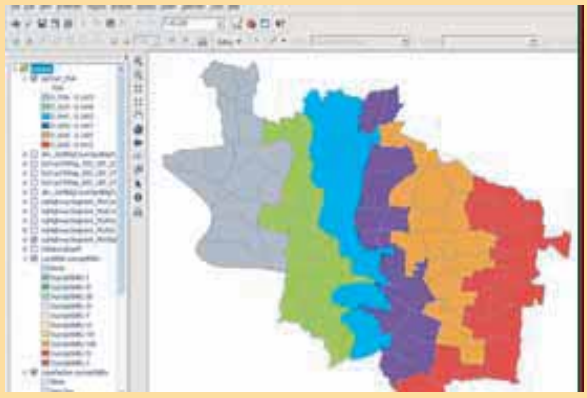
Earthquake Risk Assessment of Dhaka, Chittagong and Sylhet City Corporation Area



June 2009

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Comprehensive Disaster Management Programme (CDMP)
Ministry of Food and Disaster Management (MoFDM)
Government of the People's Republic of Bangladesh

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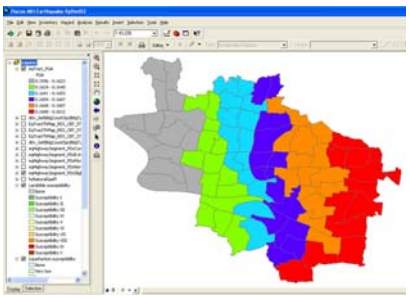
Main Report

Report On

Risk Assessment of Dhaka, Chittagong and Sylhet City Corporation Area



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Executive Summary

This report presents a seismic risk assessment of the buildings, essential facilities and lifelines based on a GIS database that was developed from existing secondary data and field survey in Dhaka, Chittagong and Sylhet City Coproration areas. The assessment provides forecasts of damage and human and economic impacts in those study areas that may result from an earthquake. The analyses are run on HAZUS software package. HAZUS risk assessment methodology include interdependent modules of (1) potential earth science hazard assessment, (2) inventory of buildings, essential facilities and lifelines, (3) direct physical damage calculation, (4) induced physical damage calculation, and (5) direct economic/social losses.

To run the assessment, city corporation wards are divided into smaller area called cluster to provide detail level of data and results. In Dhaka City Corporation area, there are 552 clusters in 91 wards (90 ward and cantonment area). While 41 wards Chittagong City Corporation are divided into 285 clusters, and 27 wards of Sylhet City Corporation into 82 clusters.

It is estimated that there are 326,000, 182,000, and 52,000 buildings in Dhaka, Chittagong, and Sylhet City Corporation Areas respectively, which have an aggregate total replacement value of 16,759 millions of dollars for Dhaka, 3,400 millions of dollars for Chittagong, and 940 millions of dollars for Sylhet. The total population of Dhaka, Chittagong and Sylhet are approximately 7.2, 2.3 and 0.4 millions respectively.

There are 600 hospitals, 2,737 schools, 10 fire stations, 62 police stations and 18 emergency response agency offices in Dhaka City Corporation area. While in Chittagong, there are 162 hospitals, 1,033 schools, 12 fire stations, 11 police stations and 11 emergency response agency offices. And in Sylhet, there are 87 hospitals, 211 schools, 2 fire stations, 6 police stations, and 9 emergency response agency offices.

The lifeline inventory in Dhaka City Corporation area includes over 1,270 kilometers of highway road, 10 highway bridges, and 2,582 kilometers of potable water, waste water, and gas pipes. While in Chittagong, the lifelines include 639 kilometers of highway road, 4 highway bridges, and 792 kilometers of potable water and gas pipes. In Sylhet, the lifelines include 148 kilometers of highway road, 2 highway bridges, and 268 kilometers of potable water and gas pipes.

For each city corporation area, three earthquake scenarios (Scenario 1-3) were selected from the study of Seismic Hazard Deterministic Analysis. Among these, two cases were selected from five fault models given in SHA and the other were selected from TAG comment that earthquake of moment magnitude 6.0 has potential to occur beneath each city. While from Seismic Hazard Probabilistic Analysis, one scenario (Scenario 4) was selected for Dhaka and Chittagong City

Corporation Areas, and two scenarios (Scenario 4 and 5) for Sylhet City Corporation Area. The worst scenario for Dhaka City Corporation Area is Scenario 4, while for Chittagong and Sylhet is Scenario 1 and 5 respectively.

For the worst case scenario, HAZUS estimates that about 270,604 buildings will be at least moderately damaged in Dhaka City Corporation area. This is over 83% of the total number of buildings in the study area. There are an estimated 238,164 buildings that will be damaged beyond repair. While in Chittagong, there are about 168,150 buildings will be at least moderately damaged, and this is over 92% of the total number of buildings in the city. There are an estimated 142,855 buildings that will be damaged beyond repair. In Sylhet, HAZUS estimates that about 51,858 buildings will be at least moderately damaged. This is over 99.50% of the total number of buildings in the city. There are an estimated 50,879 buildings that will be damaged beyond repair.

In lifeline system, 10, 4, and 2 (all) major highway bridges will be at least moderately damage in Dhaka, Chittagong, and Sylhet. It is estimated 748 potable water facilities, 7 gas compressor stations, and 54,815 electrical power facilities will be at least moderately damage in Dhaka. While in Chittagong, 72 potable water facilities, 22 gas compressor stations, and 28,407 electrical power facilities will be at least moderately damage. And in Sylhet there will be 18 potable water facilities, 1 gas compressor stations, and 9,057 electrical power facilities at least moderately damage. For the utility network, there will be around 1016 leak and break of potable water pipeline and 684 leak and break of natural gas pipeline in Dhaka. In Chittagong it will be around 727 leaks and breaks of potable water pipeline and 229 leaks and breaks of natural gas pipeline. In Sylhet, it will be around 122 leaks and breaks of potable water pipeline and 97 leaks and breaks of natural gas pipeline.

The earthquake in the worst case scenario will generate 72, 17, and 5 millions of ton of debris in Dhaka, Chittagong, and Sylhet respectively. It will also trigger 107 ignitions of fire following earthquake in Dhaka, 36 ignitions in Chittagong, and 13 in Sylhet.

Before the earthquake, there are 59,849 hospital beds available for use in Dhaka City Corporation area. On the day of the earthquake with the worst case scenario, the model estimates that only 7,441 hospital beds (12%) are available for use by patients already in the hospital and those injured by the earthquake. While in Chittagong, there are 21,664 hospital beds available for use. With the worst case earthquake scenario, HAZUS estimates that only 923 hospital beds (4%) are available for use by patients already in the hospital and those injured by the earthquake. In Sylhet there are 8,722 hospital beds available for use, and in worst case earthquake scenario it is estimated that only 17 hospital beds (0%) are available for use by patients already in the hospital and those injured by the earthquake.

Regarding fatalities in the worst case scenario, HAZUS estimates the number of killed victims is 260,788, 95,183 and 20,708 for Dhaka, Chittagong, and Sylhet respectively if the earthquake

occurs during night time (2:00AM). If the earthquake occurs during day time (2:00PM), the number of victims is 183,450, 73,213 and 14,276 for Dhaka, Chittagong, and Sylhet respectively.

In the worst case scenario, estimated total building-related economic losses are 15,603 millions of dollars, 3,112 millions of dollars, and 1,105 millions of dollars in Dhaka, Chittagong, and Sylhet City Corporation areas respectively. While for the lifeline, the losses are 364, 244, and 117 millions of dollar in Dhaka, Chittagong, and Sylhet respectively.

1. Introduction

1.1. Background Information

Over the past decades, urbanization in Bangladesh has been rapidly taking place without proper guidance. As a result many of the urban centers have developed haphazardly. These urban centers are fast growing and influence the economic developments of the country. It is therefore essential to have a realistic understanding on the nature, severity and consequences of likely damage/loss that a possible event of earthquake could cause. A strong earthquake affecting a major urban center like Dhaka, Chittagong, or Sylhet may result in damage and destructions of massive proportions and may have disastrous consequences for the entire nation.

Considering this reality, the Comprehensive Disaster management Programme (CDMP) of the Government of Bangladesh (GoB) is being implemented by the Ministry of Food and Disaster Management (MoFDM) and is supported by UNDP, DFID-B and the EC. CDMP is designed to strengthen the Bangladesh Disaster Management System and more specifically to achieve a paradigm shift from reactive response to a proactive risk reduction culture. Under Component 4a, CDMP has assigned responsibility to Asian Disaster Preparedness Center (ADPC) for implementation of Seismic Hazard and Vulnerability Mapping of Dhaka, Chittagong and Sylhet City Corporation areas.

This report presents the seismic risk assessment of Dhaka, Chittagong and Sylhet City Corporation areas - a continuation of the previous report on vulnerability assessment. Chapter one describes the project background and risk assessment methodology. Chapter two presents the general description of the study areas in Dhaka, Chittagong, and Sylhet City Corporation. Chapter three reports the inventory of the assessed components at risk that include buildings, essential facilities, and lifelines. Chapter four describe the earthquake scenarios that are considered for the risk assessment. Chapter five reports the risk assessment calculation and analysis results made by the HAZUS model. The results of risk assessment include: direct earthquake damage, induced earthquake damage, casualties, and economic losses to the components at risk.

1.2. Risk Assessment Methodology

The seismic risk assessment describes the scale and the extent of damage and disruption that may result from potential earthquakes. Damage and risk assessment for seismic hazard provide forecasts of damage and human and economic impacts that may result from earthquake. The scope of work covers the risk assessment of general building stock, essential facilities (hospitals,

emergency operation centers, schools) and lifelines (transportation and utility systems). In this project, the risk assessment is executed using the HAZUS software package. HAZUS was developed by the United States' Federal Emergency Management Agency (FEMA) and National Institute of Building Sciences (NIBS). It is a powerful risk assessment software program for analyzing potential losses from disasters on a regional basis. This risk assessment scheme can be used primarily by local, regional, and central government officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

HAZUS operates through a Geographic Information System (GIS) application i.e. ESRI ArcGIS platform. For risk assessment analyses of Dhaka, Chittagong, and Sylhet City Corporation areas, defaults databases for the United States are replaced with Bangladesh databases of the 3 cities. Ground shaking is characterized quantitatively using peak ground accelerations and spectral response accelerations. HAZUS methodology aggregates the general building stocks on a cluster basis, but is site-specific for essential facilities and lifelines. The transportation and utility lifeline losses are combined in one package with losses associated with the general building stock and essential facilities.

The framework of the HAZUS risk assessment methodology includes six major modules shown in Figure 1-1. As indicated by the arrows in the figure, the modules are interdependent with the output of one module acting as input to another. Explanation of every module is given as follows.

1. Potential Earth Science Hazards (PESH)

PESH module estimates ground motion and ground failure. Ground motion demands, for example, peak ground acceleration and spectral acceleration, are estimated based on earthquake source parameters, attenuation relations and geological data. Ground failure which is caused by landslides, liquefaction and surface fault rupture are quantified by permanent ground deformation (PGD). This PGD is determined based on topological data, geological data and ground water depth.

2. Inventory

The inventory contains tools for describing the physical infrastructure and demographics of the study area in 3 cities. It uses standardized classification systems for the groups of components at risk: (a) general building stock, (b) essential facilities, (c) transportation system components, and (d) utility system components. These groups are defined to address distinct inventory and modeling characteristics. An extensive amount of GIS database is utilized to develop dataset for these groups.

The general building stock is classified by occupancy (residential, commercial, etc.) and by model building type (structural system and material, height). Characteristic relationships

between occupancy and structure types are developed based on building survey data. Population data is derived from the average of building occupants per unit building floor area, which is obtained from the building survey. Estimates for building exposure are based on for building replacement costs (dollars per square foot) for each model building type and occupancy class that has been modified to local/Bangladesh cost. Dataset of essential facilities lifelines are developed from GIS database and secondary sources (service provider authority), clarified and enhanced through the field survey.

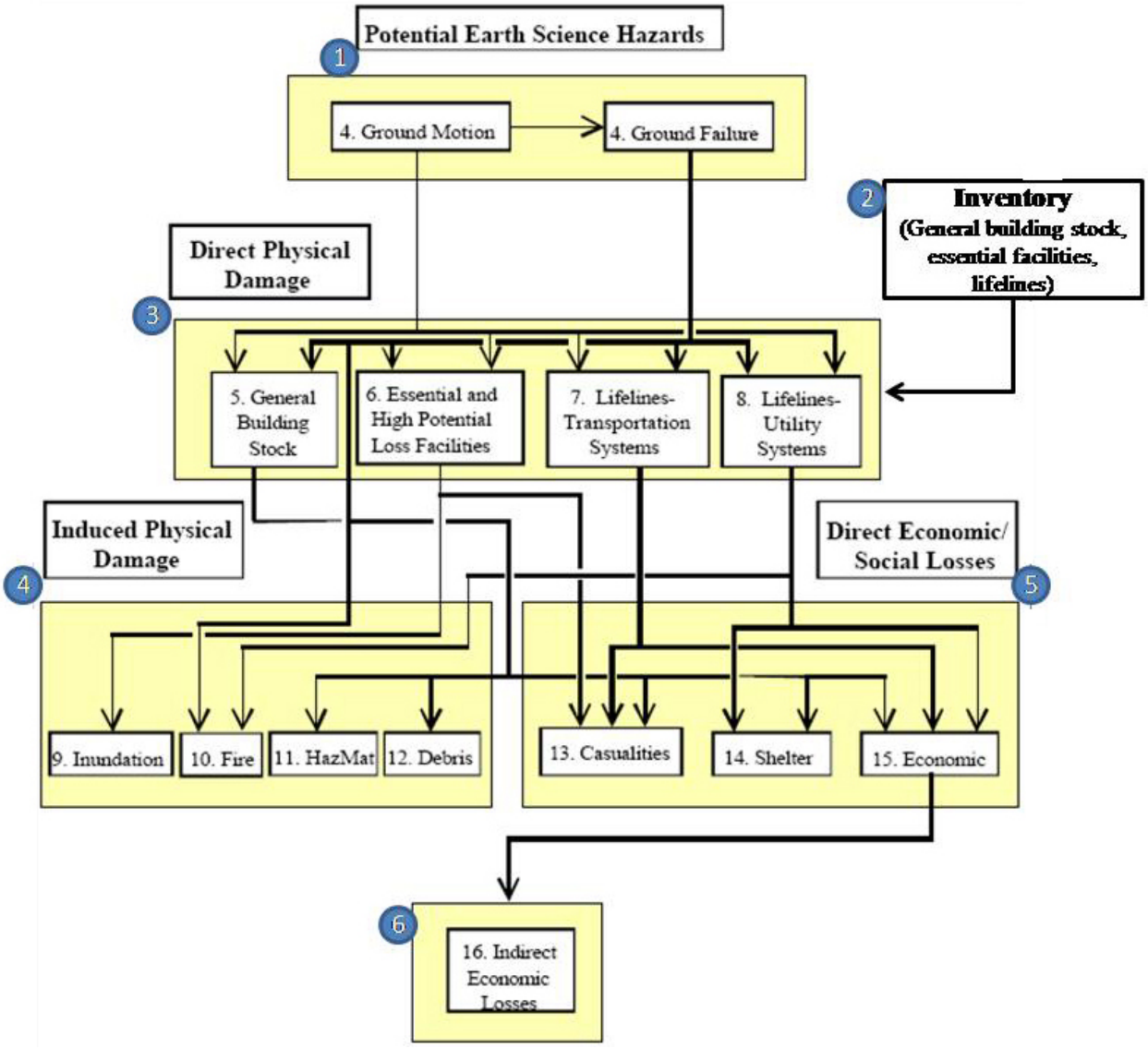


Figure 1-1 Flowchart of HAZUS Earthquake Risk Assessment Methodology

3. Direct Physical Damage

This module provides damage estimates in terms of probabilities of occurrence for specific damage states given in a specified level of ground motion and ground failure. Estimates also

include loss of function to essential facilities and lifelines and the anticipated service outages for potable water and electric power.

For buildings, the capacity-demand spectrum method as implied by HAZUS is utilized for the estimation of seismic demand. The estimated seismic demand is, thus, used to determine the probability of being in a particular damage state through fragility functions. However, the seismic performance of buildings in Bangladesh is different from that of United States. As a result, a new set of building capacity spectrum and fragility functions were developed based on the field survey data and comprehensive numerical analyses.
For both essential facilities and general building stock, damage state probabilities are determined for each facility or structural class. Damage is expressed in terms of probabilities of occurrence of specific damage states, given a level of ground motion and ground failure. Five damage states are identified - none, slight, moderate, extensive and complete.

For lifeline, the methodology focuses upon estimating damage and restoration times for every system of transportation (highway, railway, bus, and ferry) and utility (potable water, waste water, natural gas, electric power, communication). Overall fragility curves for a system are evaluated using fault tree logic to combine components fragility curves. The hazard is typically represented by peak ground acceleration and permanent ground deformation. Utilizing overall fragility curves, damage state probabilities are calculated for the lifeline components. Restoration times are evaluated from very simplified rules, relating to degree of damage and size of component.

4. Induced Physical Damage

Once direct physical damage is available, induced damage can be evaluated. Induced damage is defined as the secondary consequences of a natural hazard other than damage due to the primary hazard (earthquake) that led to losses. Here, the methodology calculates damage due to fire following an earthquake and tonnage of debris generation. For estimation of the impacts from the fires that follow an earthquake, HAZUS methodology utilizes Monte Carlo simulation techniques to assess the potential impacts and separated the module into 3 major elements: fire ignition, spread, and suppression. Number of fire ignition is estimated from the size and type of building inventory and the ground motion to which it is subjected. Spread is a function of the density of the construction, the presence of wind, fire breaks (e.g. lakes, wide streets) and low fuel areas (e.g. parks, cemeteries). Suppression is a function of the available fire fighting capabilities. The spread and suppression modules use damage and loss function out of the essential facilities and lifelines modules to determine the response capabilities and effectiveness of the fire-fighting personnel. For debris, HAZUS methodology estimates 2 different types of debris. The first type is debris that fall in large pieces like steel members or reinforced concrete elements, which require special treatment to break into smaller pieces before they are hauled away. The second one is smaller and more easily moved with bulldozers, such as brick, wood, glass, building contents, etc.

5. Direct Economic/Social Losses

Both direct and induced damage can lead to direct losses. There are 2 types of losses evaluated in the methodology: economic and social losses. The economic losses quantify the cost of repair and replacement of structures and lifeline systems that are damaged as a consequence of the earthquake. Structural and non-structural damage and also losses to contents inside buildings are included. To compute the direct economic losses, damage information from the direct damage module is combined with economic data of the study area, particularly construction/replacement cost of buildings and lifeline systems. Social losses are quantified in terms of casualties. To quantify the casualties, HAZUS methodology combines the output from direct damage module with building inventory and population data. Estimation is carried out for two times of day: 2:00PM (day time) and 2:00AM (night time).

6. Indirect Economic Losses

This module assesses the broad and long-term implications of the direct impacts (direct damage and losses) mentioned before. Examples of indirect economic impacts are changes in employment and personal income. This module is not included in this work due to inexistence of complete data of income and employment.

2. General Description of the Study Area

In this project, the loss estimation analysis is carried out by the HAZUS software. HAZUS is a regional earthquake loss estimation model that was developed by the United States Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of HAZUS is to provide a methodology and software application to estimate earthquake losses at a city corporation area scale. These loss estimates will be used primarily by local and central officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery. The earthquake loss estimates provided in this report was based on 552, 285 and 82 clusters of Dhaka, Chittagong, and Sylhet City Corporation Areas, respectively.

2.1. Dhaka City Corporation Area

The geographical size of the area is 136.4 square kilometers and contains 91 wards and 552 clusters. It has a total population of 7,279,668 people (estimated by using the total number of occupants in the nighttime). There are an estimated 326,000 buildings in the area with a total building replacement value (excluding contents) of 16,740 millions of dollars. Approximately 81% of the buildings (and 69% of the building value) is associated with residential housing. The replacement value of the transportation and utility lifeline systems is estimated to be 1,586 and 388 millions of dollars, respectively.

2.2. Chittagong City Corporation Area

Chittagong City Corporation Area is 169.4 square kilometers and contains 41 wards and 285 clusters. It has a total population of 2,332,599 people in the area (estimated by using the total number of occupants in the nighttime) as well as includes an estimated 182,000 with a total building replacement value (excluding contents) of 3,378 millions of dollars. Approximately 82% of the buildings (and 69% of the building value) is associated with residential housing. The replacement value of the transportation and utility lifeline systems is estimated to be 839 and 147 millions of dollars, respectively.

2.3. Sylhet City Corporation Area

The size of Sylhet City Corporation Area is 57.6 square kilometers and contains 27 wards and 82 clusters. A total population of the area is 401,773 people (estimated by using the total number of occupants in the nighttime). There are an estimated 52,000 buildings in the area with a total building replacement value (excluding contents) of 926 millions of dollars. Approximately 85% of the buildings (and 78% of the building value) is associated with residential housing. The replacement value of the transportation and utility lifeline systems is estimated to be 191 and 41 millions of dollars, respectively.

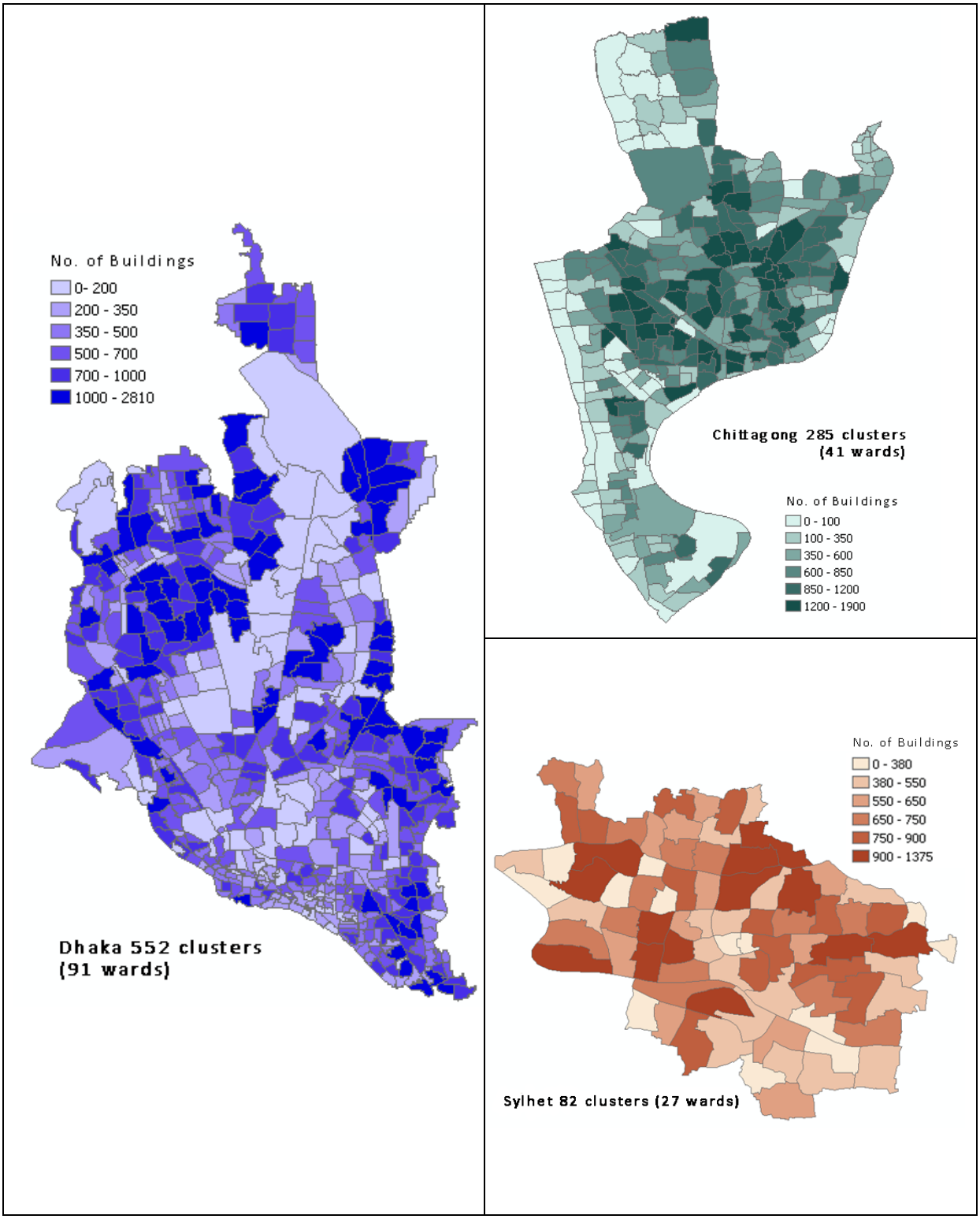


Figure 2-1 The distribution of buildings in 3 cities

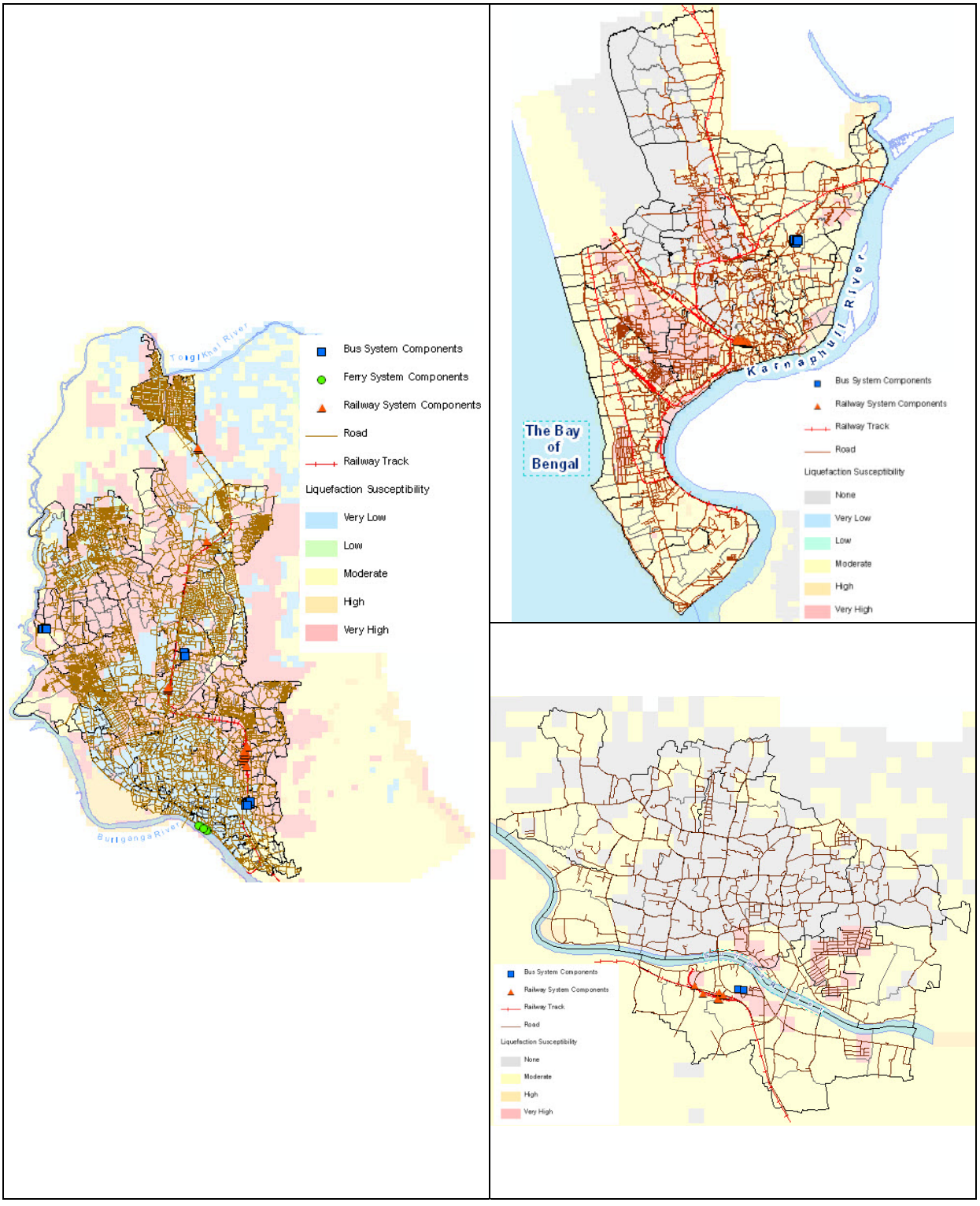

Bus System Components
Ferry System Components
Railway System Components
Road
Railway Track
Liquefaction Susceptibility
Very Low
Low
Moderate
High
Very High
Bus System Components
Railway System Components
Railway Track
Road
Liquefaction Susceptibility
None
Very Low
Low
Moderate
High
Very High
The Bay of Bengal
Karnaphuli River
Bus System Components
Railway System Components
Railway Track
Road
Liquefaction Susceptibility
None
Moderate
High
Very High

Figure 2-2 Transportation systems in Dhaka, Chittagong and Sylhet City Corporation Areas

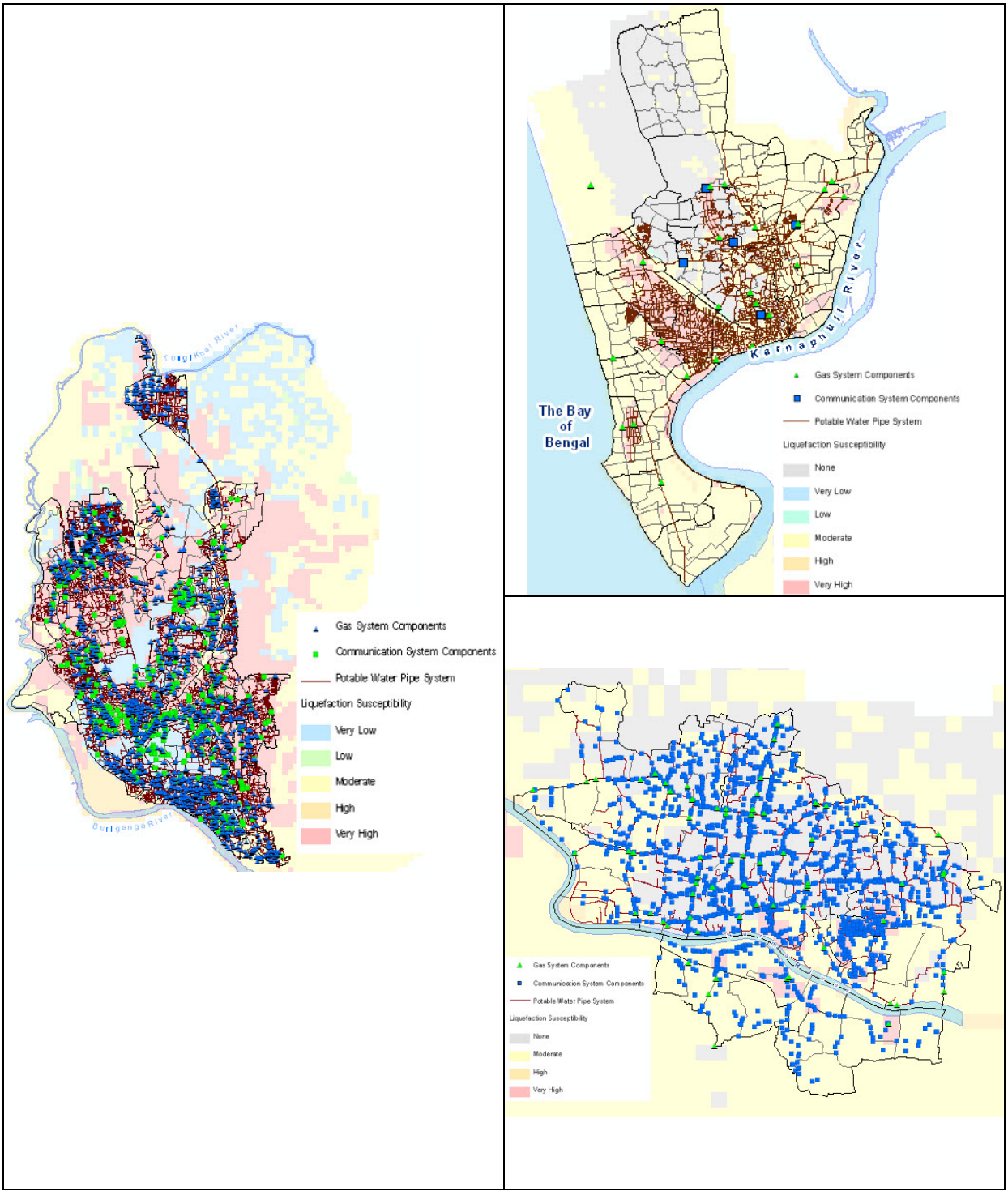


Figure 2-3 Utility systems in Dhaka, Chittagong and Sylhet City Corporation Areas

3. Building and Lifeline Inventory

This section presents the inventory of buildings and lifelines in Dhaka, Chittagong and Sylhet. The details of the inventory are organized into three parts: 1) building inventory; 2) essential facility inventory; and 3) lifeline inventory.

3.1. Building Inventory

It is estimated that there are 326,000, 182,000, and 52,000 buildings in Dhaka, Chittagong, and Sylhet City Corporation Areas, respectively, which have an aggregate total replacement value of 16,740 millions of dollars for Dhaka, 3,378 millions of dollars for Chittagong, and 926 millions of dollars for Sylhet. The total population of Dhaka, Chittagong and Sylhet are approximately 7.2, 2.3 and 0.4 millions, respectively. Appendix A provides a regional population and building value data by ward.

In terms of building construction types found in Dhaka, Chittagong and Sylhet, concrete frame and masonry building construction make up more than 80% of the building inventory. The remaining percentage is distributed between other general building types. Appendix B demonstrates the correlation matrices of structural types and building occupancy classes which are used in the regions.

3.2. Essential Facility Inventory

Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations centers. In Dhaka City Corporation area, there are 600 hospitals, 2,737 schools, 10 fire stations, 62 police stations and 1 emergency operation center (MoFDM building) and 17 emergency response agency offices. While in Chittagong, there are 162 hospitals, 1,033 schools, 12 fire stations, 11 police stations and 1 emergency operation center and 10 emergency response agency offices. In Sylhet, there are 87 hospitals, 211 schools, 2 fire stations, 6 police stations and 9 emergency response agency offices. Figure 3-1 depicts the locations of the essential facilities in the 3 cities.

