Vulnerabilities to landslides in Chittagong Metropolitan Area, Bangladesh

Kabir Md. Humayain* and Mahmud Nahid
Institute of Forestry and Environmental Sciences, University of Chittagong, BANGLADESH
*mhkabir@cu.ac.bd

Abstract

Among the common natural and man-made hazards, the hill ecosystem of the country is vulnerable to earthquake, water logging, flash flood and landslide. In Chittagong, landslide has become a common environmental phenomenon in recent years. Motijharna and Batali hill of this city are always in the news for the occurrence of landslide for the past few years. Therefore, this study was conducted to find out the vulnerabilities to landslides in the Motijharna and Batali hill using the Livelihood Vulnerability Index (LVI) method. Primary data were collected through face-to-face interview through a structured questionnaire. Seven major components of LVI e.g. Socio-demographic profile, Livelihood strategies, Water, Health, Social networks, Food and Landslide vulnerability and climate variability were considered during data collection. The study found that Batali hill households were more vulnerable than Motijharna households. Similarly, Batali hill showed greater vulnerability to livelihood strategies, food and landslide vulnerability and climate variability.

The finding of the research also showed that the overall LVI for seven major components in Motijharna and Batali hill was 0.3864 and 0.4878 respectively. Thus, result indicates that people who are living adjacent to these two hills are moderately vulnerable. It is expected that the major findings of this research will help the city planner of Chittagong to take proper actions for better urban planning.

Keywords: Landslides, Chittagong, Hazards, urban planning.

Introduction

Landslide is a geological phenomenon which includes a wide range of ground movements such as rock falls, deep failure of slopes and shallow debris flows.[33] Landslide is often promoted by large accumulation of soil water from rainfall, spring, or melting snow. This adds to the weight of the soil as pore water pressure increased.[11]

The world's urban population was estimated at 3 billion in 2003 and is expected to rise to 5 billion by 2030.[38] Population pressures are increasing in most of the world today and will certainly accelerate in the future.[39] These pressures have resulted in rapid urbanization and development, much of it on hillsides. This urban expansion will disturb geological materials and people are attracted to building on hill area.[32] Much of this disturbance will create landslide as to slope failure.

Bangladesh is one of the most disaster prone countries in the world.[25] Due to the deforestation and unplanned urbanization, manmade disaster has now become a hot topic. For the settlement development these people are cutting hills and forests for rapid residential area development, which causes environmental degradation and is responsible for natural disaster. Presently landslide is occurring frequently in the hilly regions of the country.[5]

In Bangladesh, hills occupy around 16% of total area of the country.[40] Most of the high lands are located in the foothills of the Shiolong plateau i.e. in the Chittagong Sylhet region in the south-east and partially in Mymensing, Jamalpur and Dinajpur in the north-west. About 89,811 ha of hilly area are present at Chittagong which cover the 17.3% of the total area of Chittagong (5283 sq.km). Among the area, 15.86 sq.km hilly areas are prevailing in Chittagong City Corporation (CCC) boundary.

Chittagong City Corporation (CCC) area is highly vulnerable to landslide hazard.[29] All the major landslide events occurred due to much higher rainfall. Moreover rapid urbanization, increased population density, improper land use, alterations in the hilly regions by illegally cutting the hills, indiscriminate deforestation and agricultural practices are aggravating the landslide vulnerability in Chittagong city area.[8] In the recent land slide in Chittagong, 86 people died, over 100 were injured and 22 families are directly affected. Many houses are damaged and domestic animals died in that landslide. Also, the roads are blocked and transportation hampered. 72 families were displaced from their houses and they were bound to take shelter in another safe location and about 200 families were permanently displaced.[36]

Several studies were done by different researchers about landslide in the CCC area.[18] Understanding the issues involved in urban landslide vulnerability in Chittagong Metropolitan Area,[8] Landslide Inventory Report of Chittagong Metropolitan Area, Bangladesh, Developing Dynamic Web-GIS based early warning system for the communities at landslide risks in Chittagong Metropolitan Area,[8] Landslide Risk Reduction of the Informal Foothill Settlements of Chittagong City through Strategic Design Measure[33] and so on are important. There is a research gap about Landslide Vulnerability Index in CCC area and this study can implicate that which area is more and less landslide vulnerable among the others.