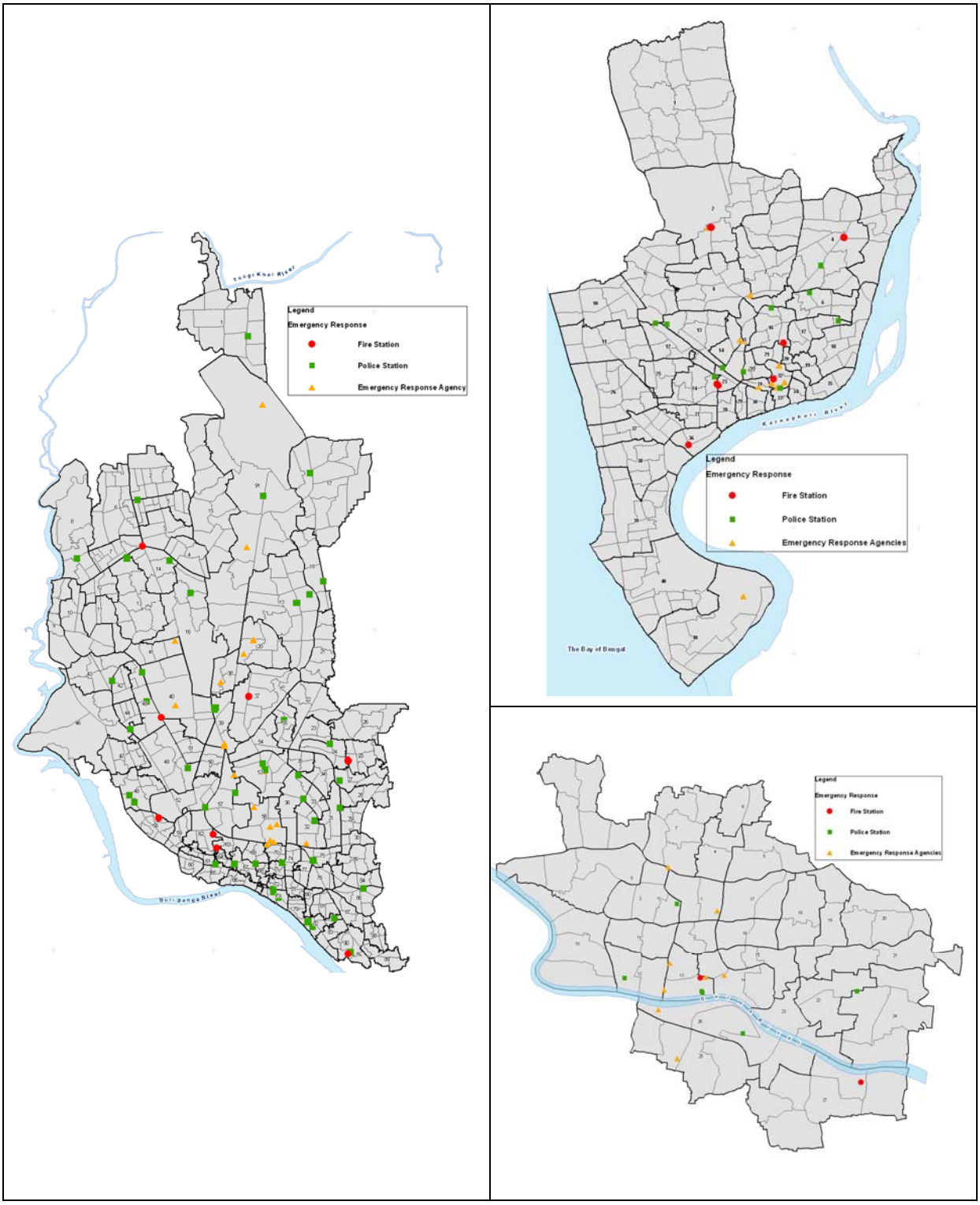


Figure 3-4 Locations of essential facilities in Dhaka, Chittagong and Sylhet City Corporation Areas

3.3. Lifeline Inventory

3.3.1. Transportation and Utility Inventory

Within HAZUS, the lifeline inventory is divided between transportation systems and utility systems. In the study area of 3 cities, there are four transportation systems that include highways, railways, bus, and ferry. There are five utility systems: potable water, wastewater, natural gas, electric power and communications. The lifeline inventory data are provided in the Tables 3-1 to 3-6.

In Dhaka City Corporation area, the total value of the lifeline inventory is over 1,974 millions of dollars. This includes over 1,250 kilometers of highways, 10 highway bridges, and 2,582 kilometers of potable water, waste water, and gas pipes.

Table 3-1 Transportation System Inventory of Dhaka City Corporation Area

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	*Bridges*	*10*	*26.50*
	Segments	*21,979*	*1,479.40*
		Subtotal	***1,505.90***
Railways	*Facilities*	*19*	*9.20*
	Segments	*217*	*66.50*
		Subtotal	***75.70***
Bus	*Facilities*	*25*	*3.70*
		Subtotal	***3.70***
Ferry	*Facilities*	*8*	*0.80*
		Subtotal	***0.80***
		Total	***1,586.10***

Table 3-2 Utility System Inventory of Dhaka City Corporation Area

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Potable Water	Facilities	748	140.20
	Pipelines	18,699	13.10
		Subtotal	**153.30**
Waste Water	Facilities	14	60.60
	Pipelines	4,082	2.90
		Subtotal	**63.50**
Natural Gas	Facilities	7	7.00
	Pipelines	10,943	7.70
		Subtotal	**14.70**
Electrical Power	Facilities	54,815	75.80
		Subtotal	**75.80**
Communication	Facilities	30	81.00
		Subtotal	**81.00**
		Total	**388.20**

In Chittagong City Corporation area, the total value of the lifeline inventory is over 987 millions of dollars. This inventory includes over 618 kilometers of highways, 4 highway bridges, and 792 kilometers of potable water and gas pipes.

Table 3-3 Transportation System Inventory of Chittagong City Corporation Area

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	4	6.60
	Segments	8,416	725.70
		Subtotal	**732.20**
Railways	Facilities	15	7.40
	Segments	211	98.20
		Subtotal	**105.60**
Bus	Facilities	11	1.60
		Subtotal	**1.60**
		Total	**839.30**

Table 3-4 Utility System Inventory of Chittagong City Corporation Area

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Potable Water	Facilities	72	69.60
	Pipelines	5,169	3.60
		Subtotal	**73.20**
Natural Gas	Facilities	22	22.00
	Pipelines	517	0.40
		Subtotal	**22.40**
Electrical Power	Facilities	28,407	33.40
		Subtotal	**33.40**
Communication	Facilities	5	19.00
		Subtotal	**19.00**
		Total	**148.00**

And in Sylhet City Corporation area, the total value of the lifeline inventory is over 232 millions of dollars. It includes over 140 kilometers of highways, 2 highway bridges, and 268 kilometers of potable water and gas pipes.

Table 3-5 Transportation System Inventory of Sylhet City Corporation Area

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	2	2.60
	Segments	4,204	178.40
		Subtotal	**180.90**
Railways	Facilities	7	3.40
	Segments	29	7.00
		Subtotal	**10.40**
Bus	Facilities	2	0.20
		Subtotal	**0.20**
		Total	**191.50**

Table 3-6 Utility System Inventory of Sylhet City Corporation Area

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Potable Water	Facilities	18	2.40
	Pipelines	784	0.50
		Subtotal	**2.90**
Natural Gas	Facilities	1	1.00
	Pipelines	607	0.40
		Subtotal	**1.40**
Electrical Power	Facilities	9,057	14.30
		Subtotal	**14.30**
Communication	Facilities	7	23.00
		Subtotal	**23.00**
		Total	**41.60**

In this project, the spatial (GIS) data inventory is transformed from local coordinate system of Bangladesh Transverse Mercator (BTM) to Geographic Coordinate System (GCS) in Western US in order to develop a HAZUS dataset and to run the damage and loss calculation. This transformation impacts to the length of network (segment) components that include highway road, railway track, potable water, waste water and gas pipeline. The distortion is relatively small, varies from 0.6% to 5.7% as presented in the following table.

Table 3-7 Distortion of Segment Length due to Coordinate System Transformation

City Corporation	Component (Segment)	Total Length (km) in Bangladesh Transverse Mercator Coordinate System	Total Length (km) in Western US Geographic Coordinate System	Percent Distortion
Dhaka	Highway Road	1,270.105	1,232.595	3.0
	Railway Track	62.133	63.630	2.4
	Potable Water Pipeline	1,137.042	1,119.405	1.6
	Waste Water Pipeline	399.548	395.640	1.0
	Natural Gas Pipeline	847.431	833.595	1.6
Chittagong	Highway Road	639.586	618.870	3.2
	Railway Track	95.600	92.925	2.8
	Potable Water Pipeline	552.049	540.750	2.0
	Natural Gas Pipeline	220.376	212.730	3.5
Sylhet	Highway Road	148.797	141.752	4.7
	Railway Track	6.696	6.656	0.6
	Potable Water Pipeline	130.944	125.216	4.4
	Natural Gas Pipeline	143.869	135.616	5.7

3.3.2. Restoration Time

Restoration time is required time for the lifeline system to recover and be partially and fully functional after the earthquake. In Hazus analysis, it is used to assess the lifeline functionality after the earthquake. Hazus derives it from different post-earthquake recovery experiences in the United States. Here, the formulation of restoration time of lifeline components is based on lifeline survey and interview with the officials and engineers of the water supply authority, power development board, and gas distribution company in the 3 cities. The restoration time is then compared to the United States' experience in restoring the lifeline as mentioned in the Hazus Technical Draft. From this comparation, it is found that the post-earthquake restoration time for lifeline in Bangladesh is about 4-5 times longer than in what mentioned in Hazus. Cross checking this calculation results with local experts, it is concluded that overall lifeline restoration time for Bangladesh is about four times longer than the Hazus restoration time. This restoration factor is used as the input parameter for functionality analysis in Hazus. The followings are calculation of restoration time.

1. **Natural Gas Pipeline**
   United States (Hazus):
   For 8" and 12" pipe diameter, it takes 1 day for a person crew to fix 1 pipe leak, and 2 days for a person crew to fix 1 pipe break *(Hazus Technical Draft Chapter 8, Table 8.1.c).*
   Bangladesh (Jalalabad Gas):
   One leak repair needs 4-5hr (1 day) of 2 a person crew + approx. 1 day of material supply.
   Pipe break replacement of 100ft needs 1 day of 5 a person crew + approx. 1 day of material supply. Assumed there is a break in 100ft (30m).
   It takes 2 days for 2 crew person to fix a pipe leak or 4 days for 1 crew person, or 4 times longer than in US. And for pipe break, it takes 2 days of 5 person crew to fix a break or 1 day of 10 person crew, or 5 times longer than in US.

2. **Potable Water Pipeline**
   United States (Hazus):
   For small pipes (<20" diameter), a 4-person crew needs 4 hours to fix a leak, while the same 4-person crew needs 8 hours to fix a break *(Hazus Technical Draft, Chapter 8, Table 8.1.c)*.
   Bangladesh:
   With the same 4 person crew, to fix a pipe leak at 12"and 10" pipes requires 24 hours (6 times longer) and at 6" and 8" pipes requires 8 hours (2 times longer).
   Average restoration time for these pipes is 16 hours or 4 times longer than in US. Still with the same 4 person crew, to fix a pipe break at 12" pipe requires 36 hours and at 10" and 8" pipes require 24 hours, and at 4" and 6" pipes requires 12 hours. Average restoration time for these pipes is 24 hours or 4 times longer than in US.

Table 3-8 Restoration Time of Potable Water Pipeline in Bangladesh

Damage Description	Pipe Diameter	Expected time to completely repair for 4 person crew
Pipe Leak	12"	24 hours
	10"	24 hours
	8"	8 hours
	6"	8 hours
Pipe Break	12"	36 hours
	10"	24 hours
	8"	24 hours
	6"	12 hours
	4"	12 hours

Source: Sylhet City Corporation

3. Electric Pole (Electric Distribution Circuit, EDC)

United States (Hazus):

In a complete damage situation of the whole city, where 80% of EDCs are damaged, it takes 30 days to restore the EDCs back *(Hazus Technical Draft, Chapter 8, Section 8.5.6 & Table 8.22.b)*.

Bangladesh (Power Development Board):

It takes 1 day of 7 person crew to repair 1 electric pole (EDC). Within SCC, there are 9057 electric poles (EDC). The total manpower in Sylhet (in 3 division) is 3x120 skilled labor and 3x13 engineers = 399 person.

In a complete damage condition there will be 80% x 9057 = 7246 damage EDCs. To restore them it requires 7246 x 7 = 50722 manpower. With existing manpower in Sylhet, it can be finished within 50722/399 = 127 days, or 4.23 times longer than in US.

3.3.3. Replacement Value

Replacement value relates to the repair and replacement of damaged lifeline components after the earthquake. In Hazus analysis, it used for estimating the direct economic loss due to the damage of lifeline components. Hazus derives it from different post-earthquake recovery experiences in the United States. Here, the replacement value is estimated from the percentage of repair and replacement values of the lifeline components in Bangladesh compared to Hazus values. Typical replacement value of lifeline components in Bangladesh can be classified as follows:

- 16% of Hazus values for simple component using local product and man power related works. It comes from the calculation of replacement value on well (potable water system) and electric pole (electric power system).
- 20% of Hazus values, where the possible facility damage mostly comes from the structure damage. It follows the percentage in building construction cost, where local cost is approximately 20% of Hazus (US) cost.
- 70% of Hazus values for the network components such as gas pipeline, potable and waste water pipeline. It comes from the calculation of leak and break repair value on gas pipeline.
- 100% of Hazus values where the components value mostly comes from the equipment cost (which normally is very expensive) such as electric substation. It implies that everywhere the replacement value will be relatively the same since the lifeline facilities or components use similar type of equipment.

Bangladesh replacement values were calculated from acquired data from water supply authority, power development board, and gas distribution company. Following are the calculation.

1. **Natural Gas System**

   Gas Pipeline break replacement value per break *(Jalalabad Gas)*

   - Pipe 12" (6m modul) BDT 36,000
   - Laying (approx. 10m) BDT 3,000
   - Welding (joint) BDT 894
   - Road Break (asphalt, 10m) BDT 790
   - RCC Coating (10m) BDT 4,940
   - Service T, Valve T, Flange T joint BDT 477
   - Plug Socket Joint BDT 45
   - Clamping BDT 2,000

   Total Cost **BDT 48,146 = USD 687.8**

   Hazus replacement value: **USD 1000** *(Hazus Technical Draft, Chapter 15, Table 15.17)*

   Percentage = 687.8/1000 = 68.8% = **70%**

2. **Electric Power System**

   Erection of every unit of electric pole (EDC) 15m height *(Power Development Board)*

   - Electric pole 15 m erection BDT 30,000
   - Man Power BDT 3,000

   Total Cost **BDT 33,000 = USD 471.4**

   Hazus replacement value: **USD 3000** *(Hazus Technical Draft, Chapter 15, Table 15.17)*

   Percentage = 471.4/3000 = 15.7% = **16%**

3. **Potable Water System**

   Construction of deep tube well per unit *(Sylhet water supply authority)*

   - Construction of deep tube well BDT 400,000
   - Man Power BDT 40,000

   Total Cost **BDT 440,000 = USD 62,857.1**

   Hazus replacement value: **USD 400,000** *(Hazus Technical Draft, Chapter 15, Table 15.17)*

   Percentage = 62,857.1/400,000 = 15.7% = **16%**

Replacement value of every lifeline components is explained in the following table.

Table 3-9 Replacement Value of Lifeline Components

System	Component	HAZUS Label	BD Value (thous. USD)	HAZUS Value (thous. USD)	Percentage
Highway Transportation	Major Roads - 4 lanes (cost/km length)	HRD1	**2,000.00**	10,000.00	20.00
	Urban Roads 2 lanes (cost/km length)	HRD2	**1,000.00**	5,000.00	20.00
	Highway Bridges	HWB	See bridge table	-	-
Railway Transportation	Rail Track (cost/km length)	RTR1	**1,050.00**	1,500.00	70.00
	Urban Station	RST	**400.00**	2,000.00	20.00
	Fuel Facility	RFF	**600.00**	3,000.00	20.00
	Maintenance Facility	RMF	**560.00**	2,800.00	20.00
	Dispatch Facility	RDF	**600.00**	3,000.00	20.00
Bus Transportation	Urban Station	BPT	**200.00**	1,000.00	20.00
	Fuel Facility	BFF	**30.00**	150.00	20.00
	Maintenance Facility	BMF	**260.00**	1,300.00	20.00
	Dispatch Facility	BDF	**80.00**	400.00	20.00
Ferry Transportation	Passenger Terminal	FPT	**200.00**	1,000.00	20.00
	Fuel Facility	FFF	**80.00**	400.00	20.00
	Maintenance Facility	FMF	**104.00**	520.00	20.00
	Dispatch Facility	FDF	**40.00**	200.00	20.00
Potable Water	Brittle Pipe	PWP1	**0.70**	1.00	70.00
	Ductile Pipe	PWP2	**0.70**	1.00	70.00
	Small WTP	PWT	**30,000.00**	30,000.00	100.00
	Well	PWE	**62.86**	400.00	15.71
	Overhead Tank	PSTAS	**160.00**	800.00	20.00
	Small Pumping Plant	PPP	**150.00**	150.00	100.00
Waste Water	Brittle Pipe	WWP1	**0.70**	1.00	70.00
	Small WWTP	WWT	**60,000.00**	60,000.00	100.00
	Small Lift Station	WLS	**48.00**	300.00	16.00
Natural Gas	Arc Welded Steel Pipe (cost/break)	NGP2	**0.69**	1.00	68.78
	Compressor Station (DRS)	NGC	**1,000.00**	1,000.00	100.00
Electric Power	Low Voltage Substation (distribution transformer	ESS	**10,000.00**	10,000.00	100.00
	Distribution Circuit (electric pole)	EDC	**0.47**	3.00	15.71
Communication	Central Office (Exchange)	CCO	**5,000.00**	5,000.00	100.00
	Radio Station/Transmitter	CBR	**2,000.00**	2,000.00	100.00
	TV Station/Transmitter	CBT	**2,000.00**	2,000.00	100.00

For the highway bridge, the replacement value is defined from expert interview on bridge construction cost due to limited access to obtain this data. The cost is estimated from the surface area of the bridge. Referring to the bridge survey in the 3 cities, typical construction cost can be classified from three general structure type as described in the following table.

Table 3-10 Typical Bridge Construction Cost Based on Structure Type and Surface Area

Type	Structure	Typical Construction Cost (BDT/sqm surface area)	Typical Construction Cost (USD/sqm surface area)
1	Slab - normal	12,000	170
2	Girder and slab	20,000 – 30,000	285 – 428
3	Box girder – prestressed	28,000	400

From this typical cost, replacement value of every bridge in the study areas were calculated from the bridge surface area with reference to its structure type and typical cost. The bridge replacement value in 3 cities is shown in the following table.

Table 3-11 Bridge Replacement Value in Dhaka, Chittagong, and Sylhet

Bridge	Type	Typical Cost (USD/m2)	Area (m2)	Replacement Value (USD)	Rounded Value (thous. USD)
Dhaka					
Amin Bazar	2	400	6082	2,432,800	**2,433**
Burigangga 1	2	428	7441	3,184,748	**3,185**
Burigangga 2	2	428	10105	4,324,940	**4,325**
Kamrangichar 1	2	285	357.5	101,888	**102**
Kamrangichar 2	2	285	165	47,025	**47**
Kamrangichar 3	2	285	550	156,750	**157**
Khilgaon Flyover	2	428	22051	9,437,828	**9,438**
Mohakhali Flyover	3	400	15930	6,372,000	**6,372**
Tongi 1	2	350	713	249,550	**250**
Tongi 2	2	350	624	218,400	**219**
Chittagong					
Shah Amanat	2	428	6883	2,945,924	**2,946**
Dewan Hut	2	350	8000	2,800,000	**2,800**
Kalurghat Karnaphuli	2	285	2487	708,795	**709**
Chittagong Port	1	170	594	100,980	**101**
Sylhet					
Keenan	2	400	2280	912,000	**912**
Shahjalal	2	400	4100	1,640,000	**1,640**

4. Geological Data and Hazard

4.1. Soil classification

The soil classification is used to evaluate the site amplification ratio in earthquake scenario study. The soil classification data used in this study was prepared by OIC. Originally, the soil classification is defined in a grid format (left column of figure 4-1). The soil was classified based on NEHRP into 5 categories: A (hard rock), B (rock), C (very dense soil and soft rock), D (stiff soil) and E (soft soil). The softer soil, e.g. class E, has tendency to amplify more earthquake signal. To use this data for earthquake scenario study in HAZUS, we redefined the soil classification at the centroid of each cluster by overlay the map containing clusters on the soil classification map from OIC. Because, one cluster may cover more than one original grid data, we set the criteria so that the program selects the soil classification from grid data that have the highest site amplification ratio (The softest soil classification in each cluster) as the representative value of the cluster.

The soil classification maps based on cluster for Dhaka, Chittagong and Sylhet City Corporation areas are shown in the right side of figure 4-1. The soil classification from OIC was interpolated into 552 clusters in Dhaka, 285 clusters in Chittagong and 82 clusters in Sylhet, respectively (Table 4-1). By comparing the maps in both columns, the soil classification by cluster is in good agreement with the original data in the grid format.

Table 4-1 The number of clusters in each City Corporation

City Corporation	Number of clusters
Dhaka	*552*
Chittagong	*285*
Sylhet	*82*

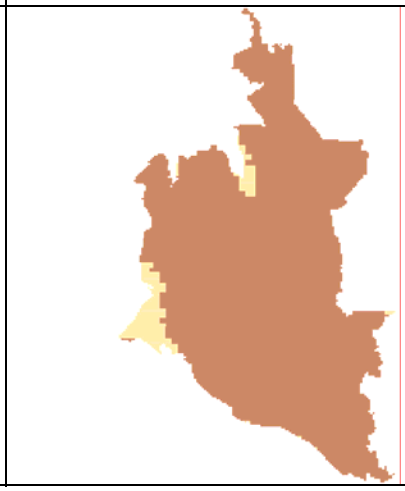
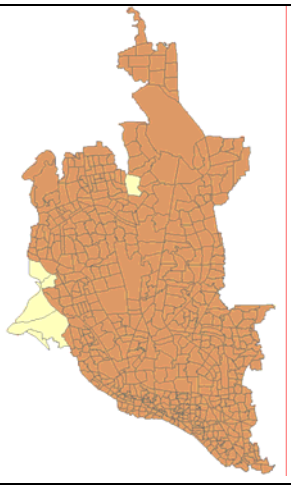
	OYO: Soil classification in grid format	HAZUS: Soil classification in cluster format
Dhaka		

Figure 4-1 Soil Class from OIC and Soil Class as compatible format for HAZUS

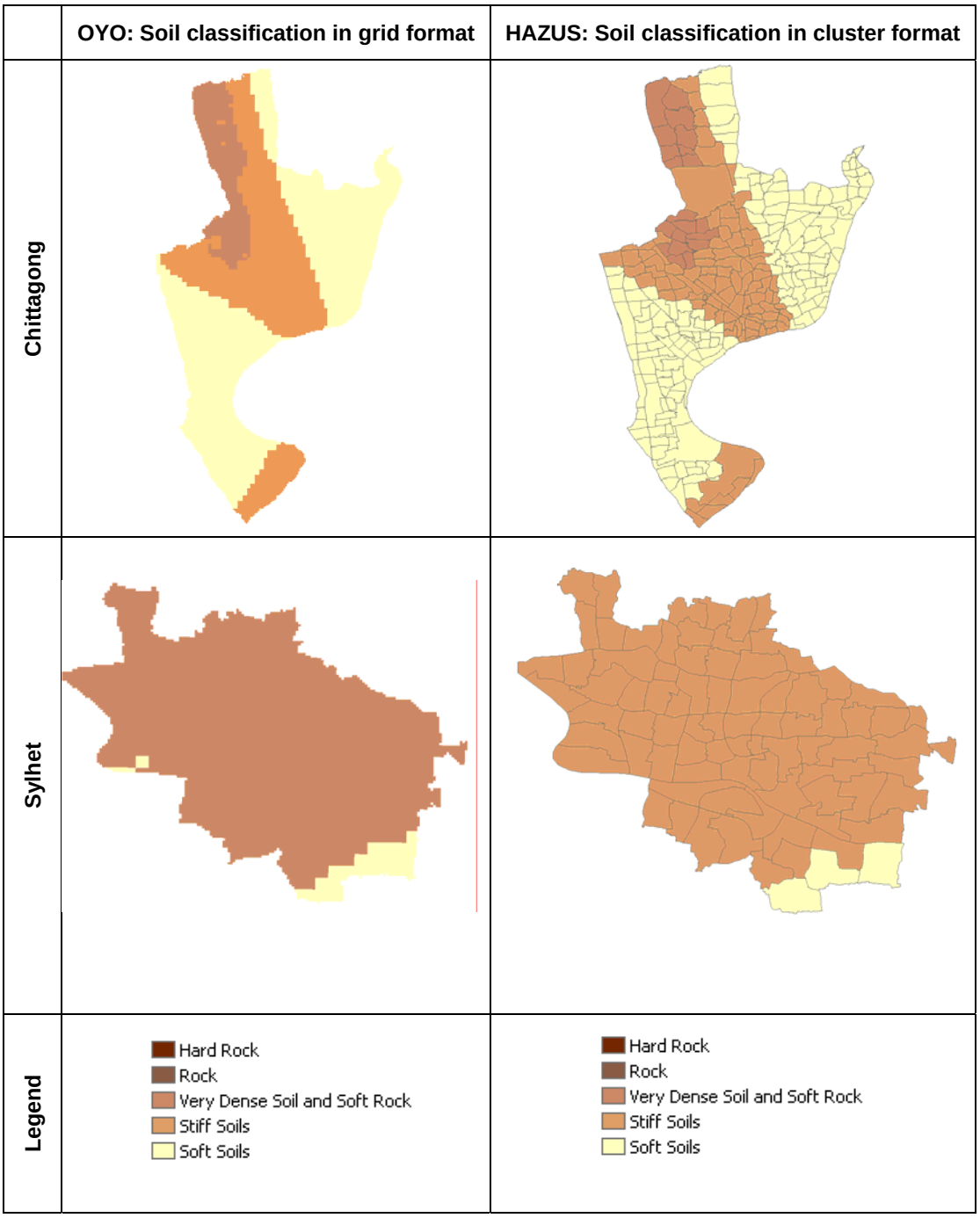


Figure 4-1 Soil Classification from OIC and Soil Class as compatible format for HAZUS (Cont'd)

4.2. Ground Failure

Two types of earthquake induced ground failure are considered in the earthquake scenario study: liquefaction and landslide. To calculate the probability of damage due to both phenomena, it is required that we must first provide the HAZUS program with the liquefaction and landslide susceptibility map in the study area. The liquefaction and landslide susceptibility maps in 3 city corporation areas were originally prepared by OIC in grid format. However, for landslide susceptibility map, the DEM data has been updated so we recalculated the slope data and construct the new landslide susceptibility map based on the original geological data. In the following sections, we explained the method for modifying the susceptibility maps from OIC so that it can be used in HAZUS program.

4.2.1. Liquefaction susceptibility

The original liquefaction susceptibility map from OIC was developed by adopting the method in the HAZUS technical manual which was originally proposed by Youd and Perkins (1978). In this method, the liquefaction susceptibility was classified into 6 categories: None, Very low, Low, Moderate, High and Very high, based on general depositional environment and geologic age of the deposit as shown in Table 4-2.

To use this liquefaction susceptibility map in HAZUS program, the consulting team followed the same method as explained in section 4.1. The original liquefaction susceptibility map was first overlaid by the cluster map from each city corporation area. Then, we set the criteria for program to select the most susceptible grid data within each cluster boundary as the representative value for that cluster. The liquefaction susceptibility maps based on cluster of Dhaka, Chittagong and Sylhet City Corporation Areas are shown in the right column of figure 4-2. It can be seen that the liquefaction susceptibility by cluster is compatible with the original susceptibility in the grid format.

Table 4-2 Liquefaction Susceptibility of Sedimentary Deposits (from Youd and Perkins, 1978)

Type of Deposit	General Distribution of Cohesionless Sediments in Deposits	Likelihood that Cohesionless Sediments when Saturated would be Susceptible to Liquefaction (by Age of Deposit)			
		< 500 yr Modern	Holocene < 11 ka	Pleistocene 11 ka - 2 Ma	Pre-Pleistocene > 2 Ma
(a) Continental Deposits					
River channel	Locally variable	Very High	High	Low	Very Low
Flood plain	Locally variable	High	Moderate	Low	Very Low
Alluvial fan and plain	Widespread	Moderate	Low	Low	Very Low
Marine terraces and plains	Widespread	---	Low	Very Low	Very Low
Delta and fan-delta	Widespread	High	Moderate	Low	Very Low
Lacustrine and playa	Variable	High	Moderate	Low	Very Low
Colluvium	Variable	High	Moderate	Low	Very Low
Talus	Widespread	Low	Low	Very Low	Very Low
Dunes	Widespread	High	Moderate	Low	Very Low
Loess	Variable	High	High	High	Unknown
Glacial till	Variable	Low	Low	Very Low	Very Low
Tuff	Rare	Low	Low	Very Low	Very Low
Tephra	Widespread	High	High	?	?
Residual soils	Rare	Low	Low	Very Low	Very Low
Sebka	Locally variable	High	Moderate	Low	Very Low
(b) Coastal Zone					
Delta	Widespread	Very High	High	Low	Very Low
Esturine	Locally variable	High	Moderate	Low	Very Low
Beach					
High Wave Energy	Widespread	Moderate	Low	Very Low	Very Low
Low Wave Energy	Widespread	High	Moderate	Low	Very Low
Lagoonal	Locally variable	High	Moderate	Low	Very Low
Fore shore	Locally variable	High	Moderate	Low	Very Low
(c) Artificial					
Uncompacted Fill	Variable	Very High	---	---	---
Compacted Fill	Variable	Low	---	---	---

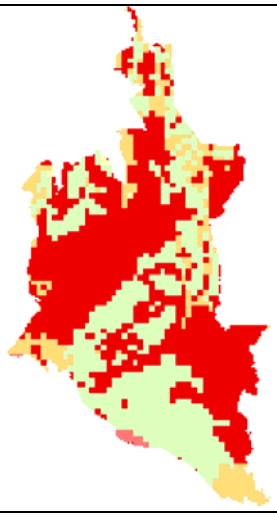
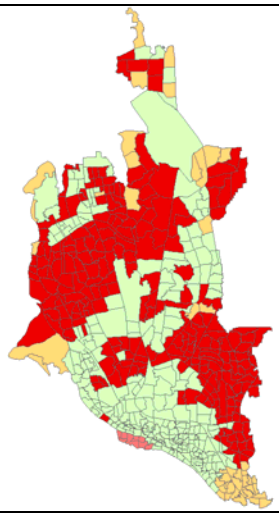
	OYO: Liquefaction Susceptibility	Liquefaction Susceptibility defined in Cluster
Dhaka		

Figure 4-2 Liquefaction susceptibility from OIC and Soil Class as compatible format for HAZUS

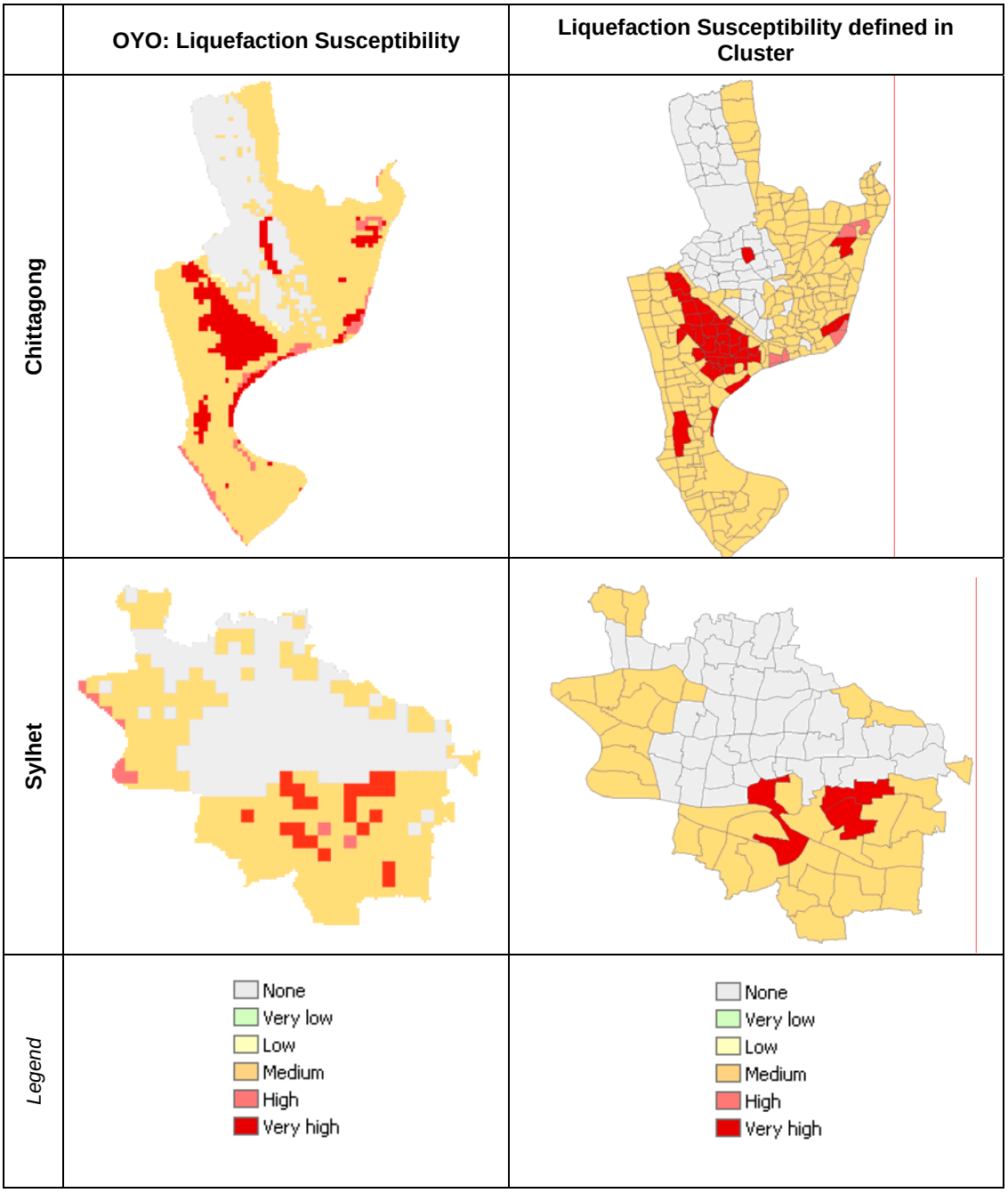


Figure 4-2 Liquefaction susceptibility from OIC and Soil Class as compatible format for HAZUS (Cont'd)

4.2.2. Landslide susceptibility

Lanslide susceptibility map is developed by combining the susceptibility from geomorphological unit with the landslide analysis. The details of the susceptibilities are shown in Table 4-3 to 4-5.

Table 4-3 Geomorphological unit and Susceptibility in Dhaka

Geomorphological Unit	Type of Deposit	Geological Age	Susceptibility
Meander Channel	River channel	Modern	Very High
Back Swamp	Flood plain	Holocene	Moderate
Swamp / Depression	Flood plain	Holocene	Moderate
Flood Plain	Flood plain	Holocene	Moderate
Shallow Alluvial Gully	Colluvium	Holocene	Moderate
Deep Alluvial Gully	Colluvium	Holocene	Moderate
Gully Head	Talus	Holocene	Low
Valley Fill	Colluvium	Holocene	Moderate
Channel Bar	Dunes / Delta and fan-delta	Modern	High
Point Bar	Dunes / Delta and fan-delta	Modern	High
Natural Levee	Dunes / Delta and fan-delta	Modern	High
Lateral Bar	Dunes / Delta and fan-delta	Modern	High
Lower Modhupur Terrace	Residual soils	Pleistocene	Very Low
Upper Modhupur Terrace	Residual soils	Pleistocene	Very Low
Modhupur Slope	Talus	Modern	Low

Table 4-4 Geomorphological unit and Susceptibility in Chittagong

Geomorphological Unit	Type of Deposit	Geological Age	Susceptibility
Depression	Flood plain	Holocene	Moderate
Sandy Beach	Beach - Low Wave Energy	Modern	High
Clayey Beach	Beach - High Wave Energy	Modern	Moderate
Lower Tidal Flat	Beach - Low Wave Energy	Holocene	Moderate
Estuarine Tidal Flat	Estuarine	Holocene	Moderate
Inter Tidal Flat	Beach - Low Wave Energy	Holocene	Moderate
Supra Tidal Flat	Beach - Low Wave Energy	Holocene	Moderate
Younger Point Bar	Dunes / Delta and fan-delta	Modern	High
Ancient Point Bar	Dunes / Delta and fan-delta	Holocene	Moderate
Natural Levee	Dunes / Delta and fan-delta	Modern	High
Sand Dune	Dunes	Modern	High
Gully Fill	Colluvium	Holocene	Moderate
Deep Valley Fill	Colluvium	Holocene	Moderate
Isolated Valley	Colluvium	Holocene	Moderate
River Tidal Flat	Flood plain	Holocene	Moderate
Fluvio Tidal Plain	Flood plain	Holocene	Moderate
Alluvial Fan	Flood plain	Holocene	Moderate
Piedmont Plain	Flood plain	Holocene	Moderate
Hill Slope	Talus	Holocene	Low
Level Hill	No liquefiable soil deposit	-	None
Rounded Top Highly Dissected Hill	No liquefiable soil deposit	-	None
Sharp Crest Highly Dissected Hill	No liquefiable soil deposit	-	None
Sharp Crest Slightly Dissected Hill	No liquefiable soil deposit	-	None

Table 4-5 Geomorphological unit and Susceptibility in Sylhet

Geomorphological Unit	Type of Deposit	Geological Age	Susceptibility
Abandoned Channel	River channel	Holocene	High
Meander Scar	River channel	Holocene	High
Back Swamp	Flood plain	Holocene	Moderate
Swamp / Depression	Flood plain	Holocene	Moderate
Floodplain	Flood plain	Holocene	Moderate
Point Bar	Dunes / Delta and fan-delta	Modern	High
Natural Levee	Dunes / Delta and fan-delta	Modern	High
Lateral Bar	Dunes / Delta and fan-delta	Modern	High
Alluvial Fan	Flood plain	Holocene	Moderate
Gully Fill	Colluvium	Holocene	Moderate
Valley	Colluvium	Holocene	Moderate
Piedmont Plain	Flood plain	Holocene	Moderate
Level Hill	No liquefiable soil deposit	-	None
Ridge	No liquefiable soil deposit	-	None
Isolated Hills	No liquefiable soil deposit	-	None

For the landslide analysis and evaluation, there are three main steps by the following:

Step 1: Preparation work

In order to examine slope angle in the areas, 100 meters spacing of spot height is collected by ADPC. Figure 4-3 shows the spot height distribution in each city.

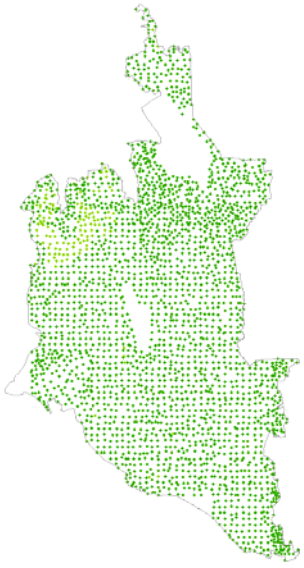
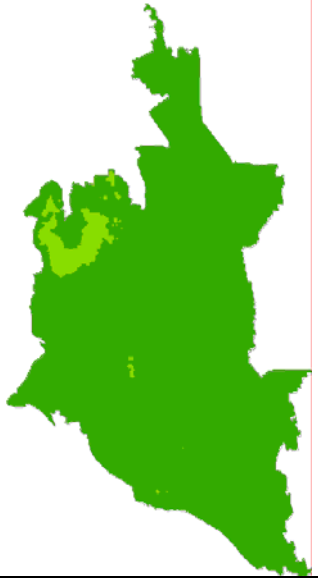
	Spot Height	DEM from Spot Height
Dhaka		

Figure 4-3 Spot Height data and Digital Elevation Model (DEM) in each City Corporation

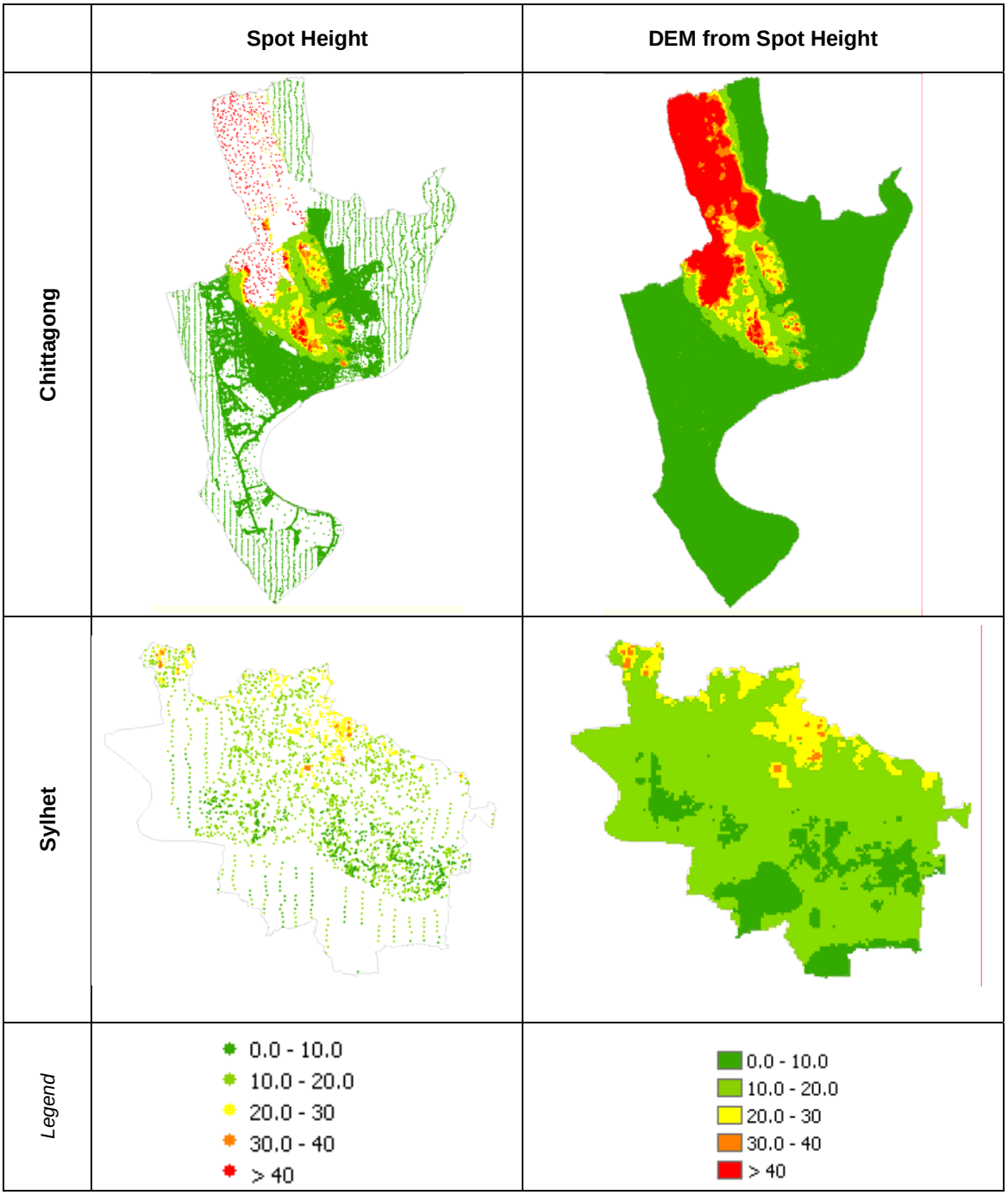


Figure 4-3 Spot Height data and Digital Elevation Model (DEM) in each City Corporation (Cont'd)

Step 2: Slope Analysis

Slope identifies the maximum rate of change in value from each cell to its neighbors. An output slope raster can be calculated as degree of slope.

Spatial analysis function in ArcGIS is applied for slope generation. Conceptually, the slope function fits a plane to the z-values of a 3 x 3 cell neighborhood around the processing or center cell. The direction the plane faces is the aspect for the processing cell. The slope for the cell is calculated from the 3 x 3 neighborhood using the average maximum technique.

$$\text{Slope} = \sqrt{\left(\frac{dz}{dx}\right)^2 + \left(\frac{dz}{dy}\right)}$$

$$\text{Degree slope} = TAN^{1}\sqrt{\left(\frac{dz}{dx}\right)^2 + \left(\frac{dz}{dy}\right)} \times 57.29578$$

where the deltas are calculated using a 3 x 3 roving window.
"a" through "i" represent the z_values in the window:

a	b	c
d	e	f
g	h	i

The slope at point e can be calculated from:

(dz/dx) = [(c + 2f + i) - (a + 2d + g)] / (8 * x cell size)
(dz/dy) = [(g + 2h + i) - (a + 2b + c)] / (8 * y cell size)

The result of slope in degree and geologic group in each city corporation show in Figure 4-4

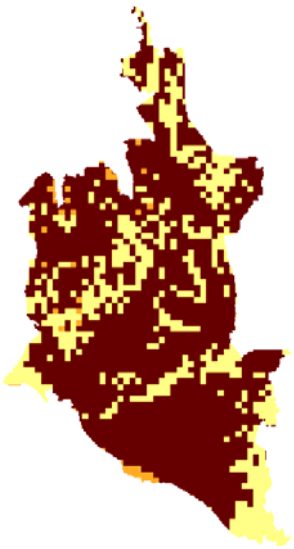
	Slope (degree)	Geologic Group
Dhaka		

Figure 4-4 Slope in degree and geologic group in each city corporation

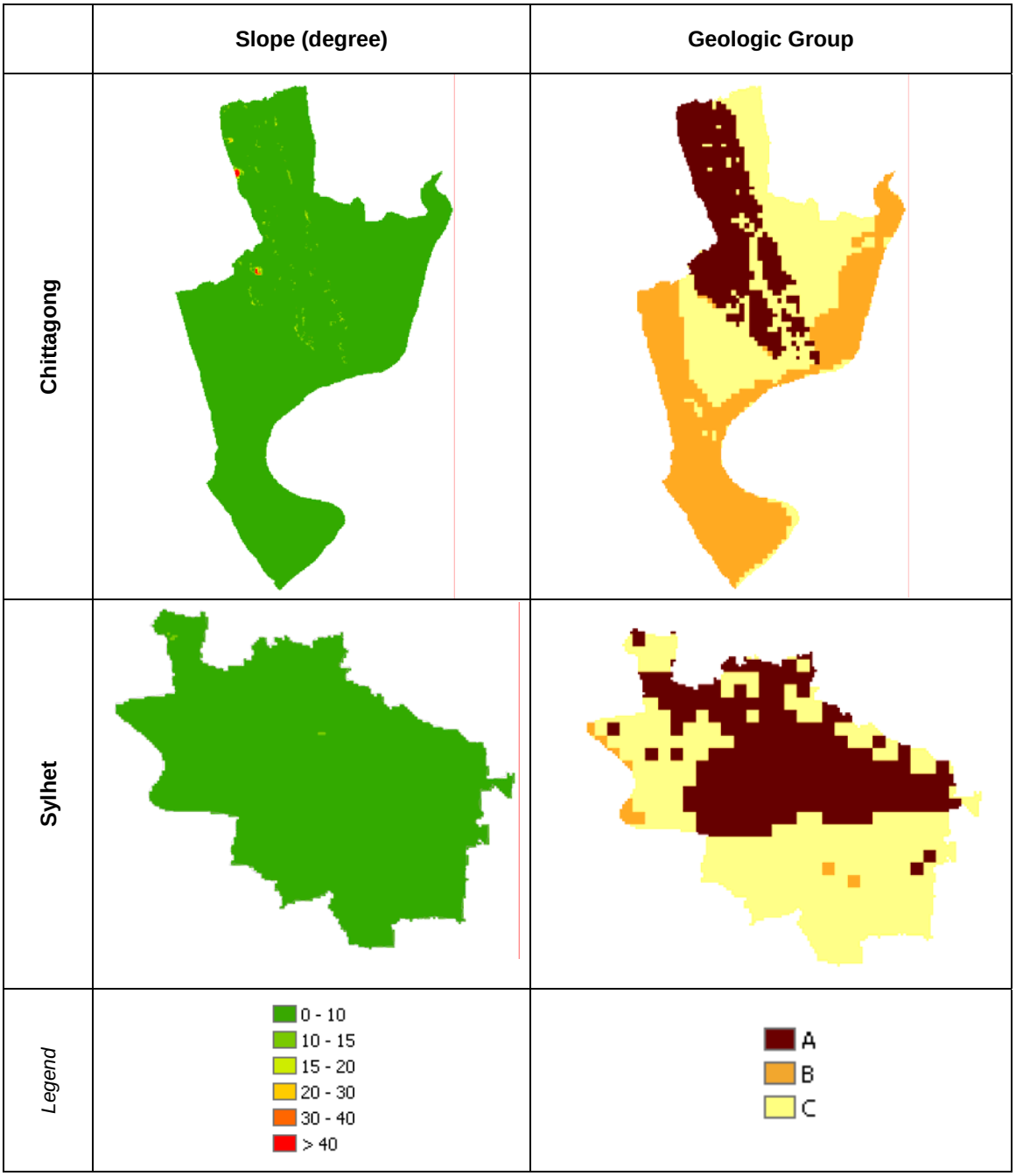


Figure 4-4 Slope in degree and geologic group in each city corporation (Cont'd)

Step 3: Evaluation

In HAZUS, the relationship between slope and critical accelation proposed by Wilson and Keefer (1985) is utilized in the methodology. This relationship is shown in Figure 4-5 Landslide susceptibility is measured on a scale of I to X, with I being the least susceptible. The site condition is identified using three geologic groups and groundwater level. The description for each geologic

group and its associated susceptibility is given in Table 4-6. The groundwater condition is divided into either dry condition (groundwater below level of the sliding) or wet condition (Groundwater level at ground surface). The critical acceleration is then estimated for the respective geologic and groundwater conditions and the slope angle. To avoid calculating the occurrence of landsliding for very low or zero slope angles and critical accelerations, lower bounds for slope angles and critical accelerations are established. These bounds are shown in Table 4-6 and Figure 4-5 shows the Wilson and Keefer relationships within these bounds.

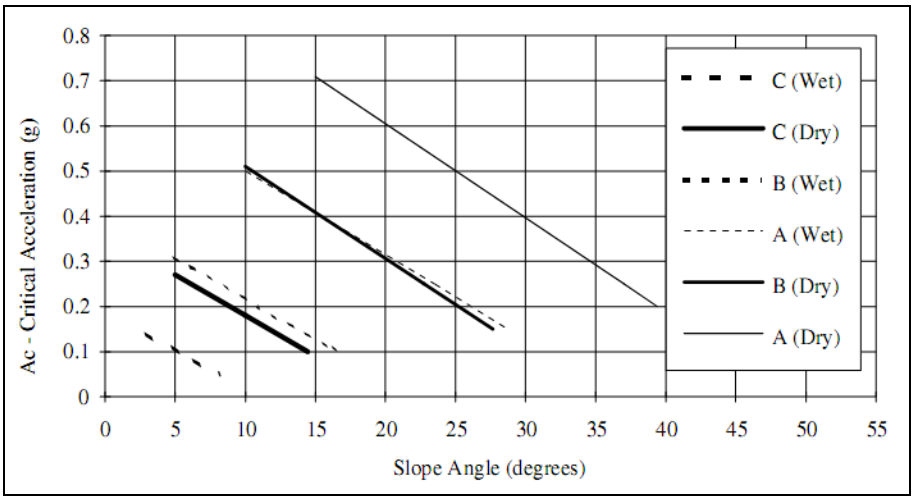


Figure 4-5 Critical Acceleration as a Function of Geologic Group and Slope Angle (Wilson and Keefer, 1985)

Table 4-6 Landslide Susceptibility of Geologic Groups

Geologic Group		Slope Angle, degrees					
		0-10	10-15	15-20	20-30	30-40	>40
(a) DRY (groundwater below level of sliding)							
A	Strongly Cemented Rocks (crystalline rocks and well-cemented sandstone, $c' = 300$ psf, $\phi' = 35^o$)	None	None	I	II	IV	VI
B	Weakly Cemented Rocks and Soils (sandy soils and poorly cemented sandstone, $c' = 0$, $\phi' = 35^o$)	None	III	IV	V	VI	VII
C	Argillaceous Rocks (shales, clayey soil, existing landslides, poorly compacted fills, $c' = 0$ $\phi' = 20^o$)	V	VI	VII	IX	IX	IX
(b) WET (groundwater level at ground surface)							
A	Strongly Cemented Rocks (crystalline rocks and well-cemented sandstone, $c' = 300$ psf, $\phi' = 35^o$)	None	III	VI	VII	VIII	VIII
B	Weakly Cemented Rocks and Soils (sandy soils and poorly cemented sandstone, $c' = 0$, $\phi' = 35^o$)	V	VIII	IX	IX	IX	X
C	Argillaceous Rocks (shales, clayey soil, existing landslides, poorly compacted fills, $c' = 0$ $\phi' = 20^o$)	VII	IX	X	X	X	X

Regarding to Table 4-6, the landslide susceptibility is adopted into wet condition and dry condition. As pervious mentioned, HAZUS requires hazard map base on boundary therefore,

landslide susceptibilities is also adopted base on cluster system in each city corporation. Figure 4-6 shows the landslide susceptibilities in each city corporation.

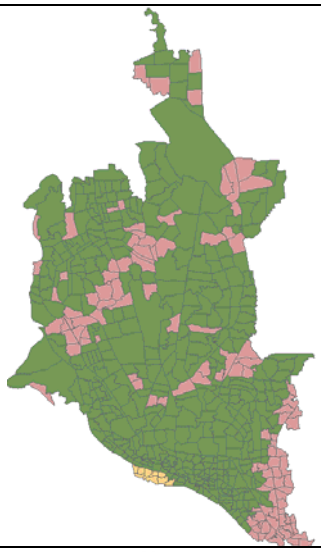
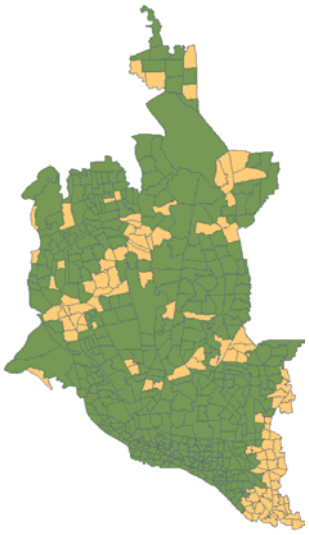
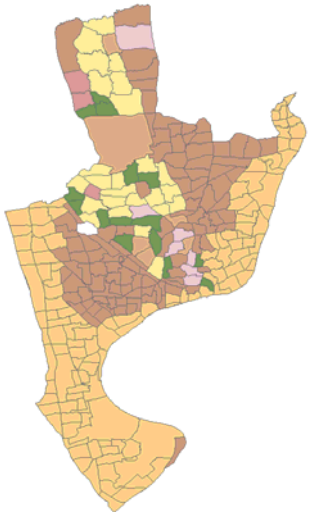
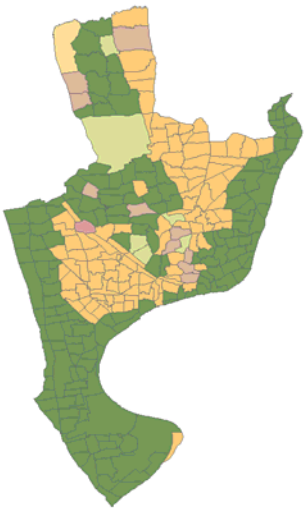
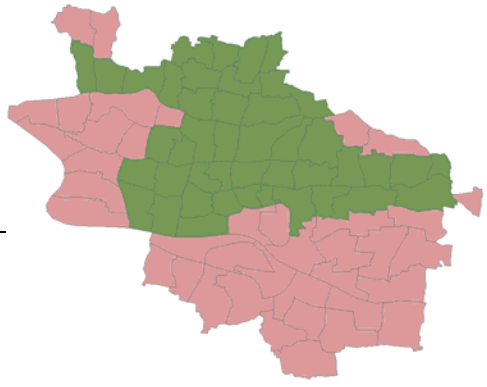
	Landslide Susceptibilities (Wet Condition)	Landslide Susceptibilities (Dry Condition)
Dhaka		
Chittagong		

Figure 4-6 Landslide Susceptibilities in each City Corporation

	Landslide Susceptibilities (Wet Condition)	Landslide Susceptibilities (Dry Condition)
		

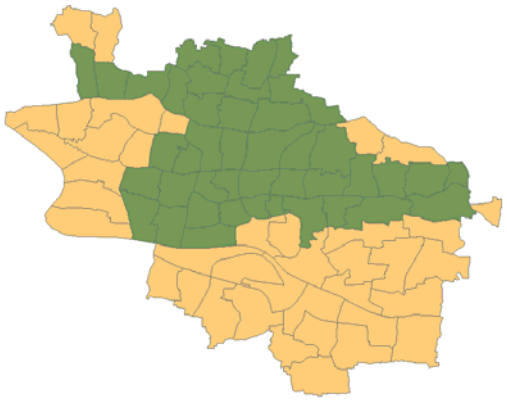
Sylhet		
Legend	Susceptibility I Susceptibility II Susceptibility III Susceptibility IV Susceptibility V Susceptibility VI Susceptibility VII Susceptibility VIII Susceptibility IX Susceptibility X	Susceptibility I Susceptibility II Susceptibility III Susceptibility IV Susceptibility V Susceptibility VI Susceptibility VII Susceptibility VIII Susceptibility IX Susceptibility X

Figure 4-6 Landslide Susceptibilities in each City Corporation (Cont'd)

5. Earthquake Scenario Parameters

Earthquake scenarios were selected based on seismic hazard assessment (SHA) study carried out by OYO International Corporation (OIC). In SHA report, OIC proposed five earthquake scenarios, where each scenario was set as a maximum possible earthquake occurring within a fault zone, and there are five major fault zones (Figure 5-1), i.e. Madhupur fault (MF), Dauki Fault (DF), Plate Boundary Fault -1 (PBF-1), Plate Boundary Fault -2 (PBF-2) and Plate Boundary Fault -3 (PBF-3). In addition to five scenarios, a special earthquake scenario where a magnitude-6 earthquake is occurring beneath each city was also recommended by OIC.

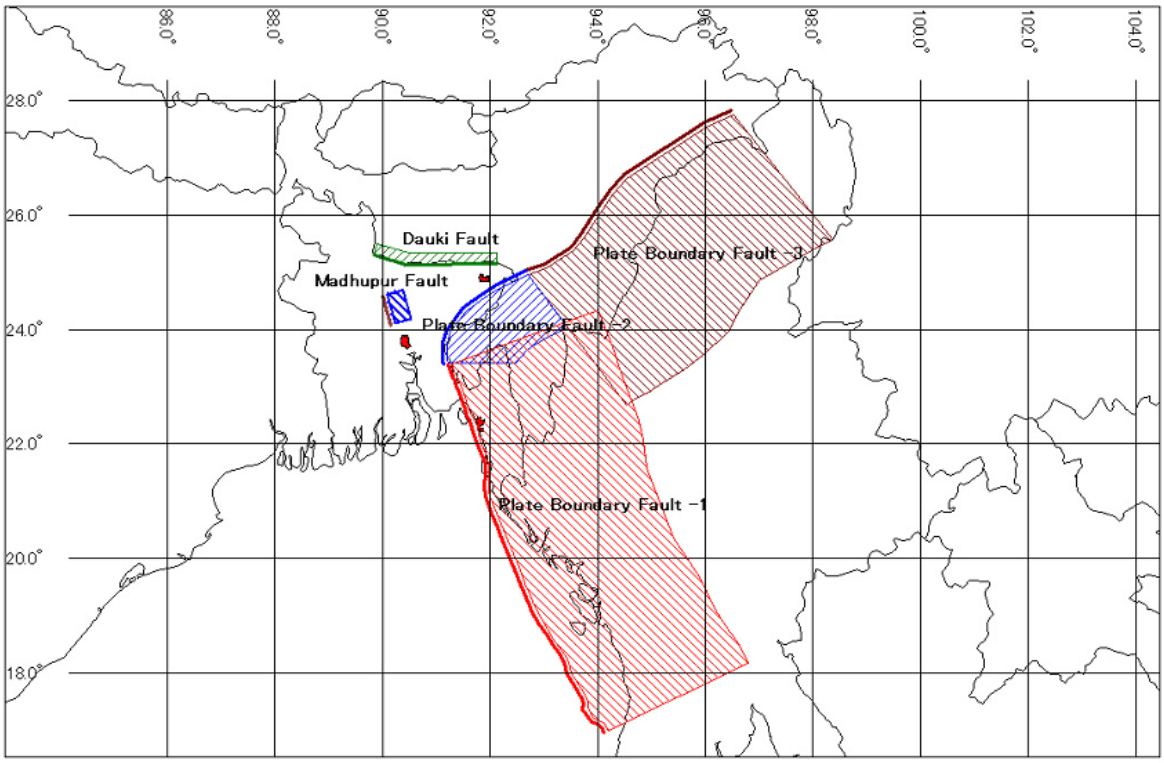


Figure 5-5 Earthquake Fault Zones

In the deterministic hazard study, three earthquake scenarios (case 1-3) were selected for each city corporation. The first scenario is the scenario that produces the highest level ground motion in the city among the OIC's five scenarios. The second scenario is the one that can represent the remaining four OIC's scenarios, as they are much lower than the first scenario and they are not so much different from each other. The third scenario is the special scenario where a magnitude-6 earthquake is occurring directly beneath the city. For the probabilistic hazard study, one or two more earthquake scenarios (case 4-5) were additional produced by determining a probabilistic seismic motion at ground surface (Table 1-4, Probabilistic seismic motion report, OIC).

The input parameters of these selected earthquake scenarios (case) are shown in Tables 5-1, 5-2 and 5-3 for Dhaka, Chittagong and Sylhet City Corporation Areas, respectively.

Table 5-1 Earthquake Scenario Parameters for Dhaka City Corporation Area

Case	Coordinate of Epicenter		M_w	Depth to Top of fault (km)	Dip Angle	Fault type	Description
	Latitude	Longitude					
1	*24.3*	*90.1*	*7.5*	*10*	*45°*	*Reverse*	*Madhupur Fault*
2	*23.8*	*91.1*	*8.0*	*3*	*20°*	*Reverse*	*Plate Boundary Fault -2*
3	*23.8*	*90.4*	*6.0*	*8*	*90°*	*Reverse*	*Mw6.0 beneath city*
4	*23.8*	*90.5*	*8.5*	*3*	*20°*	*Reverse*	*Plate Boundary Fault -2*

Table 5-2 Earthquake Scenario Parameters for Chittagong City Corporation Area

Case	Coordinate of Epicenter		M_w	Depth to Top of fault (km)	Dip Angle	Fault type	Description
	Latitude	Longitude					
1	*21.1*	*92.1*	*8.5*	*17.5*	*30°*	*Reverse*	*Plate Boundary Fault -1*
2	*23.8*	*91.1*	*8.0*	*3*	*20°*	*Reverse*	*Plate Boundary Fault -2*
3	*22.4*	*91.8*	*6.0*	*6*	*90°*	*Reverse*	*Mw6.0 beneath city*
4	*22.4*	*91.8*	*6.0*	*22*	*45°*	*Reverse*	*Mw6.0 beneath city*

Table 5-3 Earthquake Scenario Parameters for Sylhet City Corporation Area

Case	Coordinate of Epicenter		M_w	Depth to Top of fault (km)	Dip Angle	Fault type	Description
	Latitude	Longitude					
1	*25.1*	*91.2*	*8.0*	*3*	*60°*	*Reverse*	*Dauki Fault*
2	*25.7*	*93.7*	*8.3*	*3*	*30°*	*Reverse*	*Plate Boundary Fault -3*
3	*24.9*	*91.87*	*6.0*	*7*	*90°*	*Reverse*	*Mw6.0 beneath city*
4	*25.03*	*91.2*	*8.0*	*3*	*60°*	*Reverse*	*Dauki Fault*
5	*24.91*	*91.2*	*8.5*	*3*	*60°*	*Reverse*	*Dauki Fault*

HAZUS provides three methods for selecting earthquake scenario: Deterministic Calculation of Scenario Earthquake Ground Shaking, Probabilistic Seismic Hazard Maps, and User-Supplied Seismic Hazard Maps. In the latter two methods, user must provide their own PGA or Spectral acceleration contour map. This process is cumbersome as the capability to develop the maps is limited to only few experts. Also the seismic risk assessment developed in this project will be continually updated in the future by local experts. Therefore the first method which is relatively simpler was chosen. In this method, user can simply choose the earthquake events that match with their own interest by providing the parameters as shown in Tables 5-1, 5-2 and 5-3. These earthquake events can be those from catalog or can be any arbitrary event that is possible to occur in the future. The consulting team has input the parameters for earthquake scenarios in Dhaka, Chittagong and Sylhet City Corporation and obtained the distribution of ground parameters as shown in Figures 5-2 to 5-10.

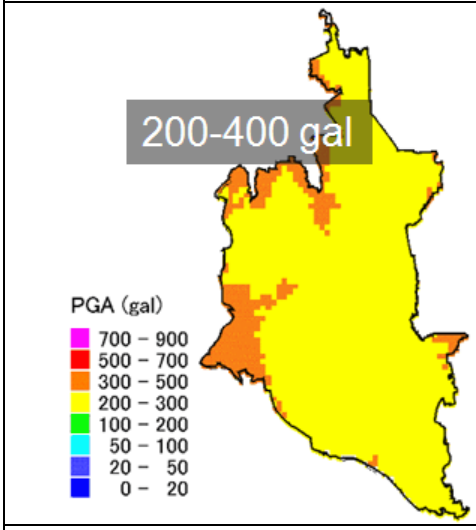
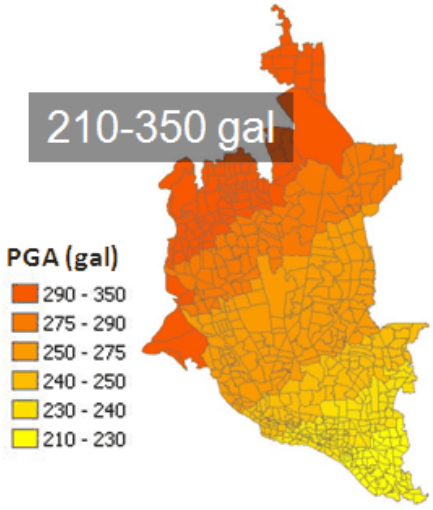
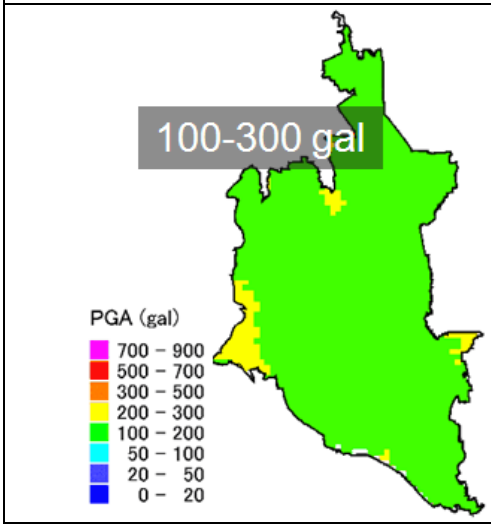
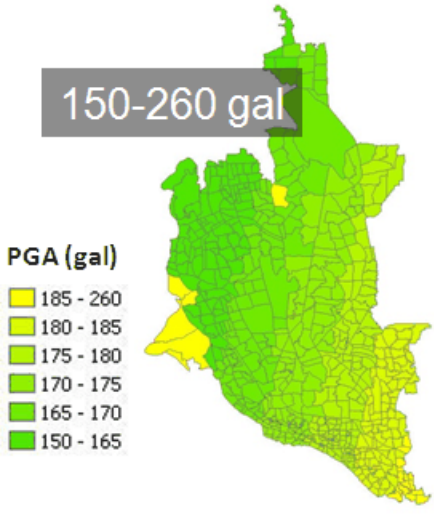
OYO: Peak Ground Acceleration (gal)	HAZUS: Peak Ground Acceleration (gal)
Case 1: Mw = 7.5 Madhupur Fault (MF)	
	
Case 2: Mw = 8.0 Plate Boundary Fault-2 (PBF-2)	
	

Figure 5-6 PGA in Dhaka (OIC results) compared with HAZUS calculations

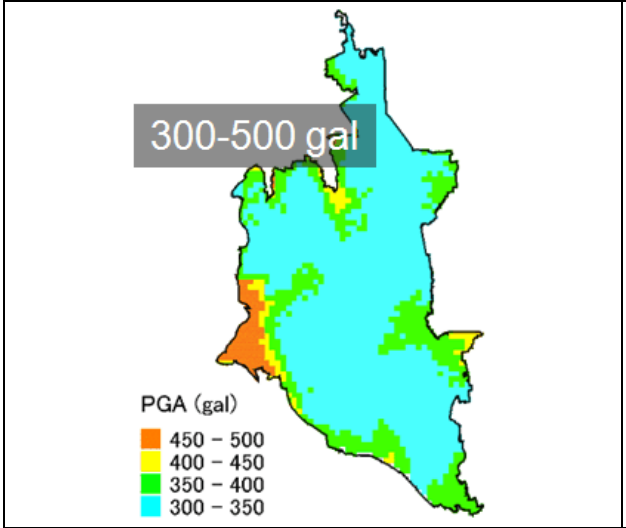
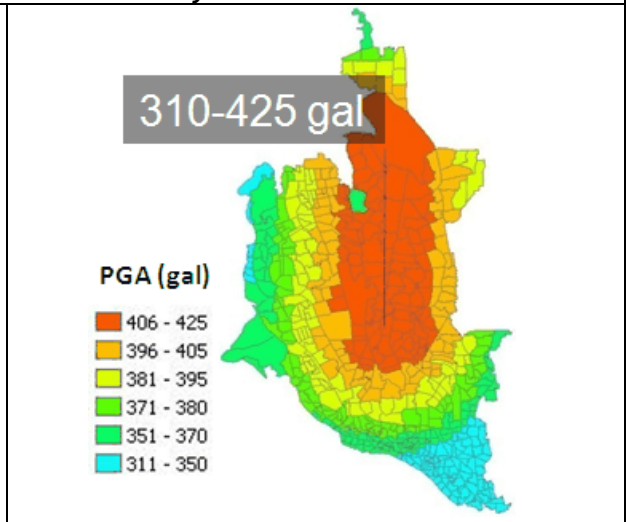
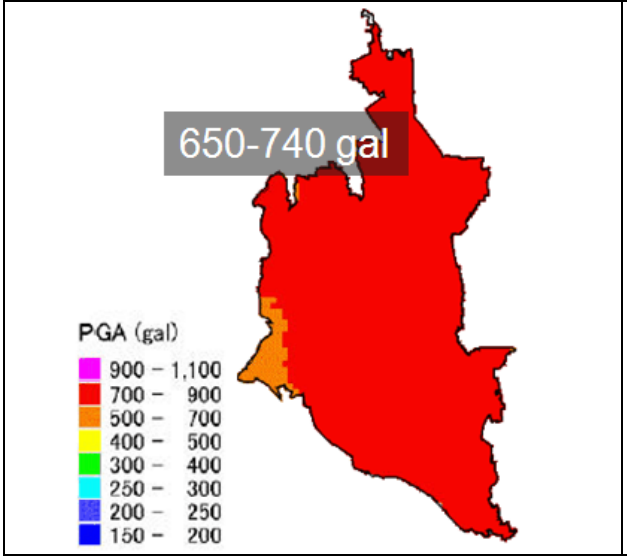
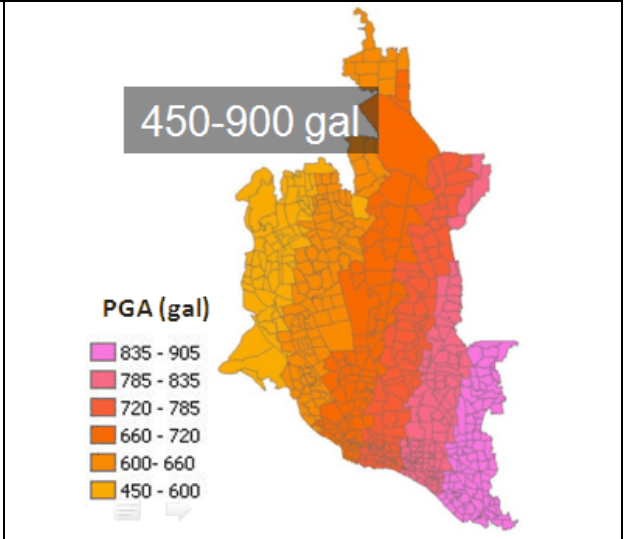
OYO: Peak Ground Acceleration (gal)	HAZUS: Peak Ground Acceleration (gal)
Case 3: Mw = 6.0 Underneath City	
	
Case 4: 2% PE in 50 Years	
	

Figure 5-2 PGA in Dhaka (OIC results) compared with HAZUS calculations (Cont'd)

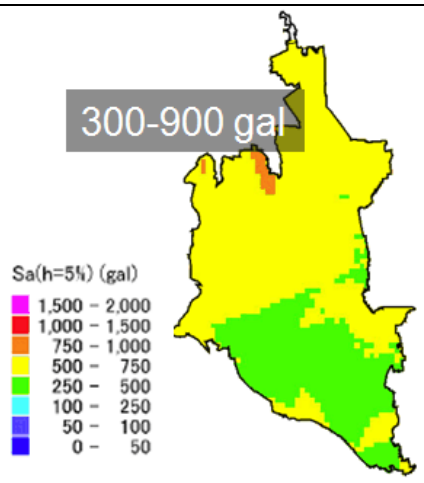
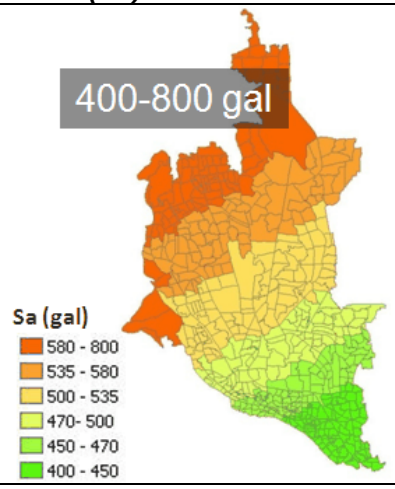
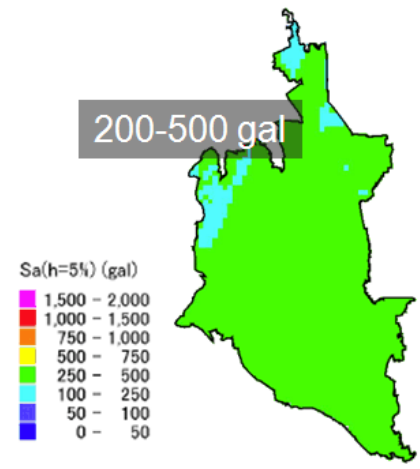
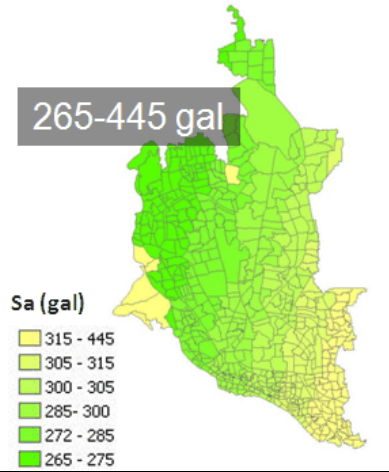
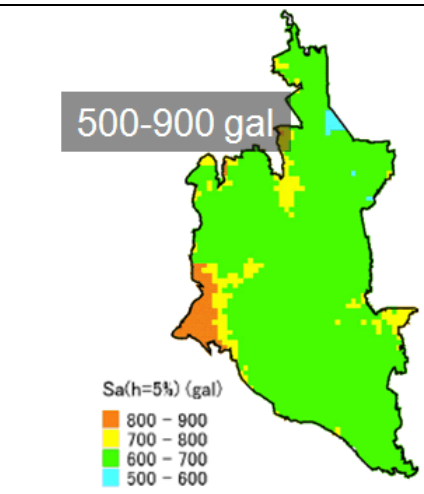
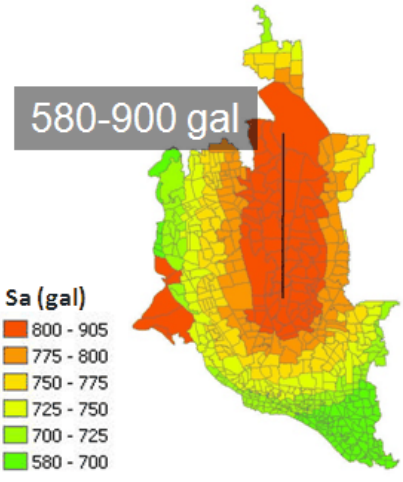
OYO: Spectral Acceleration (gal) at T=0.3 s	HAZUS: Spectral Acceleration (gal) at T=0.3 s
Case 1: Mw = 7.5 Madhupur Fault (MF)	
	
Case 2: Mw = 8.0 Plate Boundary Fault-2 (PBF-2)	
	
Case 3: Mw = 6.0 Underneath City	
	

Figure 5-7 Sa (T= 0.3 sec) in Dhaka compared with HAZUS calculations

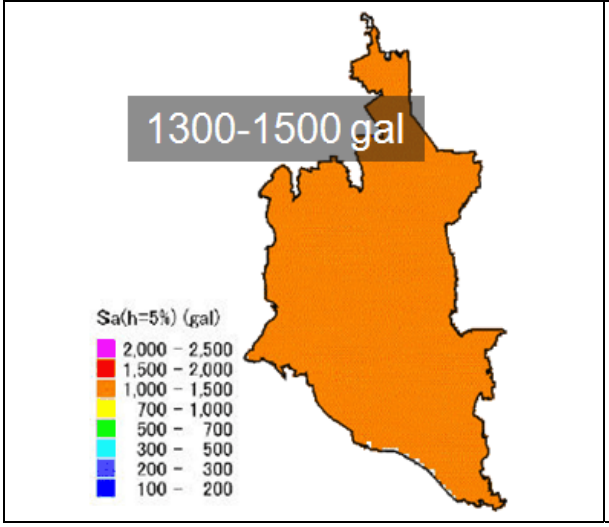
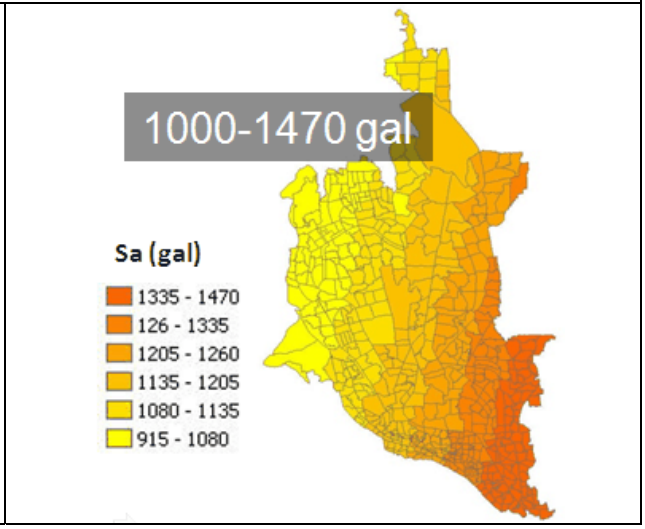
OYO: Spectral Acceleration (gal) at T=0.3 s	HAZUS: Spectral Acceleration (gal) at T=0.3 s
Case 4: 2% PE in 50 Years	
	

Figure 5-3 Sa (T= 0.3 sec) in Dhaka compared with HAZUS calculations (Cont'd)

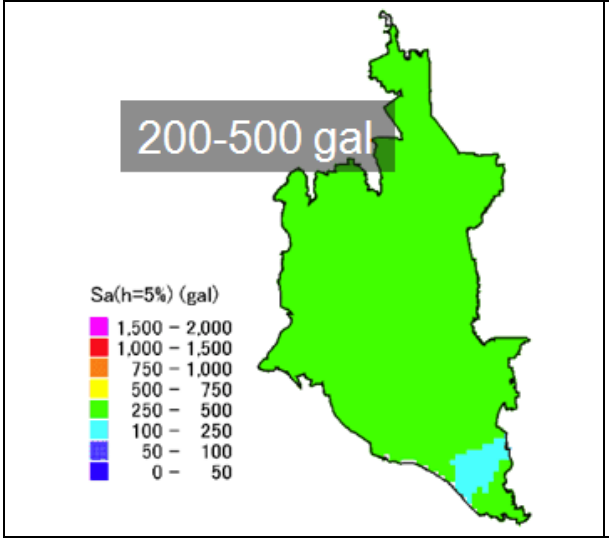
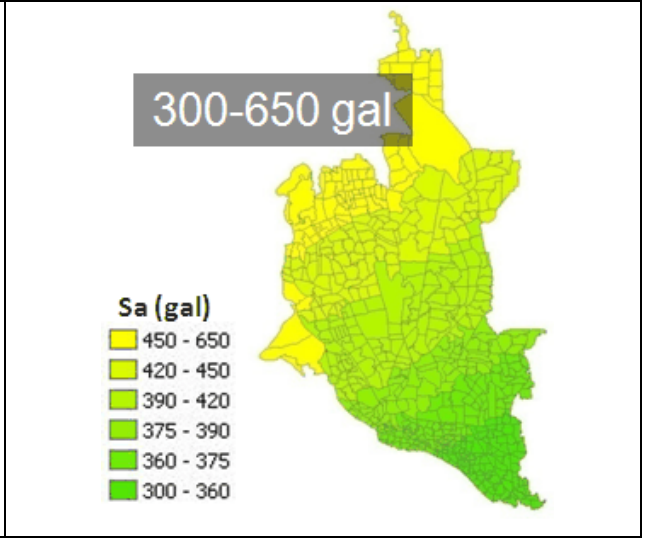
OYO: Spectral Acceleration (gal) at T=1.0 s	HAZUS: Spectral Acceleration (gal) at T=1.0 s
Case 1: Mw = 7.5 Madhupur Fault (MF)	
	

Figure 5-4 Sa (T= 1.0 sec) in Dhaka compared with HAZUS calculations

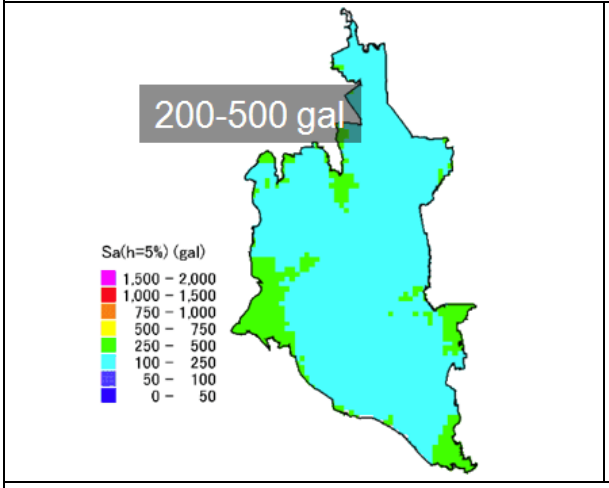
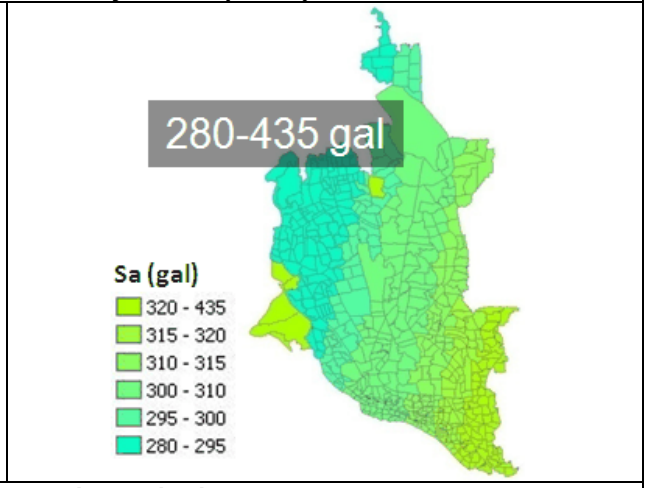
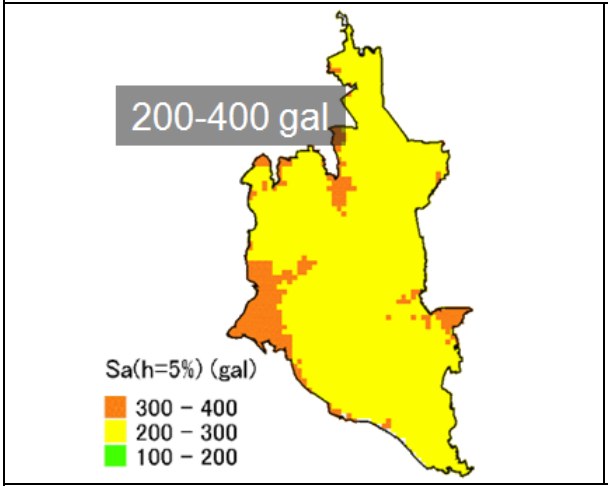
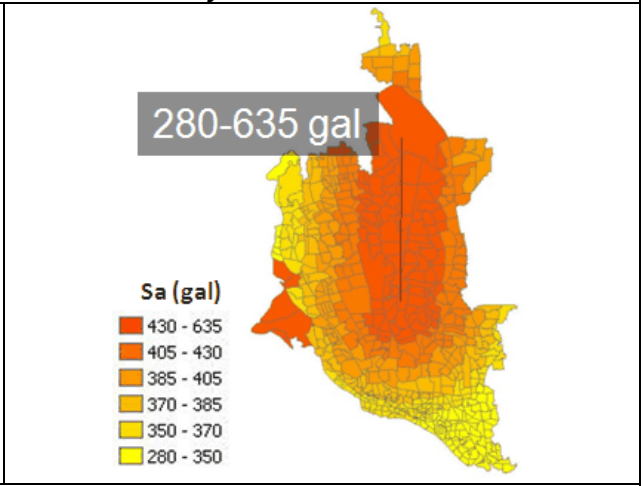
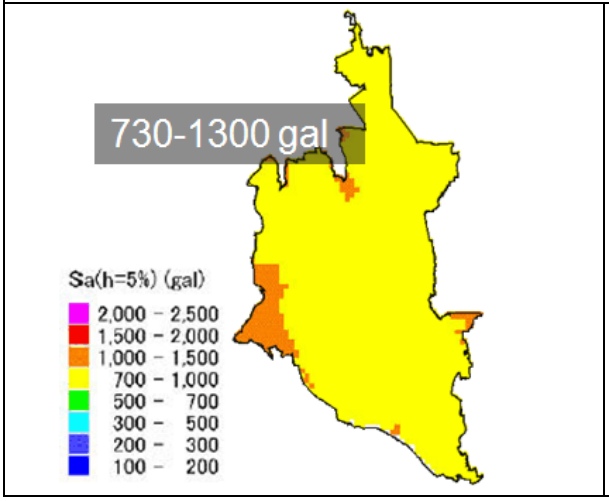
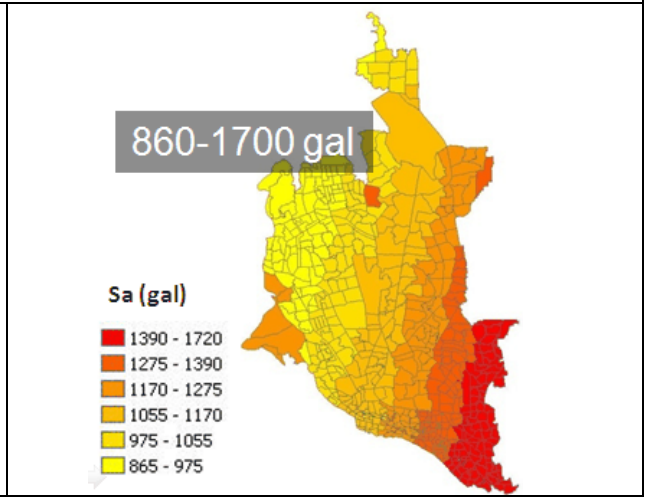
OYO: Spectral Acceleration (gal) at T=1.0 s	HAZUS: Spectral Acceleration (gal) at T=1.0 s
Case 2: Mw = 8.0 Plate Boundary Fault-2 (PBF-2)	
	
Case 3: Mw = 6.0 Underneath City	
	
Case 4: 2% PE in 50 Years	
	

Figure 5-4 Sa (T= 1.0 sec) in Dhaka compared with HAZUS calculations (Cont'd)

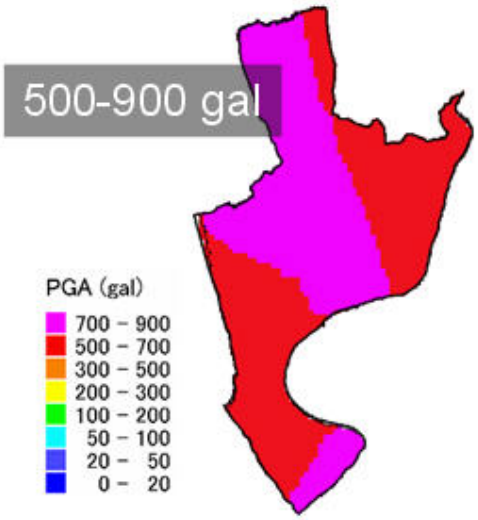
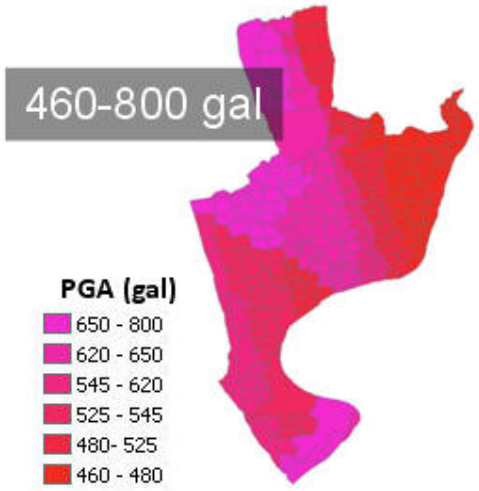
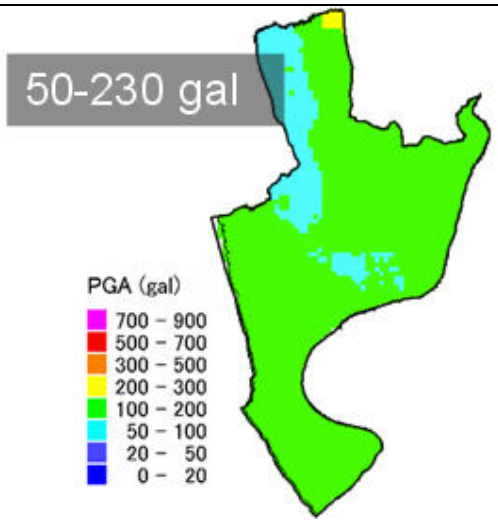
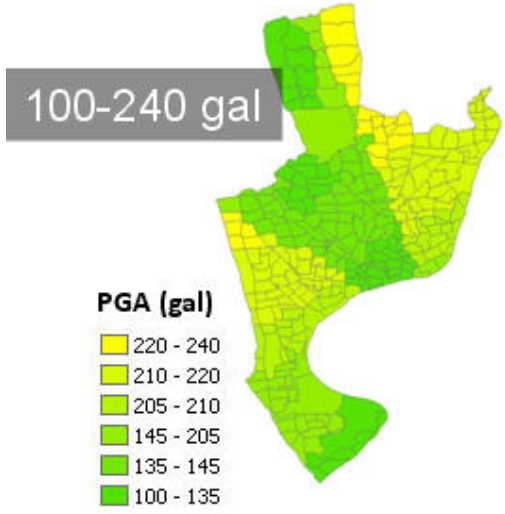
OYO: Peak Ground Acceleration (gal)	HAZUS: Peak Ground Acceleration (gal)
Case 1: Mw = 8.5 Plate Boundary Fault-1 (PBF-1)	
	
Case 2: Mw = 8.0 Plate Boundary Fault-2 (PBF-2)	
	

Figure 5-5 PGA in Chittagong (OIC results) compared with HAZUS calculations

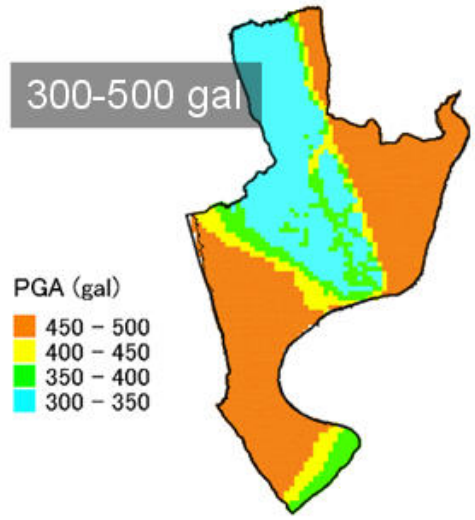
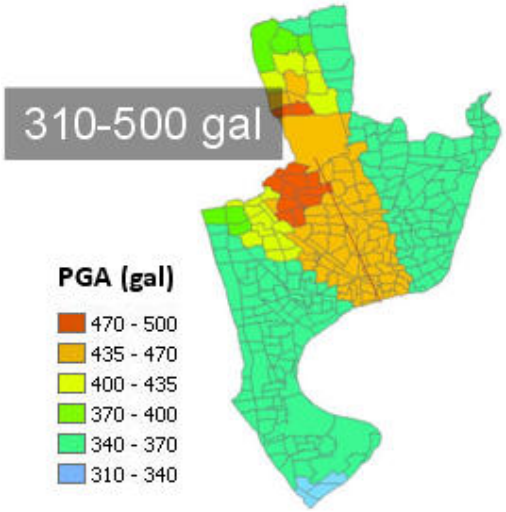
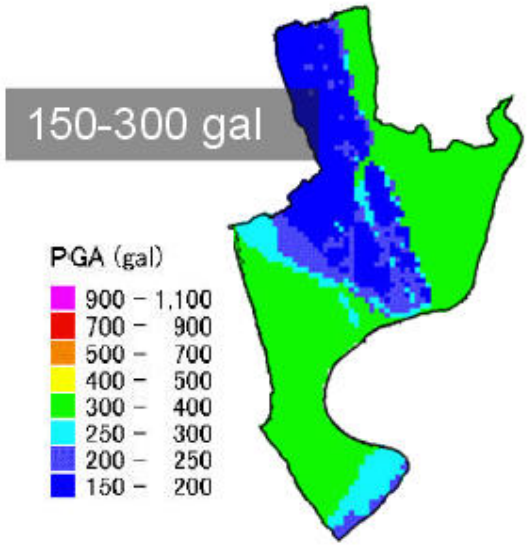
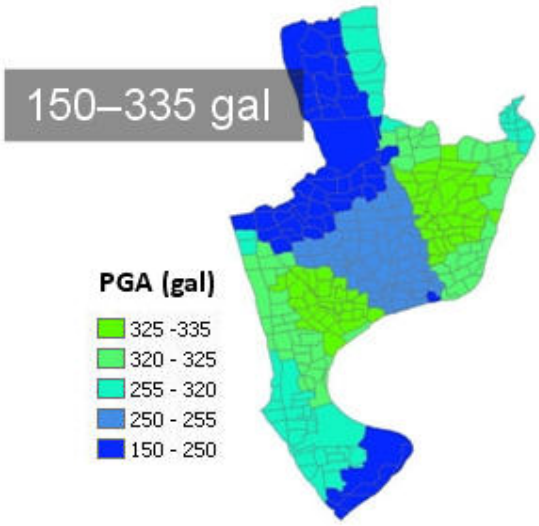
OYO: Peak Ground Acceleration (gal)	HAZUS: Peak Ground Acceleration (gal)
Case 3: Mw = 6.0 Underneath City	
	
Case 4: 10% PE in 50 Years	
	

Figure 5-5 PGA in Chittagong (OIC results) compared with HAZUS calculations (Cont'd)

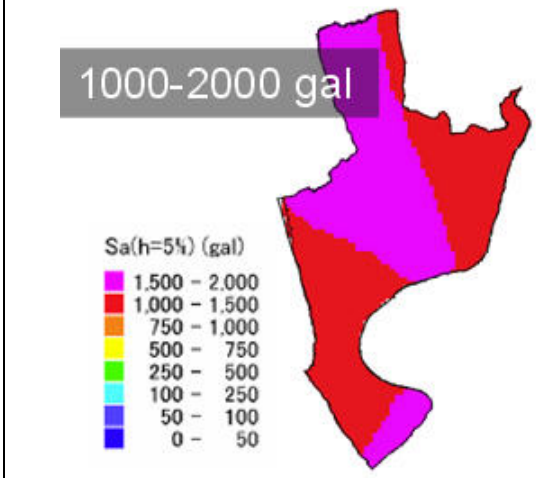
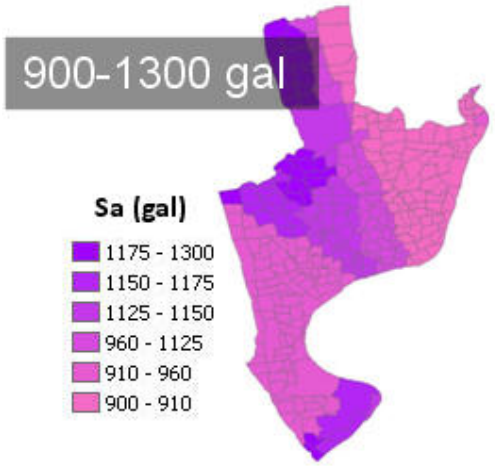
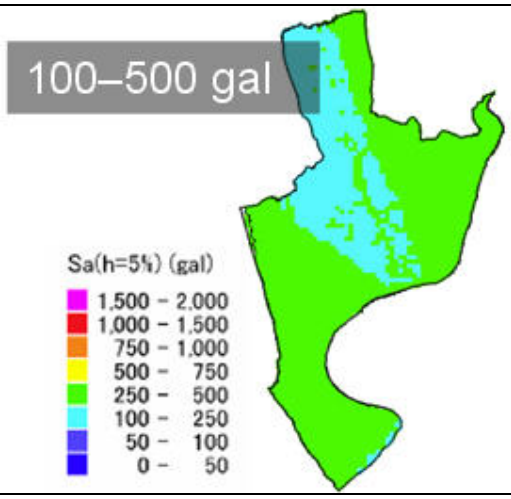
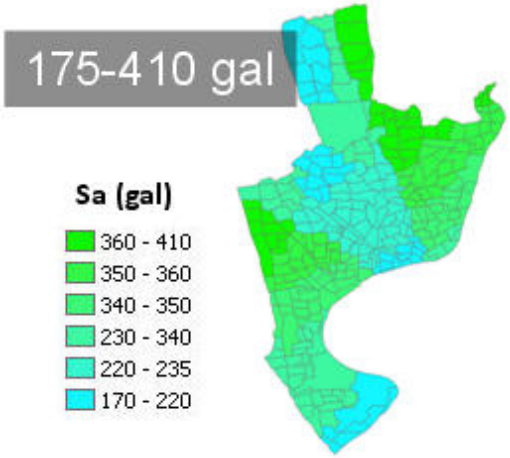
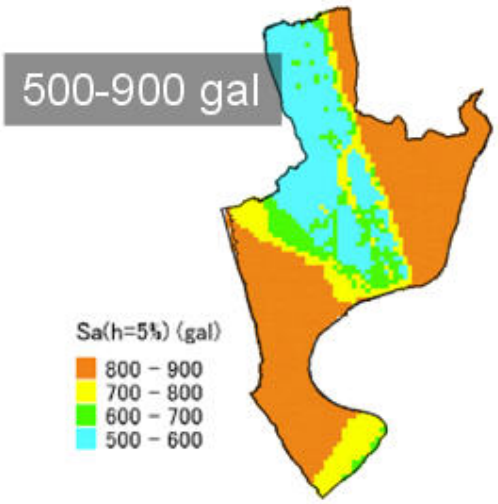
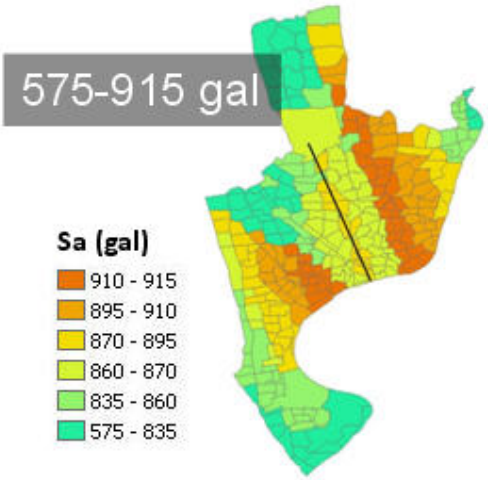
OYO: Spectral Acceleration (gal) at T=0.3 s	HAZUS: Spectral Acceleration (gal) at T=0.3 s
Case 1: Mw = 8.5 Plate Boundary Fault-1 (PBF-1)	
	
Case 2: Mw = 8.0 Plate Boundary Fault-2 (PBF2)	
	
Case 3: Mw = 6.0 Underneath City	
	

Figure 5-6 Sa (T= 0.3 sec) in Chittagong compared with HAZUS calculations

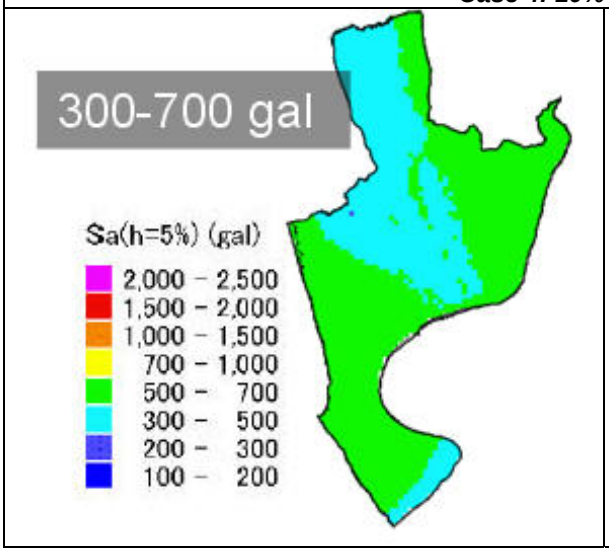
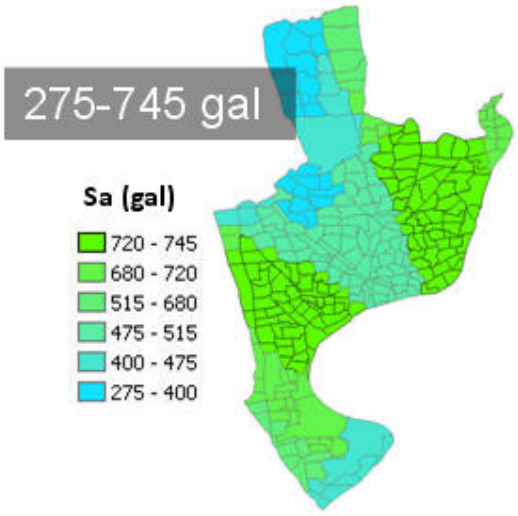
OYO: Spectral Acceleration (gal) at T=0.3 s	HAZUS: Spectral Acceleration (gal) at T=0.3 s
Case 4: 10% PE in 50 Years	
	

Figure 5-6 Sa (T= 0.3 sec) in Chittagong compared with HAZUS calculations (Cont'd)

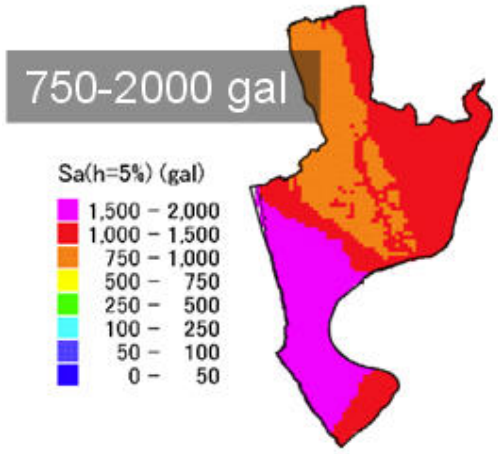
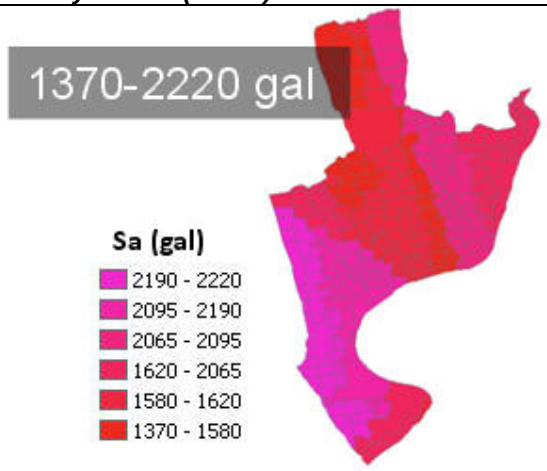
OYO: Spectral Acceleration (gal) at T=1.0 s	HAZUS: Spectral Acceleration (gal) at T=1.0 s
Case 1: Mw = 8.5 Plate Boundary Fault-1 (PBF-1)	
	

Figure 5-7 Sa (T= 1.0 sec) in Chittagong compared with HAZUS calculations

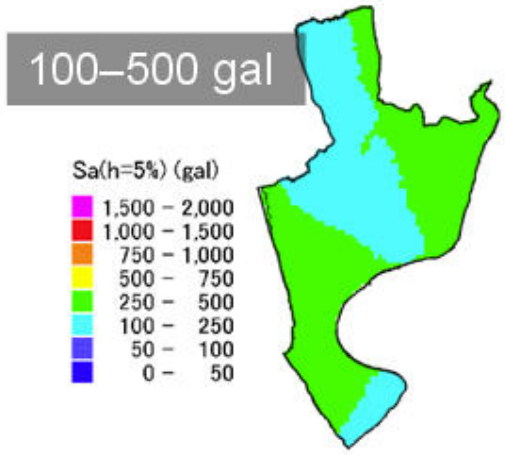
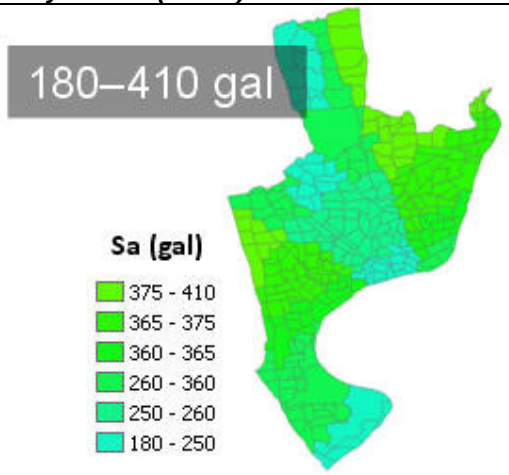
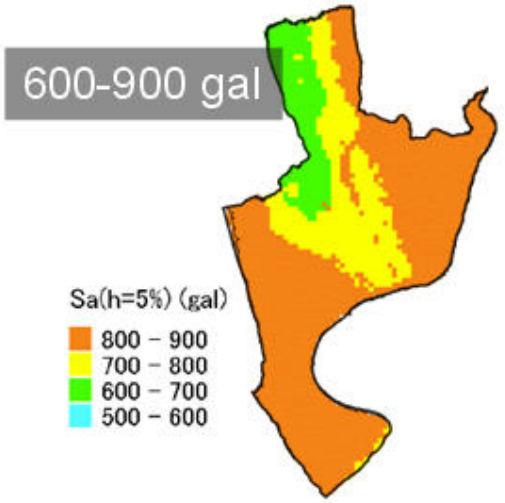
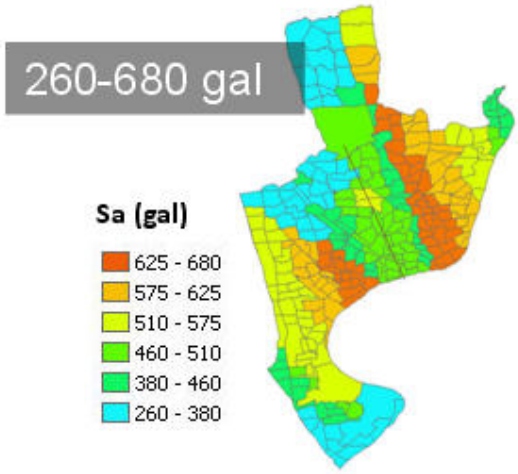
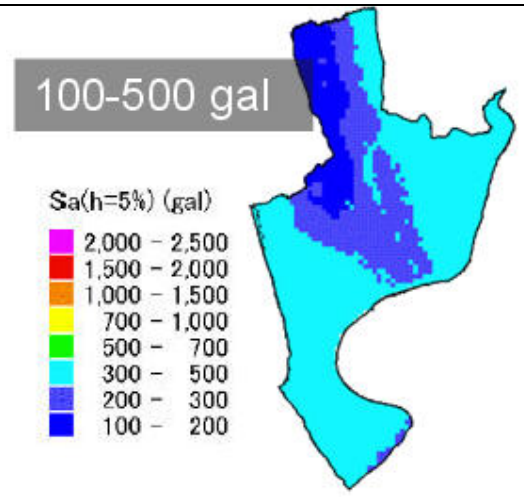
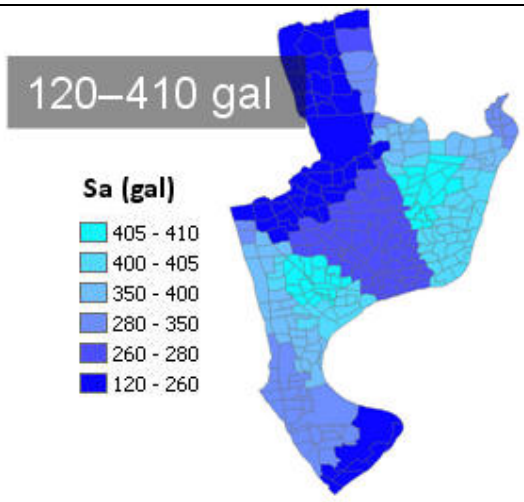
OYO: Spectral Acceleration (gal) at T=1.0 s	HAZUS: Spectral Acceleration (gal) at T=1.0 s
Case 2: Mw = 8.0 Plate Boundary Fault-2 (PBF-2)	
	
Case 3: Mw = 6.0 Underneath City	
	
Case 4: 10% PE in 50 Years	
	

Figure 5-7 Sa (T= 1.0 sec) in Chittagong compared with HAZUS calculations (Cont'd)

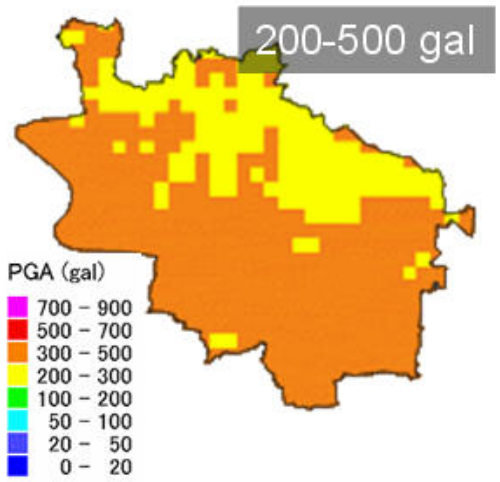
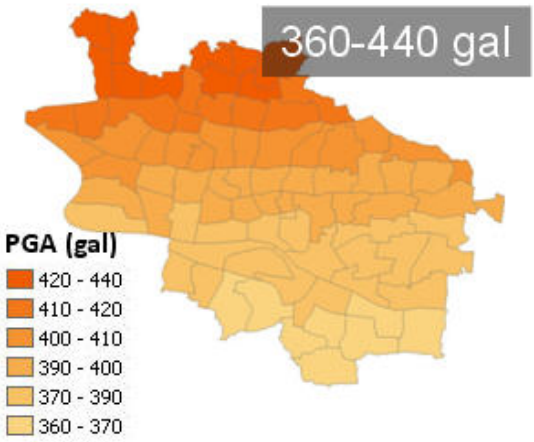
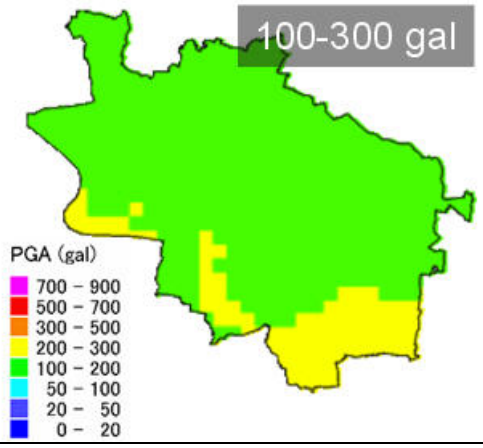
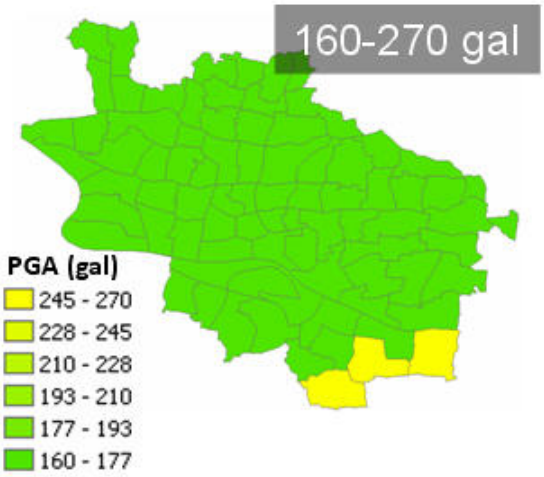
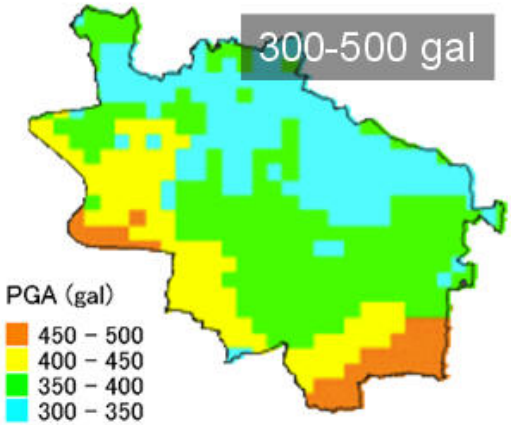
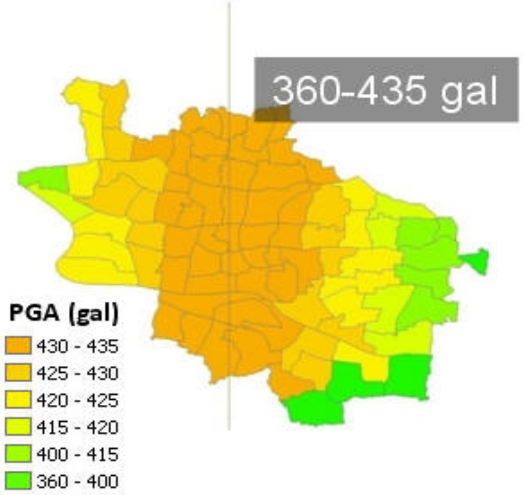
OYO: Peak Ground Acceleration (gal)	HAZUS: Peak Ground Acceleration (gal)
Case 1: Mw = 8.0 Dauki Fault (DF)	
	
Case 2: Mw = 8.3 Plate Boundary Fault-3 (PBF-3)	
	
Case 3: Mw = 6.0 Underneath City	
	

Figure 5-8 PGA in Sylhet (OIC results) compared with HAZUS calculations

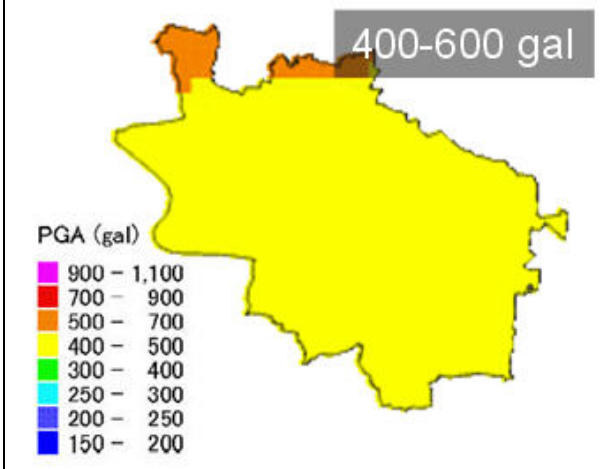
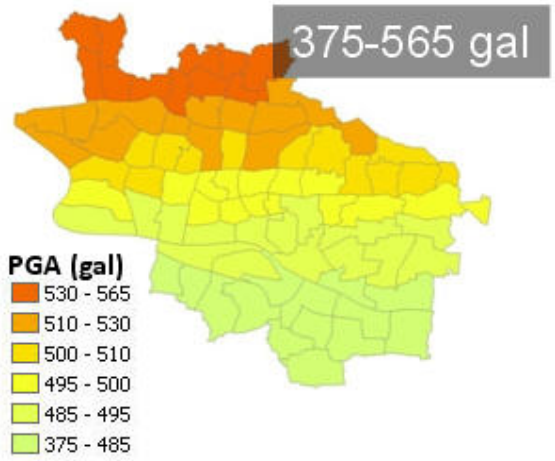
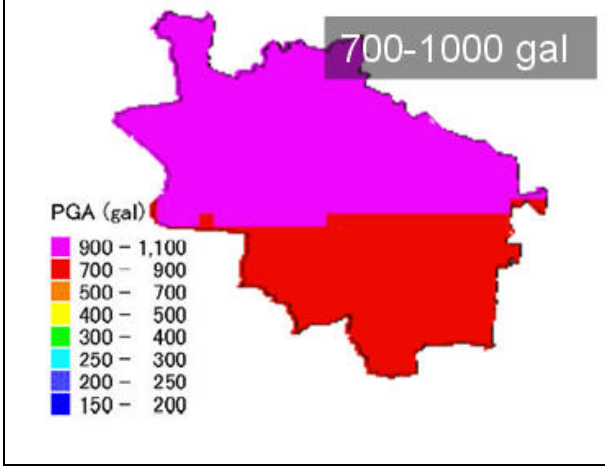
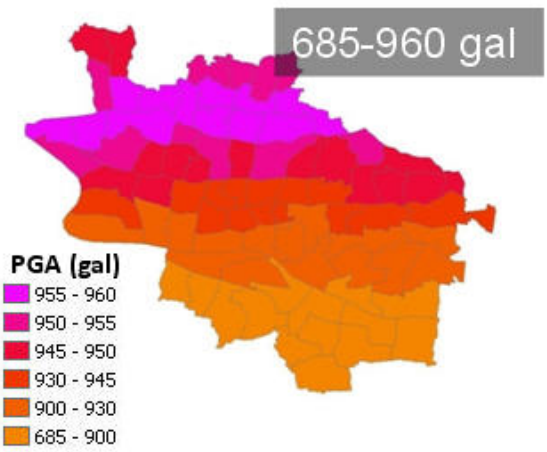
OYO: Peak Ground Acceleration (gal)	HAZUS: Peak Ground Acceleration (gal)
Case 4: 10% PE in 50 Years	
	
Case 5: 2% PE in 50 Years	
	

Figure 5-8 PGA in Sylhet (OIC results) compared with HAZUS calculations (Cont'd)

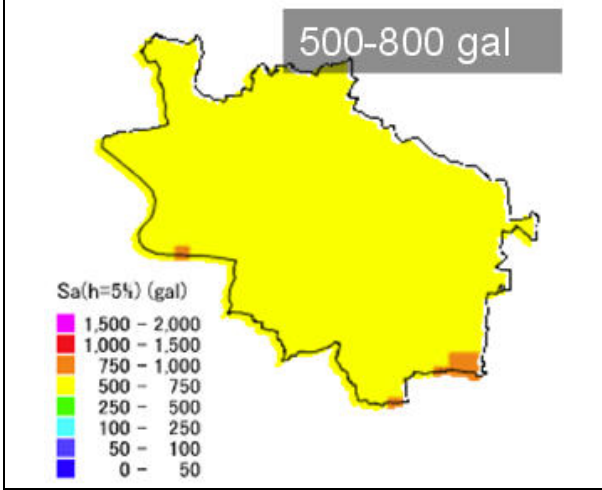
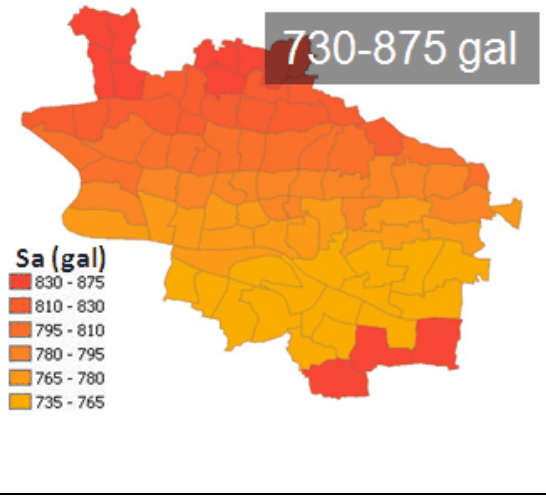
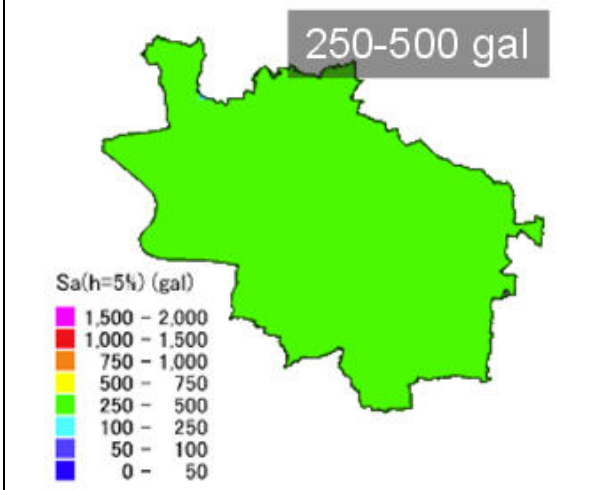
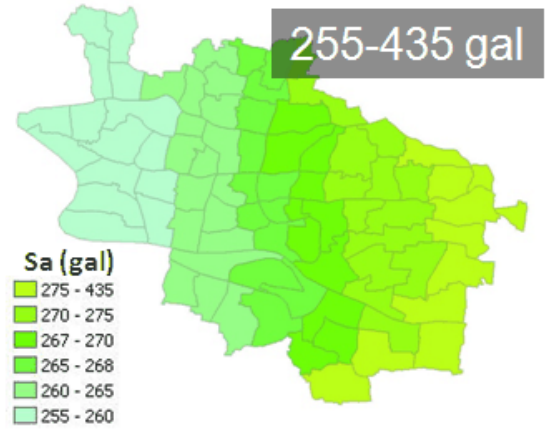
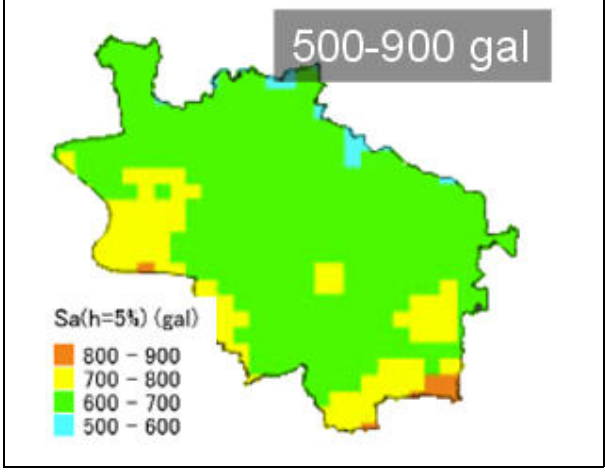
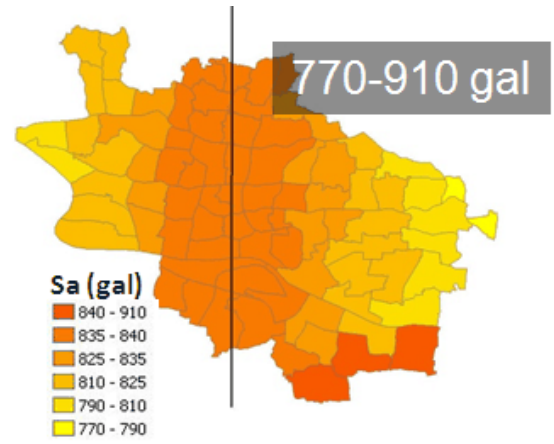
OYO: Spectral Acceleration (gal) at T=0.3 s	HAZUS: Spectral Acceleration (gal) at T=0.3 s
Case 1: Mw = 8.0 Dauki Fault (DF)	
	
Case 2: Mw = 8.3 Plate Boundary Fault-3 (PBF-3)	
	
Case 3: Mw = 6.0 Underneath City	
	

Figure 5-9 Sa (T= 0.3 sec) in Sylhet compared with HAZUS calculations

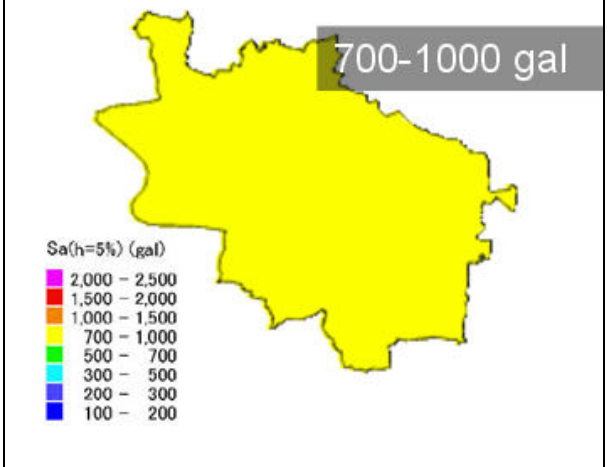
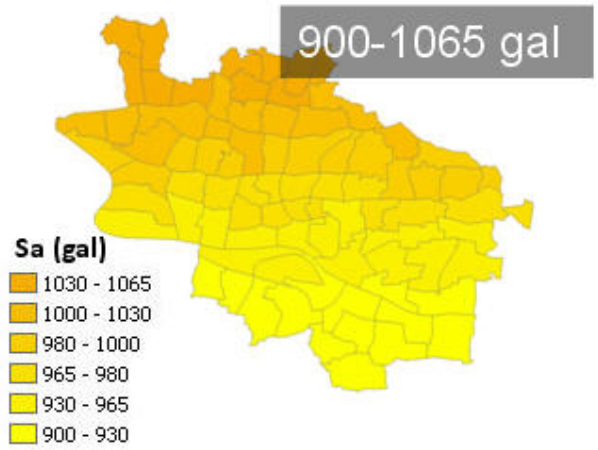
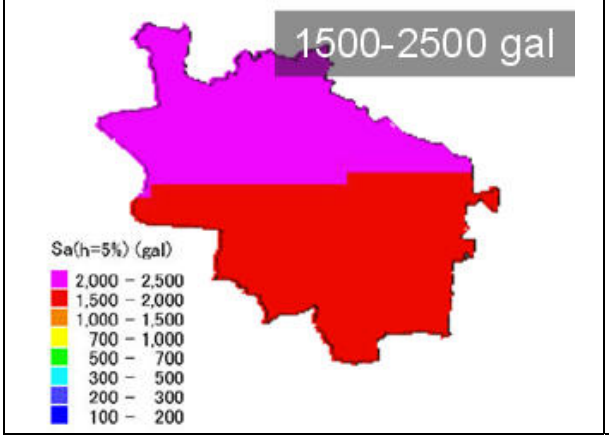
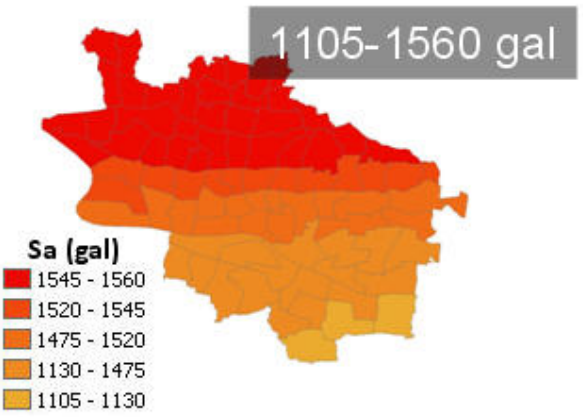
OYO: Spectral Acceleration (gal) at T=0.3 s	HAZUS: Spectral Acceleration (gal) at T=0.3 s
Case 4: 10% PE in 50 Years	
	
Case 5: 2% PE in 50 Years	
	

Figure 5-9 Sa (T= 0.3 sec) in Sylhet compared with HAZUS calculations (Cont'd)

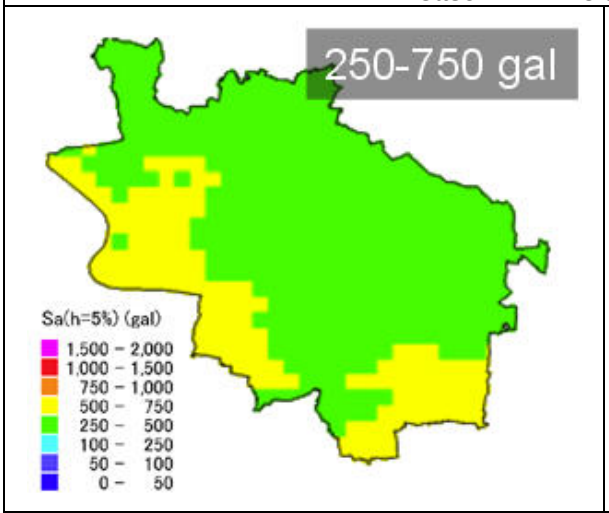
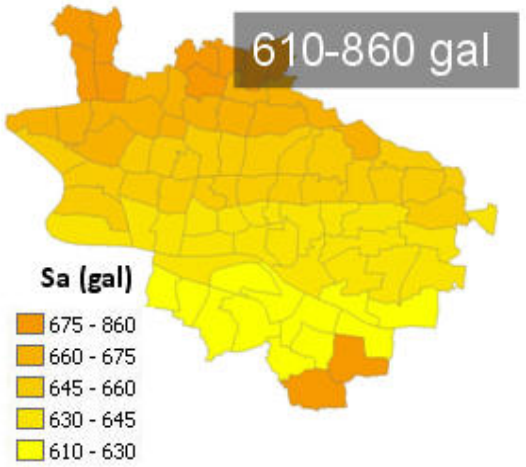
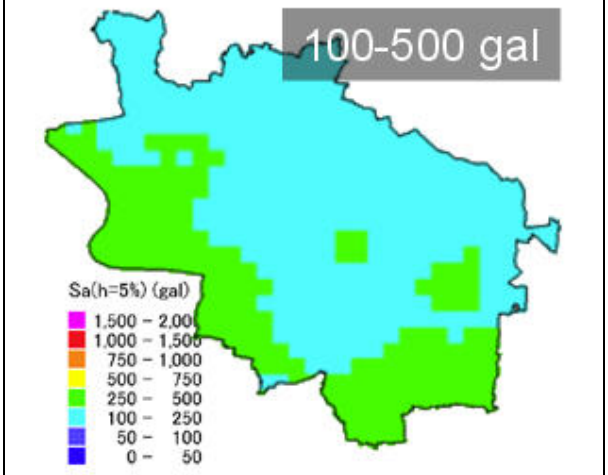
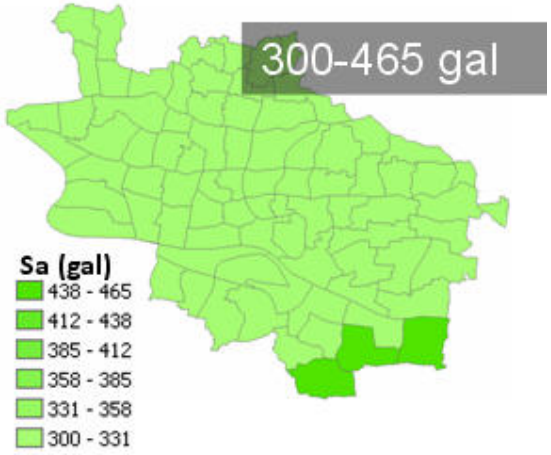
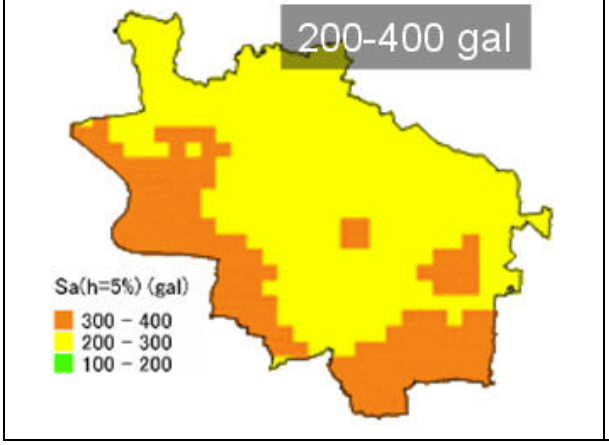
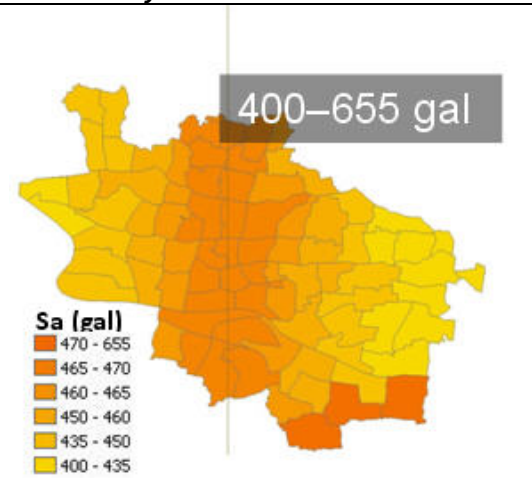
OYO: Spectral Acceleration (gal) at T=1.0 s	HAZUS: Spectral Acceleration (gal) at T=1.0 s
Case 1: Mw = 8.0 Dauki Fault (DF)	
	
Case 2: Mw = 8.3 Plate Boundary Fault-3 (PBF-3)	
	
Case 3: Mw = 6.0 Underneath City	
	

Figure 5-10 Sa (T= 1.0 sec) in Sylhet compared with HAZUS calculations

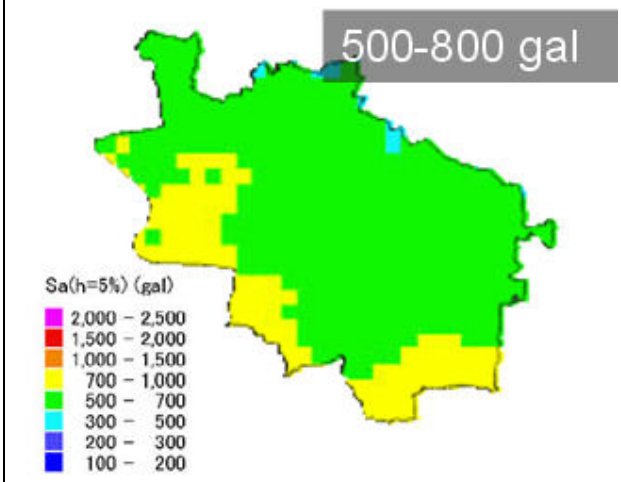
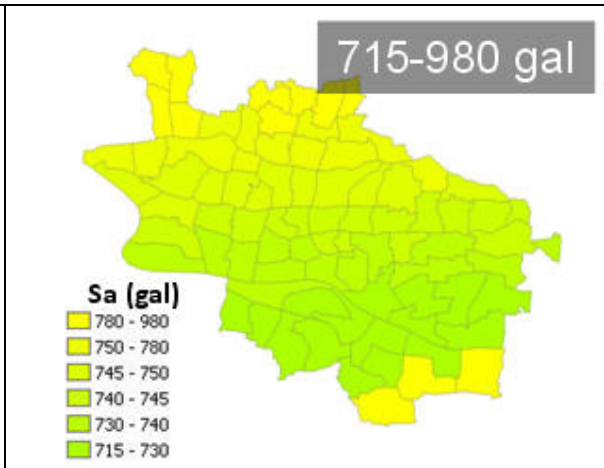
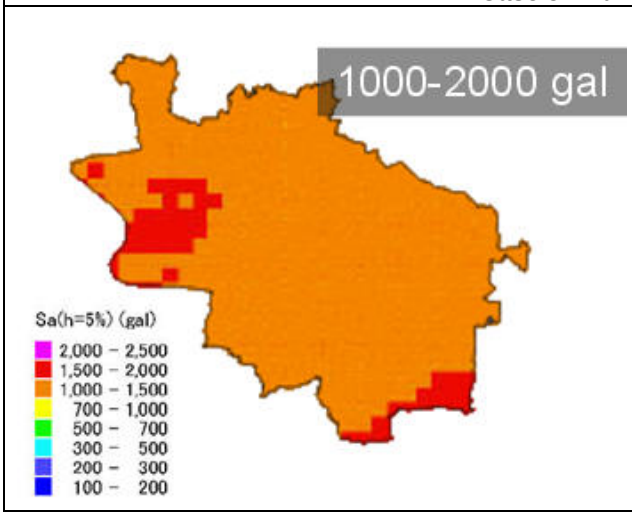
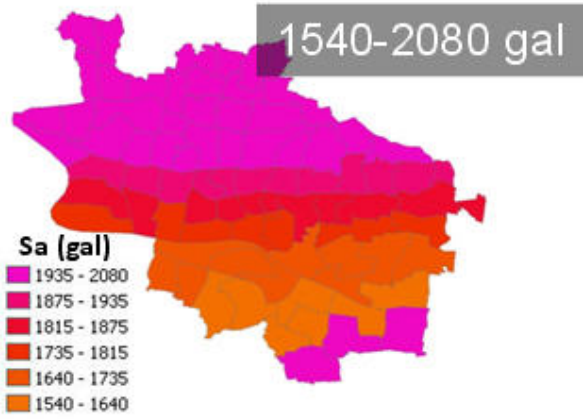
OYO: Spectral Acceleration (gal) at T=1.0 s	HAZUS: Spectral Acceleration (gal) at T=1.0 s
Case 4: 10% PE in 50 Years	
	
Case 5: 2% PE in 50 Years	
	

Figure 5-10 Sa (T= 1.0 sec) in Sylhet compared with HAZUS calculations (Cont'd)

6. HAZUS Calculations and Analysis Results

In this Chapter, the calculation and analysis results obtained from the HAZUS model of the 3 cities are presented. They are described in detail in the following.

6.1. Direct Earthquake Damage

6.1.1. Buildings Damage

Dhaka City Corporation Area

Buildings Damage in Dhaka City Corporation Area: Scenario case 1

HAZUS estimates that about 158,634 buildings will be at least moderately damaged. This is over 49.00 % of the total number of buildings in the region. There are an estimated 72,316 buildings that will be damaged beyond repair.

Table 6-1 Expected Building Damage by Occupancy Class in Dhaka City Corporation Area: Scenario Case 1

Dhaka : Case 1	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	261	0.21	291	0.67	485	0.91	264	0.80	343	0.47
Commercial	8,199	6.56	5,232	12.10	11,973	22.52	8,841	26.67	12,500	17.29
Education	476	0.38	343	0.79	844	1.59	629	1.90	870	1.20
Government	122	0.10	100	0.23	269	0.51	202	0.61	230	0.32
Industrial	1,245	1.00	748	1.73	1,538	2.89	1,137	3.43	1,708	2.36
Non-SFD Residential	112,110	89.73	35,473	82.05	36,242	68.17	20,891	63.01	54,644	75.56
Religion	407	0.33	307	0.71	567	1.07	372	1.12	526	0.73
Single Family Dwelling(SFD) Residential	2,118	1.70	739	1.71	1,248	2.35	817	2.46	1,495	2.07
Total	124,939		43,232		53,166		33,153		72,316	

Table 6-2 Expected Building Damage by Building Type in Dhaka City Corporation Area: Scenario Case 1

Dhaka : Case 1	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	8	0.01	14	0.03	125	0.24	324	0.98	948	1.31
Concrete	101,832	81.51	17,066	39.47	15,152	28.50	12,866	38.81	38,648	53.44
Masonry	6,353	5.09	10,784	24.94	26,558	49.95	17,328	52.26	21,611	29.89
Thin Shed and Bamboo	16,745	13.40	15368	35.55	11,331	21.31	2,635	7.95	11,108	15.36
Total	124,939		43,232		53,166		33,153		72,316	

Buildings Damage in Dhaka City Corporation Area: Scenario case 2

HAZUS estimates that about 93,414 buildings will be at least moderately damaged. This is over 29.00 % of the total number of buildings in the region. There are an estimated 45,609 buildings that will be damaged beyond repair.

Table 6-3 Expected Building Damage by Occupancy Class in Dhaka City Corporation Area: Scenario Case 2

Dhaka : Case 2										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	761	0.40	334	0.81	283	0.82	84	0.62	182	0.40
Commercial	19,053	9.91	7,664	18.61	9,512	27.71	3,841	28.49	6,676	14.64
Education	1,338	0.70	533	1.29	633	1.84	240	1.78	418	0.92
Government	327	0.17	157	0.38	227	0.66	96	0.71	116	0.25
Industrial	2,701	1.41	1,037	2.52	1,234	3.59	533	3.96	872	1.91
Non-SDF Residential	163,258	84.94	30,211	73.36	21,390	62.32	8,330	61.79	36,170	79.31
Religion	1,001	0.52	371	0.90	357	1.04	153	1.13	297	0.65
Single Family Dwelling(SDF) Residential	3,770	1.96	873	2.12	690	2.01	205	1.52	878	1.93
Total	**192,210**		**41,181**		**34,326**		**13,480**		**45,609**	

Table 6-4 Expected Building Damage by Building Type in Dhaka City Corporation Area: Scenario Case 2

Dhaka : Case 2										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	25	0.01	36	0.09	226	0.66	460	3.42	673	1.47
Concrete	124,630	65	13,494	33	12,062	35	8,406	62	26,972	59
Masonry	33,051	17	17,348	42	18,408	54	4,238	31	9,588	21
Thin Shed and Bamboo	34,504	17.95	10303	25.02	3,629	10.57	375	2.78	8,377	18.37
Total	**192,210**		**41,181**		**34,326**		**13,480**		**45,609**	

Buildings Damage in Dhaka City Corporation Area: Scenario case 3

HAZUS estimates that about 182,521 buildings will be at least moderately damaged. This is over 56.00 % of the total number of buildings in the region. There are an estimated 78,323 buildings that will be damaged beyond repair.

Table 6-5 Expected Building Damage by Occupancy Class in Dhaka City Corporation Area: Scenario Case 3

Dhaka : Case 3										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	151	0.15	252	0.55	524	0.80	311	0.81	407	0.52
Commercial	6,935	7.05	5,818	12.66	13,944	21.24	8,753	22.70	11,297	14.42
Education	405	0.41	393	0.86	1,006	1.53	607	1.58	751	0.96
Government	106	0.11	123	0.27	310	0.47	183	0.48	200	0.25
Industrial	1,021	1.04	842	1.83	1,794	2.73	1,138	2.95	1,582	2.02
Non-SFD Residential	87,706	89.19	37,433	81.46	46,031	70.12	26,302	68.22	61,888	79.02
Religion	302	0.31	304	0.66	655	1.00	398	1.03	519	0.66
Single Family Dwelling(SFD) Residential	1,708	1.74	786	1.71	1,382	2.11	862	2.24	1,680	2.15
Total	**98,333**		**45,951**		**65,644**		**78,323**		**78,323**	

Table 6-6 Expected Building Damage by Building Type in Dhaka City Corporation Area: Scenario Case 3

Dhaka : Case 3										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	61	0.06	70	0.15	304	0.46	462	1.20	524	0.67
Concrete	85,020	86	21,328	46	21,260	32	16,277	42	41,679	53
Masonry	4,932	5	10,685	23	28,873	44	16,753	43	21,390	27
Thin Shed and Bamboo	8,320	8.46	13868	30.18	15,207	23.17	5,062	13.13	14,731	18.81
Total	**98,333**		**45,951**		**65,644**		**38,554**		**78,323**	

Buildings Damage in Dhaka City Corporation Area: Scenario case 4

HAZUS estimates that about 270,604 buildings will be at least moderately damaged. This is over 83.00 % of the total number of buildings in the region. There are an estimated 238,164 buildings that will be damaged beyond repair.

Table 6-7 Expected Building Damage by Occupancy Class in Dhaka City Corporation Area: Scenario Case 4

Dhaka : Case 4										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	10	0.02	7	0.06	44	0.29	139	0.73	1,444	0.61
Commercial	2,593	6.14	697	5.83	1,037	6.76	2,572	13.47	39,846	16.73
Education	143	0.34	39	0.33	81	0.53	206	1.08	2,693	1.13
Government	34	0.08	9	0.08	20	0.13	58	0.30	800	0.34
Industrial	372	0.88	100	0.83	160	1.04	398	2.08	5,347	2.25
Non-SFD Residential	38,335	90.76	10,913	91.22	13,738	89.54	15,294	80.08	181,080	76.03
Religion	62	0.15	21	0.17	60	0.39	142	0.75	1,894	0.80
Single Family Dwelling(SFD) Residential	688	1.63	177	1.48	202	1.32	289	1.51	5,060	2.12
Total	**42,239**		**11,963**		**15,343**		**19,097**		**238,164**	

Table 6-8 Expected Building Damage by Building Type in Dhaka City Corporation Area: Scenario Case 4

Dhaka : Case 4										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	0	0.00	0	0.00	1	0.01	3	0.01	1,416	0.59
Concrete	42,008	99	10,366	87	7,230	47	4,160	22	121,800	51
Masonry	6	0	63	1	1,411	9	5,536	29	75,616	32
Thin Shed and Bamboo	224	0.53	1534	12.82	6,701	43.67	9,398	49.21	39,332	16.51
Total	**42,239**		**11,963**		**15,343**		**19,097**		**238,164**	

Chittagong City Corporation Area

Buildings Damage in Chittagong City Corporation Area: Scenario Case 1

HAZUS estimates that about 168,150 buildings will be at least moderately damaged. This is over 92.00 % of the total number of buildings in the Chittagong city. There are an estimated 142,856 buildings that will be damaged beyond repair.

Table 6-9 Expected Building Damage by Occupancy Class in Chittagong City Corporation: Scenario Case 1

Chittagong : Case 1										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	15	0.29	21	0.23	30	0.23	43	0.35	262	0.18
Commercial	751	15.04	1,424	15.60	2,018	15.35	1,786	14.70	22,482	15.74
Education	74	1.48	102	1.11	114	0.87	98	0.80	956	0.67
Government	6	0.12	8	0.08	11	0.09	12	0.10	192	0.13
Industrial	53	1.07	66	0.72	83	0.63	85	0.70	1,793	1.25
Non-SFD Residential	2,946	58.96	5,888	64.46	8,906	67.75	8,167	67.22	67,569	47.30
Religion	49	0.98	84	0.92	102	0.78	86	0.70	360	0.25
Single Family Dwelling (SFD) Residential	1,102	22.05	1,541	16.87	1,882	14.32	1,872	15.41	49,242	34.47
Total	**4,996**		**9,133**		**13,146**		**12,149**		**142,856**	

Table 6-10 Expected Building Damage by Building Type in Chittagong City Corporation: Scenario Case 1

Chittagong : Case 1										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	0	0.00	0	0.00	0	0.00	0	0.00	145	0.10
Concrete	4,885	98	8,389	92	10,720	82	9,045	74.46	82,590	57.81
Masonry	0	0	2	0.03	95	0.72	669	5.5	48,323	33.82
Thin Shed and Bamboo	111	2.21	742	8.13	2,333	17.74	2,434	20.04	11,798	8.26
Total	**4,996**		**9,133**		**13,146**		**13,146**		**142,856**	

Buildings Damage in Chittagong City Corporation Area: Scenario Case 2

HAZUS estimates that about 56,512 buildings will be at least moderately damaged. This is over 31.00 % of the total number of buildings. There are an estimated 17,645 buildings that will be damaged.

Table 6-11 Expected Building Damage by Occupancy Class in Chittagong City Corporation: Scenario Case 2

Chittagong : Case 2	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	226	0.24	57	0.18	38	0.14	21	0.18	29	0.16
Commercial	15,600	16.59	4,941	15.58	3,916	14.54	1,656	13.87	2,349	13.31
Education	776	0.82	212	0.67	156	0.58	77	0.65	122	0.69
Government	141	0.15	38	0.12	24	0.09	8	0.07	17	0.10
Industrial	789	0.84	337	1.06	402	1.49	252	2.11	300	1.70
Non-SFD Residential	52,205	55.50	16,146	50.92	11,808	43.85	5,056	42.35	8,261	46.82
Religion	470	0.50	108	0.34	54	0.20	19	0.16	31	0.17
Single Family Dwelling (SFD) Residential	23,850	25.36	9,872	31.13	10,530	39.10	4,850	40.62	6,537	37.05
Total	**94,057**		**31,711**		**26,929**		**11,939**		**17,645**	

Table 6-12 Expected Building Damage by Building Type in Chittagong City Corporation: Scenario Case 2

Chittagong : Case 2	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	9	0.01	7	0.02	29	0.11	45	0.38	55	0.31
Concrete	59,070	62.80	17,600	55.50	15,739	58.45	9,568	80.14	13,652	77.37
Masonry	23,095	24.55	10,813	34.10	9,985	37.08	2,201	18.43	2,995	16.97
Thin Shed and Bamboo	11,883	12.63	3291	10.38	1,176	4.37	125	1.04	943	5.34
Total	**94,057**		**31,711**		**26,929**		**11,939**		**17,645**	

Buildings Damage in Chittagong City Corporation Area: Scenario Case 3

HAZUS estimates that about 128,104 buildings will be at least moderately damaged. This is over 70.00 % of the total number of buildings. There are an estimated 55,338 buildings that will be damaged beyond repair.

Table 6-13 Expected Building Damage by Occupancy Class in Chittagong City Corporation: Scenario Case 3

Chittagong : Case 3	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	82	0.29	71	0.28	82	0.20	62	0.19	74	0.13
Commercial	4,903	17.13	4,079	15.97	6,046	15.08	5,193	15.89	8,242	14.89
Education	326	1.14	223	0.87	254	0.63	209	0.64	332	0.60
Government	54	0.19	37	0.15	46	0.12	36	0.11	56	0.10
Industrial	230	0.80	204	0.80	390	0.97	403	1.23	853	1.54
Non-SFD Residential	17,285	60.37	15,029	58.83	20,206	50.40	15,468	47.33	25,488	46.06
Religion	222	0.78	144	0.56	128	0.32	89	0.27	99	0.18
Single Family Dwelling (SFD) Residential	5,528	19.31	5,760	22.55	12,937	32.27	11,219	34.33	20,196	36.49
Total	**28,630**		**25,545**		**40,089**		**32,677**		**55,338**	

Table 6-14 Expected Building Damage by Building Type in Chittagong City Corporation: Scenario Case 3

Chittagong : Case 3	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	2	0.01	3	0.01	19	0.05	41	0.12	80	0.14
Concrete	25,498	89.06	17,342	67.89	19,614	48.93	17,759	54.35	35,416	64.00
Masonry	1,281	4.47	4,043	15.83	14,696	36.66	12,478	38.19	16,590	29.98
Thin Shed and Bamboo	1,849	6.46	4157	16.27	5,760	14.37	2,399	7.34	3,252	5.88
Total	**28,630**		**25,545**		**40,089**		**32,677**		**55,338**	

Buildings Damage in Chittagong City Corporation Area: Scenario Case 4

HAZUS estimates that about 97,608 buildings will be at least moderately damaged. This is over 54.00 % of the total number of buildings in the Chittagong city. There are an estimated 29,576 buildings that will be damaged beyond repair.

Table 6-15 Expected Building Damage by Occupancy Class in Chittagong City Corporation: Scenario Case 4

Chittagong : Case 4	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	142	0.29	77	0.22	71	0.16	41	0.17	40	0.14
Commercial	8,191	16.60	5,470	15.48	6,623	15.10	3,815	15.79	4,363	14.75
Education	480	0.97	263	0.74	261	0.60	153	0.63	186	0.63
Government	81	0.16	45	0.13	46	0.11	25	0.10	32	0.11
Industrial	466	0.94	367	1.04	519	1.18	328	1.36	400	1.35
Non-SFD Residential	28,678	58.12	18,817	53.26	20,422	46.55	11,284	46.70	14,274	48.26
Religion	300	0.61	145	0.41	110	0.25	60	0.25	67	0.22
Single Family Dwelling (SFD) Residential	11,005	22.30	10,146	28.72	15,813	36.05	8,460	35.01	10,215	34.54
Total	**49,344**		**35,328**		**43,867**		**24,165**		**29,577**	

Table 6-16 Expected Building Damage by Building Type in Chittagong City Corporation: Scenario Case 4

Chittagong : Case 4	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	15	0.03	12	0.04	40	0.09	47	0.19	32	0.11
Concrete	38,109	77	21,465	61	22,223	51	14,310	59	19,523	66
Masonry	6,022	12	8,798	25	17,413	40	8,671	36	8,185	28
Thin Shed and Bamboo	5,199	10.54	5053	14.30	4,191	9.55	1,138	4.71	1,838	6.21
Total	**49,344**		**35,328**		**43,867**		**24,165**		**29,577**	

Sylhet City Corporation Area

Buildings Damage in Sylhet City Corporation Area: Scenario Case 1

HAZUS estimates that about 41,173 buildings will be at least moderately damaged. This is over 79.00 % of the total number of buildings in the region. There are an estimated 24,944 buildings that will be damaged beyond repair.

Table 6-17 Expected Building Damage by Occupancy Class in Sylhet City Corporation Area: Scenario Case 1

Sylhet : Case 1										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	6	0.09	5	0.12	10	0.14	12	0.13	44	0.17
Commercial	982	15.28	624	13.84	796	11.43	964	10.40	2,717	10.89
Education	107	1.67	63	1.40	63	0.91	73	0.79	250	1.00
Government	27	0.42	16	0.35	16	0.23	20	0.22	89	0.36
Industrial	44	0.68	33	0.73	55	0.79	77	0.83	239	0.96
Non-SFD Residential	2,013	31.32	1,294	28.73	1,416	20.35	1,454	15.68	4,247	17.03
Religion	103	1.61	60	1.34	56	0.81	50	0.53	96	0.38
Single Family Dwelling(SFD) Residential	3,146	48.94	2,409	53.48	4,547	65.33	6,620	71.42	17,264	69.21
Total	6,429		4,504		6,960		9,269		24,945	

Table 6-18 Expected Building Damage by Building Type in Sylhet City Corporation Area: Scenario Case 1

Sylhet : Case 1										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
Concrete	6,124	95.27	3,460	76.83	2,861	41.10	2,819	30.41	11,574	46.40
Masonry	57	0.88	396	8.79	3,081	44.26	5,967	64.38	13,015	52.18
Thin Shed and Bamboo	247	3.85	648	14.39	1,018	14.63	482	5.20	354	1.42
Total	6,429		4,504		6,960		9,269		24,945	

Buildings Damage in Sylhet City Corporation Area: Scenario Case 2

HAZUS estimates that about 12,422 buildings will be at least moderately damaged. This is over 24.00 % of the total number of buildings in the region. There are an estimated 1,919 buildings that will be damaged beyond repair.

Table 6-19 Expected Building Damage by Occupancy Class in Sylhet City Corporation Area: Scenario Case 2

Sylhet : Case 2										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	43	0.15	15	0.14	11	0.14	3	0.11	6	0.29
Commercial	3,583	12.40	1,136	10.52	810	10.32	282	10.63	271	14.13
Education	303	1.05	104	0.96	80	1.02	38	1.43	32	1.69
Government	85	0.29	35	0.33	25	0.32	12	0.44	12	0.60
Industrial	216	0.75	95	0.88	77	0.98	33	1.25	26	1.34
Non-SFD Residential	6,153	21.30	1,945	18.02	1,342	17.08	523	19.73	462	24.05
Religion	250	0.87	58	0.54	33	0.42	12	0.45	12	0.63
Single Family Dwelling (SFD) Residential	18,260	63.20	7,404	68.61	5,476	69.72	1,747	65.96	1,099	57.26
Total	**28,893**		**10,791**		**7,854**		**2,649**		**1,919**	

Table6-20 Expected Building Damage by Building Type in Sylhet City Corporation Area: Scenario Case 2

Sylhet : Case 2										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	0	0.00	0	0.00	0	0.00	0	0.02	1	0.03
Concrete	14,786	51.18	5,201	48.20	3,592	45.73	1,772	66.88	1,488	77.51
Masonry	12,129	41.98	5,056	46.86	4,080	51.94	857	32.35	393	20.51
Thin Shed and Bamboo	1,977	6.84	533	4.94	183	2.33	20	0.75	37	1.95
Total	**28,893**		**10,791**		**7,854**		**2,649**		**1,919**	

Buildings Damage in Sylhet City Corporation Area: Scenario Case 3

HAZUS estimates that about 36,693 buildings will be at least moderately damaged. This is over 70.00 % of the total number of buildings in the region. There are an estimated 11,891 buildings that will be damaged beyond repair.

Table 6-21 Expected Building Damage by Occupancy Class in Sylhet City Corporation Area: Scenario Case 3

Sylhet : Case 3										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	8	0.10	9	0.12	18	0.13	14	0.13	28	0.23
Commercial	1,086	14.18	934	12.04	1,440	10.57	1,140	10.20	1,482	12.47
Education	115	1.51	88	1.14	119	0.88	100	0.89	134	1.13
Government	29	0.38	24	0.31	33	0.24	31	0.28	51	0.43
Industrial	52	0.68	61	0.79	115	0.85	98	0.88	120	1.01
Non-SFD Residential	2,196	28.69	1,757	22.66	2,352	17.26	1,821	16.30	2,297	19.32
Religion	106	1.39	71	0.92	79	0.58	55	0.50	53	0.45
Single Family Dwelling(SFD) Residential	4,063	53.07	4,812	62.03	9,473	69.50	7,914	70.83	7,724	64.96
Total	**7,656**		**7,756**		**13,629**		**11,174**		**11,891**	

Table 6-22 Expected Building Damage by Building Type in Sylhet City Corporation Area: Scenario Case 3

Sylhet : Case 3										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
Concrete	6,384	83.39	4,505	58.08	5,100	37.42	4,479	40.09	6,370	53.57
Masonry	918	11.99	2,502	32.26	7,548	55.38	6,310	56.47	5,237	44.04
Thin Shed and Bamboo	354	4.62	749	9.66	981	7.20	384	3.44	283	2.38
Total	**7,656**		**7,756**		**13,629**		**11,174**		**11,891**	

Buildings Damage in Sylhet City Corporation Area: Scenario Case 4

HAZUS estimates that about 45,216 buildings will be at least moderately damaged. This is over 87.00 % of the total number of buildings in the region. There are an estimated 33,858 buildings that will be damaged beyond repair.

Table 6-23 Expected Building Damage by Occupancy Class in Sylhet City Corporation Area: Scenario Case 4

Sylhet : Case 4										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	2	0.06	2	0.07	4	0.09	6	0.09	62	0.18
Commercial	575	15.01	422	13.78	538	11.40	678	10.22	3,869	11.43
Education	66	1.73	47	1.52	48	1.01	53	0.80	343	1.01
Government	17	0.44	12	0.39	12	0.26	15	0.22	112	0.33
Industrial	24	0.62	20	0.66	34	0.72	49	0.73	320	0.95
Non-SFD Residential	1,201	31.37	907	29.64	1,038	21.99	1,094	16.49	6,183	18.26
Religion	64	1.68	45	1.48	45	0.96	42	0.63	168	0.50
Single Family Dwelling(SFD) Residential	1,880	49.09	1,605	52.46	3,000	63.56	4,701	70.82	22,799	67.34
Total	**3,829**		**3,060**		**4,721**		**6,638**		**33,858**	

Table 6-24 Expected Building Damage by Building Type in Sylhet City Corporation Area: Scenario Case 4

Sylhet : Case 4										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	0	0.00	0	0.00	0	0.00	0	0.00	1	0.00
Concrete	3,752	97.98	2,626	85.80	2,370	50.21	2,214	33.35	15,877	46.90
Masonry	20	0.52	165	5.39	1,641	34.75	3,880	58.46	16,810	49.65
Thin Shed and Bamboo	57	1.50	269	8.81	710	15.04	544	8.19	1,170	3.45
Total	**3,829**		**3,060**		**4,721**		**6,638**		**33,858**	

Buildings Damage in Sylhet City Corporation Area: Scenario Case 5

HAZUS estimates that about 51,858 buildings will be at least moderately damaged. This is over 99.50 % of the total number of buildings in the region. There are an estimated 50,879 buildings that will be damaged beyond repair.

Table 6-25 Expected Building Damage by Occupancy Class in Sylhet City Corporation Area: Scenario Case 5

Sylhet : Case 5										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	0	0.00	0	0.00	0	0.01	0	0.02	77	0.15
Commercial	12	11.17	15	11.18	35	11.29	67	10.06	5,952	11.70
Education	1	0.96	1	0.96	3	0.95	4	0.58	548	1.08
Government	0	0.14	0	0.15	1	0.21	1	0.13	166	0.33
Industrial	1	0.53	1	0.52	2	0.56	4	0.58	440	0.86
Non-SFD Residential	46	42.24	57	40.91	104	33.06	139	20.88	10,079	19.81
Religion	2	1.53	2	1.49	4	1.24	5	0.71	353	0.69
Single Family Dwelling(SFD) Residential	47	43.44	62	44.78	165	52.68	445	67.04	33,266	65.38
Total	**109**		**138**		**314**		**664**		**50,880**	

Table 6-26 Expected Building Damage by Building Type in Sylhet City Corporation Area: Scenario Case 5

Sylhet : Case 5										
	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Steel	0	0.00	0	0.00	0	0.00	0	0.00	1	0.01
Concrete	109	99.86	134	96.44	236	75.13	221	33.20	26,139	51.37
Masonry	0	0.00	2	1.76	31	10.01	263	39.65	22,218	43.67
Thin Shed and Bamboo	0	0.14	2	1.80	47	14.86	180	27.15	2,521	4.95
Total	**109**		**138**		**314**		**664**		**50,880**	

6.1.2. Essential Facilities Damage

Dhaka City Corporation Area

Essential Facilities Damage in Dhaka City Corporation Area: Scenario case 1

Before the earthquake, the region had 59,849 hospital beds available for use. On the day of the earthquake, the model estimates that only 24,242 hospital beds (41%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 54% of the beds will be back in service. By 30 days, 72% will be operational.

Table 6-27 Expected Damage to Essential Facilities in Dhaka City Corporation Area: Scenario case1

Dhaka : Case 1				
Classification	*Total*	*Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	600	241	10	224
Schools	2,737	1,173	90	895
EOCs	18	8	2	7
Police Stations	62	30	0	15
Fire Stations	10	4	0	3

Essential Facilities Damage in Dhaka City Corporation Area: Scenario case 2

Before the earthquake, the region had 59,849 hospital beds available for use. On the day of the earthquake, the model estimates that only 37,625 hospital beds (63%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 76% of the beds will be back in service. By 30 days, 87% will be operational.

Table 6-28 Expected Damage to Essential Facilities in Dhaka City Corporation Area: Scenario case 2

Dhaka : Case 2				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	600	22	0	431
Schools	2,737	99	2	2,029
EOCs	18	7	0	11
Police Stations	62	1	0	46
Fire Stations	10	0	0	7

Essential Facilities Damage in Dhaka City Corporation Area: Scenario case 3

Before the earthquake, the region had 59,849 hospital beds available for use. On the day of the earthquake, the model estimates that only 18,561 hospital beds (31%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 45% of the beds will be back in service. By 30 days, 66% will be operational.

Table 6-29 Expected Damage to Essential Facilities in Dhaka City Corporation Area: Scenario case 3

Dhaka : Case 3				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	600	364	23	128
Schools	2,737	1,567	165	495
EOCs	18	9	0	4
Police Stations	62	39	0	2
Fire Stations	10	6	0	0

Essential Facilities Damage in Dhaka City Corporation Area: Scenario case 4

Before the earthquake, the region had 59,849 hospital beds available for use. On the day of the earthquake, the model estimates that only 7,441 hospital beds (12%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 16% of the beds will be back in service. By 30 days, 20% will be operational.

Table 6-30 Expected Damage to Essential Facilities in Dhaka City Corporation Area: Scenario case 4

Dhaka : Case 4				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	600	483	482	114
Schools	2,737	2,292	2,268	406
EOCs	18	14	14	4
Police Stations	62	61	61	1
Fire Stations	10	10	10	0

Chittagong City Corporation Area

Essential Facilities Damage in Chittagong City Corporation Area: Scenario Case 1

Before the earthquake, Chittagong city had 21,664 hospital beds available for use. Aforementioned scenarios are applied on essential facilities damage estimation in Chittagong city. On the day of the earthquake, the model estimates that only 923 hospital beds (4%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 11% of the beds will be back in service. By 30 days, 17% will be operational.

Table 6-31 Expected Damage to Essential Facilities in Chittagong City Corporation Area: Scenario Case 1

Chittagong : Case 1				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	162	158	127	0
Schools	1,033	1,011	739	0
EOCs	11	11	6	0
Police Stations	11	11	10	0
Fire Stations	12	12	8	0

Essential Facilities Damage in Chittagong City Corporation Area: Scenario Case 2

Before the earthquake, Chittagong city had 21,664 hospital beds available for use. Aforementioned scenarios are applied on essential facilities damage estimation in Chittagong city. On the day of the earthquake, HAZUS estimates that only 13,900 hospital beds (64%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 80% of the beds will be back in service. By 30 days, 91% will be operational.

Table 6-32 Expected Damage to Essential Facilities in Chittagong City Corporation Area: Scenario Case 2

Chittagong : Case 2				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	162	13	0	123
Schools	1,033	78	3	818
EOCs	11	0	0	8
Police Stations	11	1	0	7
Fire Stations	12	1	0	11

Essential Facilities Damage in Chittagong City Corporation Area: Scenario Case 3

Before the earthquake, Chittagong city had 21,664 hospital beds available for use. Aforementioned scenarios are applied on essential facilities damage estimation in Chittagong city. On the day of the earthquake, the model estimates that only 5,769 hospital beds (27%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 44% of the beds will be back in service. By 30 days, 64% will be operational.

Table 6-33 Expected Damage to Essential Facilities in Chittagong City Corporation Area : Scenario Case 3

Chittagong : Case 3				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	162	65	15	0
Schools	1,033	471	121	0
EOCs	11	3	0	0
Police Stations	11	6	2	0
Fire Stations	12	6	2	0

Essential Facilities Damage in Chittagong City Corporation Area: Scenario Case 4

Before the earthquake, the region had 21,664 hospital beds available for use. On the day of the earthquake, the model estimates that only 8,425 hospital beds (39%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 59% of the beds will be back in service. By 30 days, 78% will be operational.

Table 6-34 Expected Damage to Essential Facilities in Chittagong City Corporation Area : Scenario Case 4

Chittagong : Case 4				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	162	57	0	75
Schools	1,033	349	0	297
EOCs	11	3	0	8
Police Stations	11	5	0	5
Fire Stations	12	5	0	2

Sylhet City Corporation Area

Essential Facilities Damage in Sylhet City Corporation Area: Scenario Case 1

Before the earthquake, the region had 8,722 hospital beds available for use. On the day of the earthquake, the model estimates that only 1,742 hospital beds (20%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 33% of the beds will be back in service. By 30 days, 46% will be operational.

Table 6-35 Expected Damage to Essential Facilities in Sylhet City Corporation Area : Scenario Case 1

Sylhet : Case 1				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	87	47	43	4
Schools	211	111	105	13
EOCs	9	3	3	0
Police Stations	6	4	4	0
Fire Stations	2	0	0	0

Essential Facilities Damage in Sylhet City Corporation Area: Scenario Case 2

Before the earthquake, the region had 8,722 hospital beds available for use. On the day of the earthquake, the model estimates that only 5,148 hospital beds (59%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 78% of the beds will be back in service. By 30 days, 91% will be operational.

Table 6-36 Expected Damage to Essential Facilities in Sylhet City Corporation Area: Scenario Case 2

Sylhet : Case 2				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	87	3	0	59
Schools	211	5	0	172
EOCs	9	2	0	7
Police Stations	6	0	0	6
Fire Stations	2	0	0	2

Essential Facilities Damage in Sylhet City Corporation Area: Scenario Case 3

Before the earthquake, the region had 8,722 hospital beds available for use. On the day of the earthquake, the model estimates that only 1,890 hospital beds (22%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 38% of the beds will be back in service. By 30 days, 61% will be operational.

Table 6-37 Expected Damage to Essential Facilities in Sylhet City Corporation Area: Scenario Case 3

Sylhet : Case 3				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	87	47	5	4
Schools	211	111	26	8
EOCs	9	2	1	1
Police Stations	6	4	0	0
Fire Stations	2	0	0	0

Essential Facilities Damage in Sylhet City Corporation Area: Scenario Case 4

Before the earthquake, the region had 8,722 hospital beds available for use. On the day of the earthquake, the model estimates that only 1,083 hospital beds (12%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 21% of the beds will be back in service. By 30 days, 31% will be operational.

Table 6-38 Expected Damage to Essential Facilities in Sylhet City Corporation Area: Scenario Case 4

Sylhet : Case 4				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	87	59	59	0
Schools	211	148	139	2
EOCs	9	5	4	0
Police Stations	6	4	4	0
Fire Stations	2	1	0	0

Essential Facilities Damage in Sylhet City Corporation Area: Scenario Case 5

Before the earthquake, the region had 8,722 hospital beds available for use. On the day of the earthquake, the model estimates that only 17 hospital beds (0%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 0% of the beds will be back in service. By 30 days, 0% will be operational.

Table 6-39 Expected Damage to Essential Facilities in Sylhet City Corporation Area: Scenario Case 5

Sylhet : Case 5				
Classification	*Total*	*# Facilities*		
		At Least Moderate Damage >50%	*Complete Damage >50%*	*With Functionality >50% on day 1*
Hospitals	87	87	86	0
Schools	211	211	209	0
EOCs	9	9	9	0
Police Stations	6	6	6	0
Fire Stations	2	2	2	0

6.1.3. Transportation and Utility Damage

Transportation and Utility Damage in Dhaka City Corporation Area

The following tables provide damage estimates for the transportation systems Dhaka City Corporation Area.

Table 6-40 Expected Damage to the Transportation Systems in Dhaka City Corporation Area

System	Component	Scenario 1					Scenario 2					Scenario 3					Scenario 4				
		Number of Locations					Number of Locations					Number of Locations					Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%	
					After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7
Highway	Roads	21,979	0	0	21,979	21,979	21,979	0	0	21,979	21,979	21,979	0	0	21,979	21,979	21,979	4,368	4,030	17,590	20,838
	Bridges	10	5	0	4	9	10	0	0	5	10	10	3	0	4	10	10	10	7	0	0
Railway	Tracks	217	0	0	217	217	217	0	0	217	217	217	0	0	217	217	217	19	17	198	217
	Facilities	19	0	0	19	19	19	0	0	19	19	19	19	0	19	19	19	19	0	0	0
Bus	Facilities	25	0	0	25	25	25	0	0	25	25	25	0	0	25	25	25	25	6	0	0
Ferry	Facilities	8	0	0	8	8	8	0	0	8	8	8	0	0	8	8	8	8	0	0	0

Highway segments and railroad tracks are assumed to be damaged by ground failure only.

The following tables provide information on the damage to the utility lifeline systems. Table 6-40 provides damage to the utility system facilities. While Table 6-41 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis.

Table 6-41 Expected Utility System Facility Damage in Dhaka City Corporation Area

System	Scenario 1					Scenario 2					Scenario 3					Scenario 4				
	Number of Locations					Number of Locations					Number of Locations					Number of Locations				
	Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%		Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%		Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%		Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%	
				After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7
Potable Water	748	153	0	0	747	748	0	0	0	748	748	748	0	0	457	748	748	134	0	0
Waste Water	14	2	0	0	12	14	0	0	0	14	14	14	0	0	0	14	14	3	0	0
Natural Gas	7	2	0	0	7	7	0	0	0	7	7	7	0	0	1	7	7	2	0	0
Electrical Power	54,815	15,200	0	0	0	54,815	0	0	0	0	54,815	0	0	0	0	54,815	54,815	0	0	0
Communication	30	5	0	0	29	30	0	0	10	29	30	29	0	0	29	30	29	6	0	3

Table 6-42 Expected Utility System Pipeline Damage in Dhaka City Corporation Area

System	Scenario 1			Scenario 2			Scenario 3			Scenario 4		
	Total Pipelines Length (km)	Number of Leaks	Number of Breaks	Total Pipelines Length (km)	Number of Leaks	Number of Breaks	Total Pipelines Length (km)	Number of Leaks	Number of Breaks	Total Pipelines Length (km)	Number of Leaks	Number of Breaks
Potable Water	1,118	79	272	1,118	39	132	1,118	83	290	1,118	311	705
Waste Water	630	107	360	630	62	202	630	122	418	630	520	1020
Natural Gas	834	56	191	834	26	86	834	56	195	834	209	475

Transportation and Utility Damage in Chittagong City Corporation Area

The following tables provide damage estimates for the transportation systems Chittagong City Corporation Area.

Table 6-43 Expected Damage to the Transportation Systems in Chittagong City Corporation Area

System	Component	Scenario 1					Scenario 2					Scenario 3					Scenario 4				
		Number of Locations					Number of Locations					Number of Locations					Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%	
					After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7
Highway	Roads	8,416	2,921	1,464	5,397	8,402	8,416	0	0	8,416	8,416	8,416	0	0	8,416	8,416	8,416	0	0	8,416	8,416
	Bridges	4	4	4	0	0	4	0	0	3	4	4	1	0	3	3	4	0	0	3	4
Railway	Tracks	211	7	0	156	209	211	0	0	211	211	211	0	0	211	211	211	0	0	211	211
	Facilities	15	15	0	0	0	15	0	0	15	15	15	15	0	0	15	15	0	0	15	15
Bus	Facilities	11	10	0	1	11	11	0	0	11	11	11	5	0	11	11	11	0	0	11	11

Highway segments and railroad tracks are assumed to be damaged by ground failure only.

The following tables provide information on the damage to the utility lifeline systems. Table 6-43 provides damage to the utility system facilities. While table 6-44 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis.

Table 6-44 Expected Utility System Facility Damage in Chittagong City Corporation Area

System	Scenario 1					Scenario 2					Scenario 3					Scenario 4				
	Number of Locations					Number of Locations					Number of Locations					Number of Locations				
	Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%		Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%		Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%		Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%	
				After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7
Potable Water	72	72	4	0	0	72	0	0	46	72	72	72	0	0	28	72	25	0	0	72
Natural Gas	22	22	2	0	0	22	0	0	9	22	22	22	0	0	10	22	13	0	0	22
Electrical Power	28,407	28,407	0	0	19,237	28,407	0	0	15,084	28,407	28,407	28,407	0	0	28,405	28,407	14,555	0	196	28,407
Communication	5	5	0	0	3	5	0	0	4	5	5	5	0	0	5	5	1	0	0	5

Table 6-45 Expected Utility System Pipeline Damage in Chittagong City Corporation Area

System	Scenario 1			Scenario 2			Scenario 3			Scenario 4		
	Total Pipelines Length (km)	Number of Leaks	Number of Breaks	Total Pipelines Length (km)	Number of Leaks	Number of Breaks	Total Pipelines Length (km)	Number of Leaks	Number of Breaks	Total Pipelines Length (km)	Number of Leaks	Number of Breaks
Potable Water	542	320	407	542	17	53	542	45	129	542	25	81
Natural Gas	217	104	125	217	5	16	217	13	37	217	7	24

Transportation and Utility Damage in Sylhet City Corporation Area

The following tables provide damage estimates for the transportation systems Sylhet City Corporation Area.

Table 6-46 Expected Damage to the Transportation Systems in Sylhet City Corporation Area

System	Component	Scenario 1					Scenario 2					Scenario 3					Scenario 4					Scenario 5				
		Number of Locations					Number of Locations					Number of Locations					Number of Locations					Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality >50%	
					After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7
Highway	Roads	4,204	0	0	4,204	4,204	4,204	0	0	4,204	4,204	4,204	0	0	4,204	4,204	4,204	315	0	3,834	4,203	4,204	1,341	1,341	2,848	3,850
	Bridges	2	1	0	1	1	2	0	0	1	2	2	1	0	1	1	2	1	1	0	1	2	2	2	0	0
Railway	Tracks	29	0	0	29	29	29	0	0	29	29	29	0	0	29	29	29	0	0	27	29	29	29	28	0	29
	Facilities	7	7	0	7	7	7	0	0	7	7	7	0	0	0	7	7	7	0	0	7	7	7	7	0	0
Bus	Facilities	2	2	0	2	2	2	0	0	2	2	2	2	0	0	2	2	2	0	0	2	2	2	2	0	0

Highway segments and railroad tracks are assumed to be damaged by ground failure only.

The following tables provide information on the damage to the utility lifeline systems. Table 6-46provides damage to the utility system facilities. While Table 6-47provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis.

Table 6-47 Expected Utility System Facility Damage in Sylhet City Corporation Area

System	Scenario 1					Scenario 2					Scenario 3					Scenario 4					Scenario 5				
	Number of Locations					Number of Locations					Number of Locations					Number of Locations					Number of Locations				
	Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%		Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%		Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%		Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%		Total Number	With at Least Moderate Damage	With Complete Damage	With Functionality >50%	
				After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7				After Day 1	After Day 7
Potable Water	18	18	0	0	5	18	0	0	0	18	18	18	0	0	5	18	18	0	0	0	18	18	9	0	0
Natural Gas	1	1	0	0	1	1	0	0	0	1	1	1	0	0	0	1	1	0	0	0	1	1	1	0	0
Electrical Power	9,057	9,057	0	0	9,056	9,057	0	0	8,830	9,057	9,057	8,885	0	0	9.056	9,057	9,057	0	0	9,056	9,057	9,057	0	0	0
Communication	7	7	0	0	7	7	0	0	5	7	7	7	0	0	7	7	7	0	0	7	7	7	2	0	0

Table 6-48 Expected Utility System Pipeline Damage in Sylhet City Corporation Area

System	Scenario 1			Scenario 2			Scenario 3			Scenario 4			Scenario 5		
	Total Pipelines Length (km)	Number of Leaks	Number of Breaks	Total Pipelines Length (km)	Number of Leaks	Number of Breaks	Total Pipelines Length (km)	Number of Leaks	Number of Breaks	Total Pipelines Length (km)	Number of Leaks	Number of Breaks	Total Pipelines Length (km)	Number of Leaks	Number of Breaks
Potable Water	128	10	21	128	2	4	128	5	11	128	14	25	128	74	48
Natural Gas	141	7	15	141	1	2	141	4	8	141	11	21	141	56	41

6.2. Induced Earthquake Damage

6.2.1. Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. The fire following earthquake damages in Dhaka, Chittagong and Sylhet city corporation area are demonstrated in Table 6-49, 6-50and 6-51.

Table 6-49 Fire Following Earthquake in Dhaka City Corporation Area

Damage	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Ignitions	64	37	36	107
Displace Household	472	354	1,586	1,495
Damage Value (millions of dollars)	1.24	1.10	4.75	5.49

Table 6-50 Fire Following Earthquake in Chittagong City Corporation Area

Damage	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Ignitions	36	11	27	19
Displace Household	119	44	96	76
Damage Value (millions of tons)	0.16	0.06	0.13	0.10

Table 6-51 Fire Following Earthquake in Sylhet City Corporation Area

Damage	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Ignitions	8	3	9	10	13
Displace Household	25	21	56	46	97
Damage Value (millions of tons)	0.05	0.05	0.15	0.12	0.2

6.2.2. Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories:
a) Brick/Wood
b) Reinforced Concrete/Steel.
This distinction is made because of the different types of material handling equipment required to handle the debris. Table 6-52 to 6-54 show all debris generations in Dhaka, Chittagong and Sylhet city corporation area.

Table 6-52 Debris Generation in Dhaka City Corporation Area

Debris Generation	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Debris (millions of tons)	30	18	30	72
Brick/ Wood (%)	27.00	24.00	28.00	26.00
Concrete/ Steel (%)	73.00	76.00	72.00	74.00
Truck Load Required (@25 tons / truck)	1,200,000	720,000	1,200,000	2,880,000

Table 6-53 Debris Generation in Chittagong City Corporation Area

Debris Generation	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Debris (millions of tons)	17	3	8	5
Brick/ Wood (%)	26.00	27.00	28.00	30.00
Concrete/ Steel (%)	74.00	73.00	72.00	70.00
Truck Load Required (@25 tons / truck)	680,000	120,000	320,000	200,000

Table 6-54 Debris Generation in Sylhet City Corporation Area

Debris Generation	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Debris (millions of tons)	2	0	1	3	5
Brick/ Wood (%)	29.00	31.00	30.00	28.00	26.00
Concrete/ Steel (%)	71.00	69.00	70.00	72.00	74.00
Truck Load Required (@25 tons / truck)	80,000	0	40,000	120,000	200,000

6.3. Social Impact-Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for two times of day: 2:00 AM and 2:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum and the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum.

Dhaka City Corporation Area

Social Impact in Dhaka City Corporation Area: Scenario Case 1

Table 6-55 Summary of the casualties estimated for earthquake in Dhaka City Corporation: Scenario Case 1

Dhaka : Case 1					
		Level 1	***Level 2***	***Level 3***	***Level 4***
2 AM	*Commercial*	*964*	*182*	*53*	*390*
	Commuting	*0*	*0*	*0*	*0*
	Educational	*0*	*0*	*0*	*0*
	Hotels	*117*	*21*	*6*	*70*
	Industrial	*391*	*72*	*22*	*191*
	Other-Residential	*119,889*	*20,975*	*5,182*	*87,617*
	Single Family	*454*	*84*	*25*	*234*
	Total	***121,815***	***21,355***	***5,287***	***88,503***
2 PM	*Commercial*	*69,278*	*13,525*	*3,863*	*27,422*
	Commuting	*0*	*0*	*0*	*0*
	Educational	*18,185*	*3,659*	*1,020*	*6,120*
	Hotels	*23*	*4*	*1*	*13*
	Industrial	*2,918*	*554*	*166*	*1,390*
	Other-Residential	*40,473*	*8,132*	*1,983*	*26,273*
	Single Family	*153*	*32*	*9*	*70*
	Total	***131,029***	***25,905***	***7,043***	***61,288***

Social Impact in Dhaka City Corporation Area: Scenario Case 2

Table 6-56 Summary of the casualties estimated for earthquake in Dhaka City Corporation: Scenario Case 2

Dhaka : Case 2					
		Level 1	***Level 2***	***Level 3***	***Level 4***
2 AM	*Commercial*	*487*	*90*	*25*	*213*
	Commuting	*0*	*0*	*0*	*0*
	Educational	*0*	*0*	*0*	*0*
	Hotels	*70*	*12*	*3*	*45*
	Industrial	*178*	*32*	*9*	*90*
	Other-Residential	*74,402*	*12,830*	*3,018*	*58,356*
	Single Family	*254*	*47*	*14*	*155*
	Total	***75,391***	***13,011***	***3,069***	***58,858***
2 PM	*Commercial*	*34,993*	*6,707*	*1,825*	*14,945*
	Commuting	*0*	*0*	*0*	*0*
	Educational	*8,223*	*1,642*	*441*	*2,999*
	Hotels	*14*	*2*	*1*	*9*
	Industrial	*1,328*	*247*	*69*	*651*
	Other-Residential	*25,230*	*5,011*	*1,183*	*17,545*
	Single Family	*86*	*18*	*5*	*47*
	Total	***69,874***	***13,628***	***3,525***	***36,195***

Social Impact in Dhaka City Corporation Area: Scenario Case 3

Table 6-57 Summary of the casualties estimated for earthquake in Dhaka City Corporation: Scenario Case 3

Dhaka : Case 3					
		Level 1	***Level 2***	***Level 3***	***Level 4***
2 AM	*Commercial*	*837*	*158*	*47*	*333*
	Commuting	*0*	*0*	*0*	*0*
	Educational	*0*	*0*	*0*	*0*
	Hotels	*106*	*19*	*5*	*58*
	Industrial	*373*	*70*	*22*	*167*
	Other-Residential	*125,216*	*21,714*	*5,281*	*94,435*
	Single Family	*510*	*94*	*28*	*275*
	Total	***127,042***	***22,054***	***5,383***	***95,267***
2 PM	*Commercial*	*60,531*	*11,782*	*3,449*	*23,660*
	Commuting	*0*	*0*	*0*	*0*
	Educational	*16,488*	*3,304*	*935*	*5,555*
	Hotels	*20*	*4*	*1*	*11*
	Industrial	*2,778*	*532*	*167*	*1,214*
	Other-Residential	*42,280*	*8,429*	*2,029*	*28,339*
	Single Family	*172*	*36*	*10*	*83*
	Total	***122,271***	***24,086***	***6,590***	***58,862***

Social Impact in Dhaka City Corporation Area: Scenario Case 4

Table 6-58 Summary of the casualties estimated for earthquake in Dhaka City Corporation: Scenario Case 4

Dhaka : Case 4					
		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	2,765	561	181	1,211
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	319	61	19	190
	Industrial	1,303	263	90	651
	Other-Residential	330,701	59,925	15,848	257,875
	Single Family	1,459	282	88	860
	Total	**336,547**	**61,093**	**16,227**	**260,788**
2 PM	Commercial	192,184	40,106	12,677	82,410
	Commuting	0	0	0	0
	Educational	50,617	10,884	3,314	19,089
	Hotels	62	12	4	36
	Industrial	9,722	2,012	676	4,725
	Other-Residential	111,216	23,070	5,887	76,932
	Single Family	491	107	31	257
	Total	**364,292**	**76,191**	**22,589**	**183,450**

Chittagong City Corporation Area

Social Impact in Chittagong City Corporation Area: Scenario Case 1

Table 6-59 Summary of the casualties estimated for earthquake in Chittagong City Corporation: Scenario Case 1

Chittagong : Case 1					
		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	616	113	34	473
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	404	67	17	394
	Industrial	1,102	191	47	981
	Other-Residential	74,889	13,734	3,691	57,809
	Single Family	60,052	11,606	3,486	35,525
	Total	**137,063**	**25,712**	**7,275**	**95,183**
2 PM	Commercial	43,086	8,146	2,425	31,877
	Commuting	0	0	0	0
	Educational	6,586	1,205	320	5,550
	Hotels	78	13	3	75
	Industrial	8,284	1,509	370	7,118
	Other-Residential	25,292	5,206	1,350	17,423
	Single Family	21,239	4,701	1,321	11,169
	Total	**104,566**	**20,781**	**5,790**	**73,212**

Social Impact in Chittagong City Corporation Area: Scenario Case 2

Table 6-60 Summary of the casualties estimated for earthquake in Chittagong City Corporation: Scenario Case 2

Chittagong : Case 2					
		Level 1	***Level 2***	***Level 3***	***Level 4***
2 AM	*Commercial*	*76*	*13*	*3*	*57*
	Commuting	*0*	*0*	*0*	*0*
	Educational	*0*	*0*	*0*	*0*
	Hotels	*47*	*7*	*2*	*41*
	Industrial	*217*	*36*	*7*	*165*
	Other-Residential	*10,820*	*1,787*	*413*	*8,566*
	Single Family	*8,024*	*1,372*	*340*	*5,104*
	Total	***19,185***	***3,215***	***765***	***13,932***
2 PM	*Commercial*	*5,417*	*930*	*230*	*3,936*
	Commuting	*0*	*0*	*0*	*0*
	Educational	*854*	*143*	*33*	*681*
	Hotels	*9*	*1*	*0*	*8*
	Industrial	*1,633*	*280*	*55*	*1,194*
	Other-Residential	*3,669*	*694*	*161*	*2,573*
	Single Family	*2,860*	*568*	*138*	*1,601*
	Total	***14,442***	***2,616***	***618***	***9,993***

Social Impact in Chittagong City Corporation Area: Scenario Case 3

Table 6-61 Summary of the casualties estimated for earthquake in Chittagong City Corporation: Scenario Case 3

Chittagong : Case 3					
		Level 1	***Level 2***	***Level 3***	***Level 4***
2 AM	*Commercial*	*254*	*44*	*12*	*183*
	Commuting	*0*	*0*	*0*	*0*
	Educational	*0*	*0*	*0*	*0*
	Hotels	*186*	*30*	*7*	*172*
	Industrial	*555*	*93*	*21*	*465*
	Other-Residential	*32,314*	*5,565*	*1,405*	*24,658*
	Single Family	*26,375*	*4,818*	*1,353*	*14,976*
	Total	***59,684***	***10,550***	***2,799***	***40,453***
2 PM	*Commercial*	*17,821*	*3,213*	*899*	*12,376*
	Commuting	*0*	*0*	*0*	*0*
	Educational	*2,448*	*426*	*106*	*1,873*
	Hotels	*36*	*6*	*1*	*33*
	Industrial	*4,173*	*734*	*169*	*3,370*
	Other-Residential	*10,939*	*2,143*	*530*	*7,413*
	Single Family	*9,333*	*1,950*	*519*	*4,706*
	Total	***44,751***	***8,473***	***2,224***	***29,771***

Social Impact in Chittagong City Corporation Area: Scenario Case 4

Table 6-62 Summary of the casualties estimated for earthquake in Chittagong City Corporation: Scenario Case 4

Chittagong : Case 4					
		Level 1	**Level 2**	**Level 3**	**Level 4**
2 AM	Commercial	139	24	6	97
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	104	16	4	92
	Industrial	283	46	10	225
	Other-Residential	18,630	3,132	761	13,804
	Single Family	14,021	2,480	670	7,672
	Total	**33,176**	**5,697**	**1,451**	**21,889**
2 PM	Commercial	9,794	1,714	460	6,600
	Commuting	0	0	0	0
	Educational	1,396	236	57	1,049
	Hotels	20	3	1	18
	Industrial	2,128	362	80	1,633
	Other-Residential	6,306	1,203	288	4,155
	Single Family	4,954	999	257	2,408
	Total	**24,598**	**4,517**	**1,143**	**15,863**

Sylhet City Corporation Area

Social Impact in Sylhet City Corporation Area: Scenario Case 1

Table 6-63 Summary of the casualties estimated for earthquake in Sylhet City Corporation: Scenario Case 1

Sylhet : Case 1					
		Level 1	**Level 2**	**Level 3**	**Level 4**
2 AM	Commercial	40	7	2	29
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	41	7	2	41
	Industrial	15	3	1	10
	Other-Residential	3,633	644	193	2,801
	Single Family	10,960	2,101	760	6,625
	Total	**14,689**	**2,761**	**958**	**9,506**
2 PM	Commercial	3,296	624	199	2,214
	Commuting	0	0	1	0
	Educational	942	173	48	769
	Hotels	8	1	0	8
	Industrial	112	21	7	74
	Other-Residential	1,347	271	77	929
	Single Family	3,959	819	276	2,156
	Total	**9,665**	**1,910**	**608**	**6,151**

Social Impact in Sylhet City Corporation Area: Scenario Case 2

Table 6-64 Summary of the casualties estimated for earthquake in Sylhet City Corporation: Scenario Case 2

Sylhet : Case 2					
		Level 1	**Level 2**	**Level 3**	**Level 4**
2 AM	Commercial	5	1	0	4
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	6	1	0	5
	Industrial	2	0	0	1
	Other-Residential	451	70	16	321
	Single Family	899	140	35	561
	Total	**1,363**	**212**	**51**	**892**
2 PM	Commercial	391	64	15	264
	Commuting	0	0	0	0
	Educational	142	23	5	105
	Hotels	1	0	0	1
	Industrial	13	2	0	9
	Other-Residential	169	30	7	108
	Single Family	325	57	14	181
	Total	**1,041**	**177**	**42**	**667**

Social Impact in Sylhet City Corporation Area: Scenario Case 3

Table 6-65 Summary of the casualties estimated for earthquake in Sylhet City Corporation: Scenario Case 3

Sylhet : Case 3					
		Level 1	**Level 2**	**Level 3**	**Level 4**
2 AM	Commercial	23	4	1	17
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	26	4	1	25
	Industrial	8	1	0	5
	Other-Residential	2,076	351	96	1,548
	Single Family	5,375	968	319	3,129
	Total	**7,508**	**1,329**	**417**	**4,723**
2 PM	Commercial	1,853	332	97	1,237
	Commuting	0	0	0	0
	Educational	544	95	25	429
	Hotels	5	1	0	5
	Industrial	61	11	3	39
	Other-Residential	771	148	39	516
	Single Family	1,940	379	117	1,017
	Total	**5,173**	**966**	**282**	**3,242**

Social Impact in Sylhet City Corporation Area: Scenario Case 4

Table 6-66 Summary of the casualties estimated for earthquake in Sylhet City Corporation: Scenario Case 4

Sylhet : Case 4					
		Level 1	**Level 2**	**Level 3**	**Level 4**
2 AM	Commercial	56	10	3	42
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	52	8	2	54
	Industrial	20	4	1	14
	Other-Residential	5,190	929	274	4,209
	Single Family	14,138	2,750	995	8,788
	Total	**19,455**	**3,701**	**1,275**	**13,107**
2 PM	Commercial	4,592	873	275	3,301
	Commuting	0	0	0	0
	Educational	1,253	230	65	1,071
	Hotels	10	2	0	10
	Industrial	149	29	10	100
	Other-Residential	1,908	385	107	1,385
	Single Family	5,094	1,067	359	2,855
	Total	**13,005**	**2,586**	**817**	**8,724**

Social Impact in Sylhet City Corporation Area: Scenario Case 5

Table 6-67 Summary of the casualties estimated for earthquake in Sylhet City Corporation: Scenario Case 5

Sylhet : Case 5					
		Level 1	**Level 2**	**Level 3**	**Level 4**
2 AM	Commercial	83	15	5	69
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	77	12	3	83
	Industrial	27	5	2	19
	Other-Residential	8,233	1,466	422	7,300
	Single Family	19,806	3,872	1,382	13,236
	Total	**28,226**	**5,370**	**1,814**	**20,708**
2 PM	Commercial	7,100	1,341	412	5,645
	Commuting	0	0	0	0
	Educational	1,924	350	99	1,771
	Hotels	15	2	1	16
	Industrial	202	40	13	141
	Other-Residential	3,031	609	166	2,403
	Single Family	7,142	1,506	500	4,301
	Total	**19,414**	**3,850**	**1,190**	**14,276**

6.4. Economic Loss

6.4.1. Building Losses

Table 6-68 Building-Related Economic Loss Estimates (Millions of dollars) in Dhaka City Corporation Area

Case	Capital Stock Loses	Single Family Dwelling (SFD) Residential	Non-SFD	Commercial	Industrial	Others	Total
1	Structural	2.11	506.99	499.53	38.22	65.31	1,112.15
	Non_ Structural	6.07	2,548.89	755.94	154.86	238.45	3,704.21
	Content	1.59	685.41	461.56	114.56	129.86	1,392.99
2	Structural	1.10	316.55	278.97	19.71	33.71	650.04
	Non_ Structural	3.31	1,524.76	405.95	80.28	123.13	2,137.43
	Content	0.89	393.10	253.3	59.21	69.07	775.57
3	Structural	2.33	533.91	439.56	37.15	62.99	1,075.93
	Non_ Structural	6.92	2,797.11	670.53	158.32	221.42	3,854.31
	Content	1.95	820.14	427.30	118.46	125.78	1,493.63
4	Structural	5.39	1,216.98	1,071.05	88.15	154.42	2,535.99
	Non_ Structural	17.34	6,352.31	2,000.20	439.14	634.52	9,443.52
	Content	4.45	1,703.53	1,245.12	317.48	352.66	3,623.24

Table 6-69 Building-Related Economic Loss Estimates (Millions of dollars) in Chittagong City Corporation Area

Case	Capital Stock Loses	Single Family Dwelling(SFD) Residential	Non-SFD	Commercial	Industrial	Others	Total
1	Structural	173.10	228.45	263.40	26.74	19.32	711.00
	Non_ Structural	553.71	971.86	348.75	135.30	67.63	2,077.25
	Content	0	0	186.30	100.41	37.17	323.88
2	Structural	35.06	39.72	51.09	6.74	2.96	135.58
	Non_ Structural	85.49	150.69	45.85	23.52	8.37	313.93
	Content	0	0	25.63	17.72	4.82	48.17
3	Structural	93.43	109.9	139.77	15.80	8.16	367.05
	Non_ Structural	260.69	456.03	154.30	69.41	25.98	966.41
	Content	0	0	87.59	52.69	16.08	156.36
4	Structural	55.70	69.15	85.60	8.91	5.12	224.47
	Non_ Structural	142.53	266.08	87.67	34.82	15.44	546.54
	Content	0	0	51.15	26.77	9.67	87.59

Table 6-70 Building-Related Economic Loss Estimates (Millions of dollars) in Sylhet City Corporation Area

Case	Capital Stock Loses	Single Family Dwelling(SFD) Residential	Non-SFD	Commercial	Industrial	Others	Total
1	Structural	69.50	18.45	30.06	1.51	4.69	124.21
	Non_ Structural	201.09	94.78	45.29	6.68	17.98	365.82
	Content	48.89	23.79	25.52	4.91	10.72	113.84
2	Structural	8.80	3.33	5.96	0.27	0.90	19.26
	Non_ Structural	16.73	13.04	6.27	0.88	2.69	39.61
	Content	5.21	3.49	3.75	0.69	1.70	14.84
3	Structural	41.94	12.49	21.06	0.98	3.26	79.73
	Non_ Structural	105.61	60.32	29.38	4.01	11.39	210.71
	Content	28.48	16.44	17.69	3.05	7.33	73.00
4	Structural	84.03	24.64	38.47	1.88	6.14	155.15
	Non_ Structural	256.72	131.06	61.90	9.17	24.47	483.32
	Content	63.67	32.24	34.44	6.60	14.24	151.19
5	Structural	110.51	38.01	53.89	2.40	8.97	213.77
	Non_ Structural	351.02	197.79	87.92	12.43	36.93	686.09
	Content	85.33	45.15	46.64	8.70	19.70	205.51

6.4.2. Transportation and Utility Losses

Dhaka City Corporation Area

Transportation and Utility Systems Economic Losses in Dhaka City Corporation Area

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 6-71 and 6-72 provide a detailed breakdown in the expected lifeline losses.

The following table provides economic losses estimates for the transportation systems of Dhaka City Corporation Area.

Table 6-71 Transportation System Economic Losses in Dhaka City Corporation Area (in million of dollars)

System	Component	Scenario 1			Scenario 2			Scenario 3			Scenario 4		
		Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)
Highway	Roads	1,479.39	95.43	6.45	1,479.39	36.73	2.48	1479.39	101.71	6.88	1,479.39	311.43	21.05
	Bridges	26.53	1.24	4.66	26.53	0.86	3.23	26.53	1.17	4.40	26.53	2.66	10.04
	Subtotal	**1,505.90**	**96.7**		**1,505.90**	**37.6**		**1505.90**	**102.9**		**1505.90**	**314.10**	
Railways	Tracks	66.52	2.04	3.07	66.52	0.76	1.15	66.52	0.46	4.62	66.52	12.42	18.67
	Facilities	9.20	2.11	22.92	9.20	1.24	13.5	9.20	3.52	38.22	9.20	6.04	65.61
	Subtotal	**75.7**	**4.20**		**75.7**	**2.00**		**75.70**	**6.60**		**75.70**	**18.50**	
Bus	Facilities	3.68	0.93	25.37	3.68	0.53	14.53	3.68	1.41	38.30	3.68	2.83	77.02
	Subtotal	**3.70**	**0.90**		**3.70**	**0.50**		**3.70**	**1.40**		**3.70**	**2.80**	
Ferry	Facilities	0.80	0.14	17.78	0.80	0.10	12.51	0.80	0.24	29.98	0.80	0.51	63.89
	Subtotal	**0.80**	**0.10**		**0.80**	**0.10**		**0.80**	**0.20**		**0.80**	**0.50**	
	Total	**1586.1**	**101.9**		**1,586.10**	**40.2**		**1586.1**	**111.1**		**1586.10**	**335.90**	

The following tables provide information on the economic losses to the utility systems.

Table 6-72 Utility System Economic Losses in Dhaka City Corporation Area (in million of dollars)

System	Component	Scenario 1			Scenario 2			Scenario 3			Scenario 4		
		Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)
Potable Water	Pipelines	13.10	1.61	12.32	13.10	0.80	6.13	13.10	1.74	13.29	13.09	0.80	6.13
	Facilities	140.20	20.58	14.68	140.20	10.18	7.26	140.20	36.32	25.91	140.19	10.18	7.26
	Subtotal	**153.28**	**22.19**		**153.28**	**10.99**		**153.28**	**38.06**		**153.28**	**10.99**	
Waste Water	Pipelines	2.90	3.18	111.13	2.90	1.98	69.15	2.90	3.92	137.22	2.86	1.98	69.15
	Facilities	60.60	5.33	8.79	60.6	4.13	6.81	60.60	10.02	16.53	60.62	4.13	6.81
	Subtotal	**63.48**	**8.51**		**63.48**	**6.10**		**63.48**	**13.94**		**63.48**	**6.10**	
Natural Gas	Pipelines	7.70	0.43	5.66	7.70	0.20	2.58	7.70	0.45	5.82	7.66	0.20	2.58
	Facilities	7.00	1.28	18.35	7.00	0.49	6.94	7.00	1.94	27.72	7.00	0.49	6.94
	Subtotal	**14.66**	**1.72**		**14.66**	**0.68**		**14.66**	**2.39**		**14.66**	**0.68**	
Electrical Power	Facilities	75.80	15.6	20.59	75.80	5.40	7.13	75.80	21.77	28.74	75.76	5.40	7.13
	Subtotal	**75.76**	**15.6**		**75.76**	**5.40**		**75.76**	**21.77**		**75.76**	**5.40**	
Communication	Facilities	81.00	11.24	13.87	81.00	5.20	6.42	81.00	19.79	24.44	81.00	5.20	6.42
	Subtotal	**81.00**	**11.24**		**81.00**	**5.20**		**81.00**	**19.79**		**81.00**	**5.20**	
	Total	**388.18**	**59.25**		**388.18**	**28.37**		**388.18**	**95.96**		**388.18**	**28.37**	

Chittagong City Corporation Area

Transportation and Utility Systems Economic Losses in Chittagong City Corporation Area

The following table provides economic losses estimates for the transportation systems of Chittagong City Corporation Area.

Table 6-73 Transportation System Economic Losses in Chittagong City Corporation Area (in million of dollars)

System	Component	Scenario 1			Scenario 2			Scenario 3			Scenario 4		
		Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)
Highway	Roads	725.67	164.49	22.67	725.67	11.81	1.63	725.67	26.04	3.59	725.67	15.54	2.14
	Bridges	6.56	1.23	18.84	6.56	0.08	1.24	6.56	0.36	5.49	6.56	0.15	2.30
	Subtotal	**732.2**	**165.7**		732.2	11.9		**732.2**	**26.4**		**732.2**	**15.70**	
Railways	Tracks	98.2	9.09	9.25	98.2	0.18	0.19	98.2	0.59	0.6	98.20	0.27	0.27
	Facilities	7.36	4.88	66.25	7.36	0.52	7.03	7.36	2.97	40.3	7.36	1.47	20.00
	Subtotal	**105.6**	**14**		**105.6**	**0.7**		**105.6**	**3.6**		**105.6**	**1.70**	
Bus	Facilities	1.55	0.71	45.53	1.55	0.25	15.88	1.55	0.48	31.12	1.55	0.43	27.74
	Subtotal	**1.6**	**0.7**		**1.6**	**0.2**		**1.6**	**0.5**		**1.6**	**0.40**	
	Total	**839.3**	**180.4**		**839.3**	**12.8**		**839.3**	**30.4**		**839.3**	**17.90**	

The following tables provide information on the economic losses to the utility systems.

Table 6-74 Utility System Economic Losses in Chittagong City Corporation Area (in million of dollars)

System	Component	Scenario 1			Scenario 2			Scenario 3			Scenario 4		
		Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)
Potable Water	Pipelines	3.6	2.47	68.38	3.6	0.25	6.94	3.6	0.67	18.4	3.6	0.41	11.19
	Facilities	69.6	24.76	35.6	69.6	5.87	8.44	69.6	15.56	22.37	69.6	11.87	17.07
	Subtotal	**73.18**	**27.24**		**73.18**	**6.12**		**73.18**	**16.23**		**73.18**	**12.28**	
Natural Gas	Pipelines	0.4	0	0	0.4	0	0	0.4	0	0	0.4	0.00	0.00
	Facilities	22.00	10.52	47.82	22.00	1.57	7.14	22.00	5.67	25.76	22.00	3.58	16.26
	Subtotal	**22.36**	**10.52**		**22.36**	**1.58**		**22.36**	**5.67**		**22.36**	**3.58**	
Electrical Power	Facilities	33.4	15.94	47.8	33.4	1.47	4.42	33.4	9.58	28.73	33.4	3.99	11.97
	Subtotal	**33.35**	**15.94**		**33.35**	**1.47**		**33.35**	**9.58**		**33.35**	**3.99**	
Communication	Facilities	19.00	9.53	50.16	19.00	0.77	4.05	19.00	5.31	27.97	19.00	2.20	11.60
	Subtotal	**19.00**	**9.53**		**19.00**	**0.77**		**19.00**	**5.31**		**19.00**	**2.20**	
	Total	**147.89**	**63.23**		**147.89**	**9.94**		**147.89**	**36.79**		**147.89**	**22.05**	

Sylhet City Corporation Area

Transportation and Utility Systems Economic Losses in Sylhet City Corporation Area

The following table provides economic losses estimates for the transportation systems of Sylhet City Corporation Area.

Table 6-75 Transportation System Economic Losses in Sylhet City Corporation Area (in million of dollars)

System	Component	Scenario 1			Scenario 2			Scenario 3			Scenario 4			Scenario 5		
		Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)
Highway	Roads	178.35	6.78	3.8	178.35	1.27	0.71	178.35	4.03	2.26	178.35	11.00	6.17	178.35	75.31	42.23
	Bridges	2.55	0.41	15.9	2.55	0.16	6.2	2.55	0.32	12.34	2.55	0.45	17.57	2.55	0.58	22.85
	Subtotal	**180.9**	**7.2**		**180.9**	**1.4**		**180.9**	**4.3**		**180.90**	**11.50**		**180.90**	**75.90**	
Railways	Tracks	6.99	9.2	2.84	6.99	0.01	0.15	6.99	0.06	0.89	6.99	0.34	4.89	6.99	6.15	88.07
	Facilities	3.44	1.2	34.76	3.44	0.35	10.18	3.44	1.33	38.63	3.44	1.58	45.90	3.44	3.44	100.00
	Subtotal	**10.4**	**1.4**		**10.4**	**0.4**		**10.4**	**1.4**		**10.40**	**1.90**		**10.40**	**9.60**	
Bus	Facilities	0.16	0.06	34.88	0.16	0.02	10.25	0.16	0.06	38.63	0.16	0.07	46.06	0.16	0.16	100.00
	Subtotal	**0.2**	**0.1**		**0.2**	**0**		**0.2**	**0.1**		**0.20**	**0.10**		**0.20**	**0.20**	
	Total	**191.5**	**8.6**		**191.5**	**1.8**		**191.5**	**5.8**		**191.50**	**13.40**		**191.50**	**85.70**	

The following tables provide information on the economic losses to the utility systems.

Table 6-76 Utility System Economic Losses in Sylhet City Corporation Area (in million of dollars)

System	Component	Scenario 1			Scenario 2			Scenario 3			Scenario 4			Scenario 5		
		Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)	Inventory Value	Economics Loss	Loss Ratio (%)
Potable Water	Pipelines	0.5	0.92	168.15	0.5	0.16	29.12	0.5	0.47	86.41	0.5	1.15	209.89	0.5	2.53	461.52
	Facilities	2.4	0.63	26.73	2.4	0.12	5.17	2.4	0.64	27.29	2.4	0.90	38.37	2.4	1.91	81.03
	Subtotal	**2.9**	**1.55**		**2.9**	**0.28**		**2.9**	**1.12**		**2.90**	**2.06**		**2.90**	**4.44**	
Natural Gas	Pipelines	0.4	0.3	72.13	0.4	0.04	8.6	0.4	0.16	38.44	0.40	0.43	102.55	0.40	0.99	236.96
	Facilities	1	0.23	23.16	1	0.05	5.06	1	0.28	27.95	1.00	0.34	34.31	1.00	1.00	100.00
	Subtotal	**1.42**	**0.53**		**1.42**	**0.09**		**1.42**	**0.44**		**1.42**	**0.77**		**1.42**	**1.99**	
Electrical Power	Facilities	14.3	3.66	25.69	14.3	0.76	5.34	14.3	3.9	27.37	14.30	5.00	35.09	14.30	9.09	63.73
	Subtotal	**14.26**	**3.66**		**14.26**	**0.76**		**14.26**	**3.9**		**14.30**	**5.00**		**14.26**	**0.09**	
Communication	Facilities	23	5.49	23.85	23	1.53	6.65	23	5.81	25.25	23.00	7.30	31.75	23.00	15.71	68.32
	Subtotal	**23**	**5.49**		**23**	**1.53**		**23**	**5.81**		**23.00**	**7.30**		**23.00**	**15.71**	
	Total	**41.58**	**11.23**		**41.58**	**2.66**		**41.58**	**11.27**		**41.58**	**15.13**		**41.58**	**31.23**	

Appendix A: Regional population and Building value data

Table A-7 Regional population and Building value data of Dhaka City Corporation Area

VAZ No.	Characteristics	Ward No.	Population	Building Value (millions of dollars)		
				Residential	Non-Residential	Total
1	This zone is a newly developed residential area	1	217,075	515	205	721
2	This zone is the most restricted area of Dhaka city containing the Airport and Cantonment	Cantonment and Airport Area	0	0	0	0
3	Bhasantek, Manikdi, Balurghat	15	214,930	173	47	220
4	Mirpur10, Pallabi, Senpara	2 3 4 5	395,300	601	180	781
5	Mirpur1,2,6,7	6 7	275,625	489	130	620
6	This zone is the main recreational zone of the city containing the national zoo and botanical garden	8	117,468	221	52	274
7	Diabari,Golartek, Jahanabad, Bagbari, Paikpara	9 10 11 12	332,887	562	158	720
8	Kazipar, Shewrapar, Monipur	13 14	407,767	795	131	926
9	Old Airport, Kafrul, Ibrahimpur	16	196,701	330	73	403
10	Bashundhara, Khilkhet, Kuril	17	253,020	420	110	530
11	Shahjadpur, Uttar Badda	18	73,343	176	45	222
12	This part is the High Class Residential area in the Eastern part of Dhaka	19 20	246,398	484	297	781
13	This zone is well known as eastern fringe and densely populated	21	126,237	259	69	328
14	Rampura, Hajipara	22	164,727	153	55	208
15	Khilgaon, Malibag	23	64,862	56	35	92
16	Meradia, Goran Madartek	24 25 26	291,416	247	107	355
17	Bashabo, Mayakanon, Mugdapara,	27 28 29	263,775	235	120	355
18	Maniknagar, Jatrabari, Saidabad	30 84 85 86	306,219	324	184	509
19	Shajahanpur, Shantibag, Fakirapul, Motijheel	31 32 33 34 35	226,996	300	259	559
20	Shantinagar, Shiddeshawri, Ramna	36 53	112,733	191	114	306
21	This part is the one and only Industrial area	37	57,637	114	160	275
22	Nakhalpara, Shahinbag	38	75,325	76	90	166
23	Farmgate, Indira road, Kawranbazar	39	58,562	139	76	215
24	Sherebangla Nagar,	40	76,136	211	77	288
25	Agargaon	41	32,197	66	29	95

Appendix

Table A-1 Regional population and Building value data of Dhaka City Corporation Area (Cont'd)

VAZ No.	Characteristics	Ward No.	Population	Building Value (millions of dollars)		
				Residential	Non-Residential	Total
26	Shaymoli, Lalmatia,	42	302,547	674	158	832
		43				
		44				
		45				
27	Adabor, Bashbari	46	221,230	456	81	537
		47				
28	Rayerbazar, Hazaribag	48	108,441	270	78	348
29	Dhanmondi, Mohammodpur	49	73,114	272	109	382
30	Kathalbagan, Green Road	50	64,598	220	35	256
31	Kalabagan, Sobahanbag,Shukrabad	51	55,954	190	38	228
32	BDR HQ, New Market, Elephant Road	52	40,286	127	81	208
33	Magbazar, Newskaton	54	92,712	119	47	166
34	Nayatola, Modhubag	55	82,559	71	46	118
35	Shegunbagicha, Bijoynagar, Palton	56	27,305	40	105	146
36	Dhaka University, Shahbag	57	40,238	86	89	175
37	Azimpur, Nawabgonj, Companyghat	58	96,617	236	29	266
38	This is one of the parts of old Dhaka containing different higher educational institution	59	320,744	612	251	864
		60				
		61				
		62				
		63				
		64				
		65				
39	This is one of the parts of old Dhaka and performs as the CBD of old Dhaka	66	278,351	214	501	716
		67				
		68				
		69				
		70				
		71				
		72				
		73				
40	This is considered as the only planned area of the entire old part of Dhaka	74	232,715	322	240	563
		75				
		76				
		77				
41	This is one of the parts of old Dhaka and mostly performs the residential characteristics	78	334,746	308	258	567
		79				
		80				
		81				
		82				
		83				
42	Gendaria, Dholaipar, Jurain, Faridabad	87	320,175	257	161	419
		88				
		89				
		90				
Total Region			**7,279,668**	**11,611**	**5,110**	**16,740**

Table A-8 Regional population and Building value data of Chittagong City Corporation Area

Ward No.	Population	Building Value (millions of dollars)		
		Residential	Non-Residential	Total
1	61,736	69	24	94
2	109,556	110	80	190
3	71,403	58	32	90
4	131,212	129	73	203
5	62,707	61	20	82
6	84,568	79	39	119
7	108,044	103	57	160
8	145,948	148	66	215
9	98,272	91	28	119
10	53,550	49	29	78
11	73,468	77	15	92
12	67,199	64	28	92
13	71,385	79	25	105
14	35,553	39	9	48
15	40,284	44	14	59
16	65,586	53	40	93
17	58,058	60	14	75
18	54,769	59	18	78
19	31,243	35	13	49
20	23,773	30	3	33
21	32,959	37	7	44
22	26,817	25	11	37
23	30,481	29	13	42
24	128,613	141	37	178
25	62,725	62	18	81
26	45,956	48	10	59
27	52,679	52	19	71
28	40,149	38	23	61
29	33,674	33	14	47
30	36,305	34	27	61
31	16,586	11	16	27
32	24,687	24	18	42
33	24,559	21	22	43
34	24,066	15	31	47
35	17,297	9	34	44
36	31,985	36	11	47
37	28,239	30	6	37
38	60,042	71	18	89
39	53,178	50	36	86
40	74,096	84	20	105
41	39,199	50	5	56
Total Region	**2,332,606**	**2,337**	**1,023**	**3,378**

Appendix

Table A-9 Regional population and Building value data of Sylhet City Corporation Area

Ward No.	Population	Building Value (millions of dollars)		
		Residential	Non-Residential	Total
1	9,277	26	5	32
2	6,624	12	5	18
3	10,949	19	8	28
4	9,958	23	5	28
5	17,263	28	4	33
6	10,750	18	3	22
7	23,371	54	4	58
8	24,200	48	6	54
9	22,349	38	9	48
10	20,367	46	8	55
11	14,963	24	4	29
12	14,836	20	7	28
13	10,149	18	9	28
14	12,008	15	24	39
15	9,009	15	8	24
16	9,642	17	5	23
17	14,484	26	8	34
18	14,410	27	2	30
19	17,594	28	3	31
20	13,338	29	6	35
21	17,385	33	4	37
22	9,576	31	4	35
23	7,846	10	4	14
24	24,292	31	5	37
25	14,053	26	7	34
26	17,621	25	23	49
27	25,459	28	14	43
Total Region	**401,773**	**715**	**194**	**926**

Appendix B: Correlation Matrix in use

Table B-1 Correlation Matrix of Structural type and Building occupancy in Dhaka (Shown in a percentage of the buildings floor area)

Occ.	C1L	C1M	C1H	LCL	LCM	C2H	C3L	C3M	C3H	C4L	C4M	C4H	Concrete	S3	S1L	Steel	BCL	BCM	BFL	BLL	Masonry	TSL	BAL	TS+BA	Total
RES1	5			10	2		71	5		3	4		55			0	63	5	29	3	44	88	12	1	100
RES2A				13	6		48	33					73			0	61	6	31	3	26	92	8	1	100
RES2B				1	9		7	80		1	2		94			0	27	63	9	1	6	85	15	0	100
RES2C				3	13		1	46	37				88			0	6	90	4		12			0	100
RES3A				2	6		12	69		1	8		89			0	28	70	2		11			0	100
RES3B		1			1		1	72	11		11	3	97			0		100			3			0	100
RES3C					1	4		29	52		2	10	99			0		100			1			0	100
RES3D								4	82			14	100			0					0			0	100
RES4	8	40					8	44					62			0	62		38		38			0	100
RES5					11		15	65			9		34			0	18	66	16		61	100		5	100
RES6							100						0			0	30		70		1	90	10	99	100
COM1	16	14		18	16		23	9		1	3		2	100		6	34		63	2	87	90	10	5	100
COM2	1	15	41	1	6		4	13	11		3	5	32			0	15	36	49		68			0	100
COM3				11			58	30					63	100		19			50	50	12	100		5	100
COM4	2	4		2	2	30	15	32	12	1	2		22		100	0	46	48	6		78			0	100
COM5	21						5			4	16	53	70			0	100				30			0	100
COM6		2	19		1	38	2	19	15		5		51			0	29	71			48	100		1	100
COM7				12	8		47	33					64			0	100				36			0	100
COM8	7			11			41	21			20		13			0	62		22	16	80	59	41	7	100
COM9				15	27		19	39					55			0	100				45			0	100
COM10	1	5	5	3	9		9	50	12		2		41			0	42	43	11	4	59			0	100
IND1		6	16	1	2		6	27	37			6	78	100		0	13	33	53		18	100		3	100
IND2	5	15		7	3		12	34	23				7	52	48	0	26		74		85	100		8	100
IND3				9				91					28			0			100		72			0	100
IND4				100									2	100		2	45		55		80	100		16	100
IND5							33	67					100			0					0			0	100
IND6	1	2			1	26	5	32	10	1	14	10	100			0					0			0	100
AGR1				15	5		19	23	37				6	35	65	4	43		44	13	75	81	19	15	100
REL1	19	19		6	4		35	17					35			0	77		23		59	100		6	100
GOV1	2	6		2		30	11	15	24		4	6	52			0	42	42	12	4	47		100	2	100
GOV2				8			50	42					9			0	91		9		91			0	100
EDU1		3		6	4		41	46					16			0	63	30	7		81	100		3	100
EDU2		3	53	1			9	21	8	1	5		53			0	85		15		47			0	100

Appendix

Table B-2 Correlation Matrix of Structural type and Building occupancy in Chittagong (Shown in a percentage of the buildings floor area)

Occ.	C1L	C1M	LCL	LCM	C3L	C3M	C3H	C4L	C4M	Concrete	S3	Steel	BCL	BCM	BFL	BLL	Masonry	TSL	BAL	TSL+BAL	Total
RES1	4		17		77	2				57		0	33		65	3	40	21	79	3	100
RES2A	1		13	2	70	12				66		0	37		60	2	24	26	74	10	100
RES2B	1		9	11	27	51				87		0	39	22	38		12	28	72	1	100
RES2C		6	9	25	10	51				90		0	52	32	16		10			0	100
RES3A			7	3	35	53				94		0	59	25	17		6	59	41	0	100
RES3B				3	8	79	10			94		0	22	75	3		6			0	100
RES3C				1		24	75			96		0	17	83			4			0	100
RES3D						100				100		0					0			0	100
RES4					49	51				92		0			100		5		100	3	100
RES5			10	6	48	36				66		0	56	16	28		33	42	58	1	100
RES6	39				61					8		0			78	22	19	21	79	73	100
COM1	7		30		63					53		0	22		77		40	41	59	7	100
COM2			5	19	9	67				95		0		80	20		5			0	100
COM3			18	17	57			8		62		0	20		80		26	68	32	12	100
COM4			5	2	24	30	39			87		0	66	16	18		13		100	0	100
COM5					66	34				89		0	100				11			0	100
COM6					46	54				91		0	100				9			0	100
COM7					42	58				77		0	100				23			0	100
COM8			8		50	42				69	100	5	66		34		23		100	3	100
COM9					100					86		0					14			0	100
COM10			13	9	31	42	4		1	88		0	31	22	46		11	30	70	1	100
IND1			8		16	22	53			96		0			100		3	100		1	100
IND2	3		7	2	20	55	14			90	100	4	47		53		6	74	26	1	100
IND3				17	59	24				71	100	18			100		9	100		2	100
IND4			16		41	43				75		0					25			0	100
IND5					100					70	100	3			100		28			0	100
IND6					20	14	66			93		0					4	19	81	3	100
AGR1					100					54	100	13			100		16		100	18	100
REL1			14		84	3				90		0	72		28		10			0	100
GOV1			6		63	31				77		0	81		11	8	23			0	100
GOV2					100					90		0	87		13		10	42	58	0	100
EDU1	3		9	5	68	15				87		0	78		22		12	100		1	100
EDU2				4	45	23	28			93		0	83		17		7			1	100

Appendix

Table B-3 Correlation Matrix of Structural type and Building occupancy in Sylhet (Shown in a percentage of the buildings floor area)

Occ.	C1L	LCL	LCM	C2H	C3L	C3M	C3H	C4L	C4M	C4H	Concrete	S3	S1H	Steel	BCL	BCM	BFL	BLL	Masonry	TSL	BAL	TSL+BAL	Total
RES1		10			53	33		4			43	21	79	0	2		98		52	89	11	5	100
RES2A		2			75	21		1	1		90			0	1		99		8	88	12	2	100
RES2B					22	77					96			0		2	98		2	68	32	1	100
RES2C		2		2	74	22					100			0					0			0	100
RES3A		8			49	28	2	8	4		87	100		0	27	1	72		12	98	2	0	100
RES3B		1	1		7	44	6		14	27	98			0			100		2			0	100
RES3C						32	34		34		100			0					0			0	100
RES4		3	2		20	40		35			100			0	100				0			0	100
RES5		8			85	7					53			0	39		61		45	100		2	100
RES6		27			14	5	55				9			0			99	1	59	89	11	33	100
COM1		21			53	24		2			45			0	7		92		49	97	3	6	100
COM2		36	1		22	27	4	5	4	1	96			0			100		4	100		0	100
COM3		4			53	14		28			43	100		1			100		40	84	16	16	100
COM4		7			25	18			1	49	95			0	8		90	2	5			0	100
COM5		1			25	24		7	9	32	96			0	57		43		4	100		0	100
COM6		1			75	21		3			96			0			100		2	100		2	100
COM7		2			32	65		1			96			0			100		3	100		0	100
COM8	5	15			39	41					69			0	10		90		26	100		5	100
COM9					38	62					97			0			100		3			0	100
COM10		13	1		37	28	8	8	3	2	90	94	6	0	6		94		9	100		1	100
IND1		7			4	88					13			0			100		85	100		2	100
IND2					56	44					49			0	2		98		51			0	100
IND3		11			71	19					30			0	1		99		53	100		17	100
IND6		3			11	65	16	5			99			0			100		1			0	100
AGR1		45			39	16					22			0			100		63	94	6	15	100
REL1	1	10	1		72	9		6			77			0	51		49		21	78	22	2	100
GOV1		2	3		50	44		1			88			0	13		85	1	11	100		0	100
GOV2					9	91					95			0			100		5			0	100
EDU1		8			52	27		2	1	11	84			0	7		93		16	100		1	100
EDU2		1			44	48		3	4		87			0	6		94		13			0	100

Appendix C: HAZUS inputting Parameters

Table C-1 Scenario cases in Dhaka City Corporation Area

Dhaka	*Case 1*	*Case 2*	*Case 3*	*Case 4*
Attenuation Function	*WUS Shallow Crustal Event - Non Extensional*			
Epicenter parameters				
Bangladesh (Latitude, Longitude)	*(24.3,90.1)*	*(23.8,91.1)*	*(23.8,90.4)*	*(23.8,90.5)*
Conversion to HAZUS (Latitude, Longitude)	*(39.3,-116.9)*	*(38.8,-115.9)*	*(38.8,-116.6)*	*(38.8,-116.5)*
Magnitude (M_w)	*7.5*	*8*	*6*	*8.5*
Depth (km)	*10*	*3*	*8*	*3*
Width (km)	*42*	*50*	*25*	*50*
Fault rapture parameters				
Orientation (Degree)	*170 °*	*10 °*	*0 °*	*10 °*
Dip Angle (Degree)	*45 °*	*20 °*	*90 °*	*20 °*

Table C-2 Scenario cases in Chittagong City Corporation Area

Chittagong	*Case 1*	*Case 2*	*Case 3*	*Case 4*
Attenuation Function	*WUS Shallow Crustal Event - Non Extensional*			
Epicenter parameters				
Bangladesh (Latitude, Longitude)	*(21.1,92.1)*	*(23.8,91.1)*	*(22.4,91.8)*	*(22.4,91.8)*
Conversion to HAZUS (Latitude, Longitude)	*(36.1,-114.9)*	*(38.8,-115.9)*	*(37.36,-115.18)*	*(37.36,-115.18)*
Magnitude (M_w)	*8.5*	*8*	*6*	*6*
Depth (km)	*17.5*	*3*	*6*	*22*
Width (km)	*50*	*50*	*6*	*10*
Fault rapture parameters				
Orientation (Degree)	*165°*	*10°*	*160°*	*45°*
Dip Angle (Degree)	*30°*	*20°*	*90°*	*45°*

Table C-3 Scenario cases in Sylhet City Corporation Area

Chittagong	*Case 1*	*Case 2*	*Case 3*	*Case 4*	*Case 5*
Attenuation Function	*WUS Shallow Crustal Event - Non Extensional*				
Epicenter parameters					
Bangladesh (Latitude, Longitude)	*(25.1,91.2)*	*(25.7,93.7)*	*(24.9,91.87)*	*(25.03,91.2)*	*(24.91,91.2)*
Conversion to HAZUS (Latitude, Longitude)	*(40.1,-115.8)*	*(40.7,-113.3)*	*(39.9,-115.13)*	*(40.03,-115.8)*	*(39.91,-115.8)*
Magnitude (M_w)	*8*	*8.3*	*6*	*8*	*8.5*
Depth (km)	*3*	*3*	*7*	*3*	*3*
Width (km)	*43*	*50*	*20*	*43*	*43*
Fault rapture parameters					
Orientation (Degree)	*90°*	*45°*	*0°*	*90°*	*90°*
Dip Angle (Degree)	*60°*	*30°*	*90°*	*60°*	*60°*

Table C-4 Building damage functions - Capacity Curves (Pre-code) in Dhaka City Corporation Area

No.	Building Type (Survey)	Building Type (Input)	Sd Yield (inches)	Sa Yield (g's)	Sd Ultimate (inches)	Sa Ultimate (g's)	Kappa/ Short Duration	Kappa/ Medium Duration	Kappa/ Long Duration	Damping	Fraction
1	C3L	C3L	0.24	0.23	1.64	0.70	0.40	0.20	0	10	0.50
2	C3M	C3M	0.63	0.14	2.36	0.27	0.40	0.20	0	10	0.33
3	C3H	C3H	0.73	0.06	4.13	0.14	0.40	0.20	0	10	0.20
4	C4L	PC2L	0.24	0.23	1.64	0.70	0.40	0.20	0	10	0.50
5	C4M	PC2M	0.63	0.14	2.36	0.27	0.40	0.20	0	10	0.33
6	C4H	PC2H	0.73	0.06	4.13	0.14	0.40	0.20	0	10	0.20
7	LCL	C2L	0.24	0.25	1.29	0.66	0.40	0.20	0	10	0.50
8	LCM	C2M	0.63	0.13	1.91	0.20	0.40	0.20	0	10	0.33
9	BCL	URML	0.24	0.20	2.40	0.40	0.45	0.25	0.05	10	0.50
10	BCM	URMM	0.27	0.11	1.81	0.22	0.45	0.25	0.05	10	0.33
11	BFL	RM1L	0.24	0.20	2.40	0.40	0.45	0.25	0.05	10	0.50
12	BLL	RM2L	0.24	0.20	2.40	0.40	0.45	0.25	0.05	10	0.50
13	TSL+BAL	MH	0.24	0.20	4.32	0.60	0.50	0.30	0.10	15	0.50

Table C-5 Building damage functions - Capacity Curves (Pre-code) in Chittagong City Corporation Area

No.	Building Type (Survey)	Building Type (Input)	Sd Yield (inches)	Sa Yield (g's)	Sd Ultimate (inches)	Sa Ultimate (g's)	Kappa/ Short Duration	Kappa/ Medium Duration	Kappa/ Long Duration	Damping	Fraction
1	C3L	C3L	0.24	0.39	1.55	1.05	0.40	0.20	0	10	0.50
2	C3M	C3M	0.63	0.15	2.40	0.28	0.40	0.20	0	10	0.33
3	C3H	C3H	0.74	0.06	4.13	0.14	0.40	0.20	0	10	0.20
4	C4L	PC2L	0.24	0.39	1.55	1.05	0.40	0.20	0	10	0.50
5	C4M	PC2M	0.63	0.15	2.40	0.28	0.40	0.20	0	10	0.33
6	C4H	PC2H	0.74	0.06	4.13	0.14	0.40	0.20	0	10	0.20
7	LCL	C2L	0.24	0.35	1.17	0.84	0.40	0.20	0	10	0.50
8	LCM	C2M	0.63	0.14	1.84	0.21	0.40	0.20	0	10	0.33
9	BCL	URML	0.24	0.20	2.40	0.40	0.45	0.25	0.05	10	0.50
10	BCM	URMM	0.27	0.11	1.81	0.22	0.45	0.25	0.05	10	0.33
11	BFL	RM1L	0.24	0.20	2.40	0.40	0.45	0.25	0.05	10	0.50
12	BLL	RM2L	0.24	0.20	2.40	0.40	0.45	0.25	0.05	10	0.50
13	TSL+BAL	MH	0.24	0.20	4.32	0.60	0.50	0.30	0.10	15	0.50

Table C-6 Building damage functions - Capacity Curves (Pre-code) in Sylhet City Corporation Area

No.	Building Type (Survey)	Building Type (Input)	Sd Yield (inches)	Sa Yield (g's)	Sd Ultimate (inches)	Sa Ultimate (g's)	Kappa/ Short Duration	Kappa/ Medium Duration	Kappa/ Long Duration	Damping	Fraction
1	C3L	C3L	0.24	0.44	1.54	1.13	0.40	0.20	0	10	0.50
2	C3M	C3M	0.63	0.15	2.32	0.28	0.40	0.20	0	10	0.33
3	C3H	C3H	0.73	0.06	4.13	0.14	0.40	0.20	0	10	0.20
4	C4L	PC2L	0.24	0.44	1.54	1.13	0.40	0.20	0	10	0.50
5	C4M	PC2M	0.63	0.15	2.32	0.28	0.40	0.20	0	10	0.33
6	C4H	PC2H	0.73	0.06	4.13	0.14	0.40	0.20	0	10	0.20
7	LCL	C2L	0.24	0.56	1.01	1.15	0.40	0.20	0	10	0.50
8	LCM	C2M	0.63	0.15	1.74	0.20	0.40	0.20	0	10	0.33
9	BCL	URML	0.24	0.20	2.40	0.40	0.45	0.25	0.05	10	0.50
10	BCM	URMM	0.27	0.11	1.81	0.22	0.45	0.25	0.05	10	0.33
11	BFL	RM1L	0.24	0.20	2.40	0.40	0.45	0.25	0.05	10	0.50
12	BLL	RM2L	0.24	0.20	2.40	0.40	0.45	0.25	0.05	10	0.50
13	TSL+BAL	MH	0.24	0.20	4.32	0.60	0.50	0.30	0.10	15	0.50

Table C-7 Building damage functions - Structural Fragility Curves (Pre-code) in Dhaka City Corporation Area

No.	Building Type (Survey)	Building Type (Input)	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta	Complete Median	Complete Beta
1	C3L	C3L	0.45	1.19	0.82	1.15	1.72	1.16	3.51	0.92
2	C3M	C3M	0.67	0.90	1.11	0.86	2.28	0.90	4.36	0.96
3	C3H	C3H	1.04	0.73	2.07	0.74	5.18	0.90	12.10	0.95
4	C4L	PC2L	0.45	1.19	0.82	1.15	1.72	1.16	3.51	0.92
5	C4M	PC2M	0.67	0.90	1.11	0.86	2.28	0.90	4.36	0.96
6	C4H	PC2H	1.04	0.73	2.07	0.74	5.18	0.90	12.10	0.95
7	LCL	C2L	0.40	1.19	0.83	1.15	1.63	1.16	3.20	0.92
8	LCM	C2M	0.46	0.90	0.94	0.86	1.87	0.90	3.60	0.96
9	BCL	URML	0.32	0.99	0.65	1.05	2.28	1.10	5.66	1.08
10	BCM	URMM	0.57	0.91	1.02	0.92	3.15	0.87	7.03	0.91
11	BFL	RM1L	0.29	1.07	0.60	1.12	1.90	1.15	5.04	1.13
12	BLL	RM2L	0.29	1.07	0.60	1.12	1.90	1.15	5.04	1.13
13	TSL+BAL	MH	0.40	1.01	1.00	1.05	3.09	1.07	7.56	1.06

Table C-8 Building damage functions - Structural Fragility Curves (Pre-code) in Chittagong City Corporation Area

No.	Building Type (Survey)	Building Type (Input)	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta	Complete Median	Complete Beta
1	C3L	C3L	0.33	1.19	0.71	1.15	1.51	1.16	3.11	0.92
2	C3M	C3M	0.57	0.90	1.04	0.86	2.14	0.90	3.99	0.96
3	C3H	C3H	1.04	0.73	2.07	0.74	5.18	0.90	12.10	0.95
4	C4L	PC2L	0.33	1.19	0.71	1.15	1.51	1.16	3.11	0.92
5	C4M	PC2M	0.57	0.90	1.04	0.86	2.14	0.90	3.99	0.96
6	C4H	PC2H	1.04	0.73	2.07	0.74	5.18	0.90	12.10	0.95
7	LCL	C2L	0.35	1.19	0.75	1.15	1.58	1.16	3.26	0.92
8	LCM	C2M	0.48	0.90	0.89	0.86	1.86	0.90	3.79	0.96
9	BCL	URML	0.32	0.99	0.65	1.05	2.28	1.10	5.66	1.08
10	BCM	URMM	0.57	0.91	1.02	0.92	3.15	0.87	7.03	0.91
11	BFL	RM1L	0.29	1.07	0.60	1.12	1.90	1.15	5.04	1.13
12	BLL	RM2L	0.29	1.07	0.60	1.12	1.90	1.15	5.04	1.13
13	TSL+BAL	MH	0.40	1.01	1.00	1.05	3.09	1.07	7.56	1.06

Table C-9 Building damage functions - Structural Fragility Curves (Pre-code) in Sylhet City Corporation Area

No.	Building Type (Survey)	Building Type (Input)	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta	Complete Median	Complete Beta
1	C3L	C3L	0.32	1.19	0.68	1.15	1.48	1.16	3.10	0.92
2	C3M	C3M	0.54	0.90	1.01	0.86	2.09	0.90	3.94	0.96
3	C3H	C3H	1.04	0.73	2.07	0.74	5.18	0.90	12.10	0.95
4	C4L	PC2L	0.32	1.19	0.68	1.15	1.48	1.16	3.10	0.92
5	C4M	PC2M	0.54	0.90	1.01	0.86	2.09	0.90	3.94	0.96
6	C4H	PC2H	1.04	0.73	2.07	0.74	5.18	0.90	12.10	0.95
7	LCL	C2L	0.30	1.19	0.69	1.15	1.45	1.16	3.04	0.92
8	LCM	C2M	0.49	0.90	0.90	0.86	1.85	0.90	3.82	0.96
9	BCL	URML	0.32	0.99	0.65	1.05	2.28	1.10	5.66	1.08
10	BCM	URMM	0.57	0.91	1.02	0.92	3.15	0.87	7.03	0.91
11	BFL	RM1L	0.29	1.07	0.60	1.12	1.90	1.15	5.04	1.13
12	BLL	RM2L	0.29	1.07	0.60	1.12	1.90	1.15	5.04	1.13
13	TSL+BAL	MH	0.40	1.01	1.00	1.05	3.09	1.07	7.56	1.06

Table C-10 Fire Following Earthquake Parameters

Parameters	
Number of Simulations	*10*
Total simulation time(min)	*10,000*
Time increment(min)	*15*
Engine speed (mph)	*15*
Wind speed (mph)	*0*
Wind direction (degree)	*0*

Table C-11 Indoor Casualty Rates by Model Building Type for Complete Structural Damage (With Collapse)

Building Type (Survey)	Building Type (Input)	Injury Severity 1 (%)	Injury Severity 2 (%)	Injury Severity 3 (%)	Injury Severity 4 (%)
C1L	*C1L*	*20*	*2*	*2*	*56*
C1M	*C1M*	*20*	*2*	*2*	*56*
C1H	*C1H*	*20*	*2*	*2*	*56*
LCL	*C2L*	*20*	*2*	*2*	*56*
LCM	*C2M*	*20*	*2*	*2*	*56*
C2H	*C2H*	*20*	*2*	*2*	*56*
C3L	*C3L*	*20*	*2*	*2*	*56*
C3M	*C3M*	*20*	*2*	*2*	*56*
C3H	*C3H*	*20*	*2*	*2*	*56*
C4L	*PC2L*	*20*	*2*	*2*	*56*
C4M	*PC2M*	*20*	*2*	*2*	*56*
C4H	*PC2H*	*20*	*2*	*2*	*56*
BFL	*RM1L*	*30*	*7*	*6*	*27*
BLL	*RM2L*	*30*	*7*	*6*	*27*
BCL	*URML*	*30*	*7*	*6*	*27*
BCM	*URMM*	*30*	*7*	*6*	*27*
TSL+BAL	*MH*	*40*	*20*	*3*	*5*

Table C-12 Demographic Data

Parameters	*Inputting Data*
Population	*Population in night time*
ResidDay	*RES 1 - RES6 in daytime*
ResidNight	*RES 1 - RES6 in night time*
Hotel	*RES 4 in night time*
Visitor	*0*
WorkingCom	*COM1- COM10 in daytime*
WorkingInd	*IND1- IND6 in daytime*
Commuting5PM	*0.04(default parameter)*Population*
SchoolEnrollmentKto12	*EDU1 in daytime*
SchoolEnrollmentCollege	*EDU2 in daytime*

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