Landslides in Bangladesh

Landslide is a major and common geologic hazard in Bangladesh, especially in Chittagong and the South-eastern Part of the country.[35] In recent years, the intensity and magnitude of the landslide occurrences have crossed all previous records.[30] Landslides caused death to more than 300 peoples in Bangladesh since 2000 with a loss of hundreds of houses and millions of dollars of properties.[35]

In Chittagong Hill Tracts, about 152 people died on 13th June 2017 and on11th June, 2007 about 127 people died in Chittagong city. Natural factors such as heavy rainfall, cyclone, flooding and man-made factors such as deforestation, hill cutting, unplanned settlement and development are the triggering factors. Bangladesh is a densely populated country and around 12% area of the total country is occupied by hilly region. So, low income people are forced to live near or under the hill by risking their own lives.[23]

According to geological data, hilly region of Bangladesh developed in tertiary age.[4] As per the statistics of EM-DAT from 1950 to 2014, total 306 natural disasters occurred in different portions of this country which affected more than 40 million people and stranded about more than 14 million people.[4]

Bangladesh hills are basically composed of unconsolidated sedimentary rocks such as sandstone, siltstone, shale and conglomerate.[30,33] Unsustainable land use and alteration in the hills including indiscriminate deforestation and hill cutting are two major factors in Bangladesh that aggravated the landslide vulnerability in the hilly areas. Excessive rainfall within shorter time span often causes landslide specifically in the areas composed of unconsolidated rocks. This situation is further aggravated if the slopes are steep and exposed because of indiscriminate hill cutting.[30]

Every year, a number of landslide occurred in the south-eastern region of Bangladesh triggered by natural process and human intervention but most of them do not get media attention and are not recorded in the international database. Landslides event not only occurred in the south-eastern part of the country but also hit consecutively in the north-eastern part with massive damage. For example, in 2009 two successive landslide/ mudslide hit the hill slope of tea garden of Sylhet region and killed about 12 people including child.[4]

Landslide is becoming one of the regular geological hazards especially in Chittagong, Chittagong Hill tracts and Cox's Bazaar region.[4] Particularly, the influx of Rohingya taking refuge within camps in Cox's Bazar is contributing to deforestation and hill-cutting at an alarming rate.

Though, Cox's Bazar previously had relatively low impact of landslides, the risk is becoming increasingly higher since 2010. Rainfall patterns in Bangladesh have also changed in recent years with short periods of intense rainfall becoming common. These are more likely to induce landslides on unstable slopes such as those in Chittagong.

Material and Methods

Site selection: The study areas are Motijharna and Batali Hill. The study areas are in the Chittagong City Corporation (CCC) area. In recent period, with the increasing number of population, the city is experiencing a tremendous need for land to accommodate the people of its own as well as the people coming from outside. The unusual pressure of urbanization has created an opportunity for the land speculators to destroy the hills without considering the environmental impacts or any other consequences especially within the city core area. As a result, huge number of people get settled in these landslide vulnerable areas. Considering the situation, these two areas were selected purposely for the study by consultation with different stakeholders in order to identify the abuses of hills prevailing in the city.

Description of the study area: Due to port, district headquarter and metropolitan commercial area, the vital city, Chittagong is the second largest city of Bangladesh located by the Bay of Bengal in the eastern part of the country. It has a population estimated at about 5 million inhabitants. The Karnafuli River lies to the south, the coastal plain to the west and flood plain of Halda River to the east. Geographically, the city is located between 20 35' N to 22 59' N longitudes and 91 27' E to 92 22' E latitudes which is the south-eastern part of Bangladesh. Both in terms of economy and ecology, this is a very important city. The main sea port gives it an economic significance. The core of the city is some 15 kilometers upstream of the river mouth where Karnafuli meets the Bay of Bengal.

A north-south central hill range extends into the urban zone from the north and gradually loses height as it comes closer to the river. The city comprises area of small hills and narrow valleys. The highest ground level within the city area is about 60m above Mean Sea Level (MSL). The city terrain is undulated and the major hills of the country are located in this region.[9] Figure 1 shows that map of the Chittagong City Corporation area.

The field study was limited to the area of Batali Hill and Motijharna, with in Chittagong City Corporation (CCC) area, two of the most affected settlements in the 2007 and 2012 landslides. Studies show that these settlements have already been identified as highly vulnerable to landslides because of a high population density along hill slopes. The informal settlements are located at the core of the city. Easy access to work places and availability of government hills have over the last 20 years, attracted low-income people who have built up the settlements along hill slopes (Batali Hill area) and foot hill (Motijharna area).

Batali Hill: The Batali Hill is the highest hill within the Chittagong Metropolitan area. The hill is about 280 feet high. About 500 families are living in this area. From the

peak of the Batali Hill, one can have a clear bird's eye view of the city. Aperture of the river Karnafuli, a comprehensive portion of the Bay of Bengal, Jetties of the Chittagong Sea port and a large portion of the city can be seen. Batali Hill area is situated in the Tiger Pass area of the city. It is only 1 km. from the Zero point and is under Pahartoli Thana.

Motijharna Area: Motijharna is the biggest informal settlement sitting at the core of the city. It has developed at the valley of Motijharna- Batali Hill. It was once been the main source of water supply for Chittagong city before water supply system was introduced. The entire settlement was severely damaged in the landslide occurrence of 2007 and still counted as one of vulnerable areas to landslide. Motijharna area is situated at Lalkhan Bazar area near the Tiger Pass. It is almost impossible today to distinguish Motijharna informal settlement from Batali Hill informal settlement as they are so closely spaced. It is also under control of Pahartoli Thana.

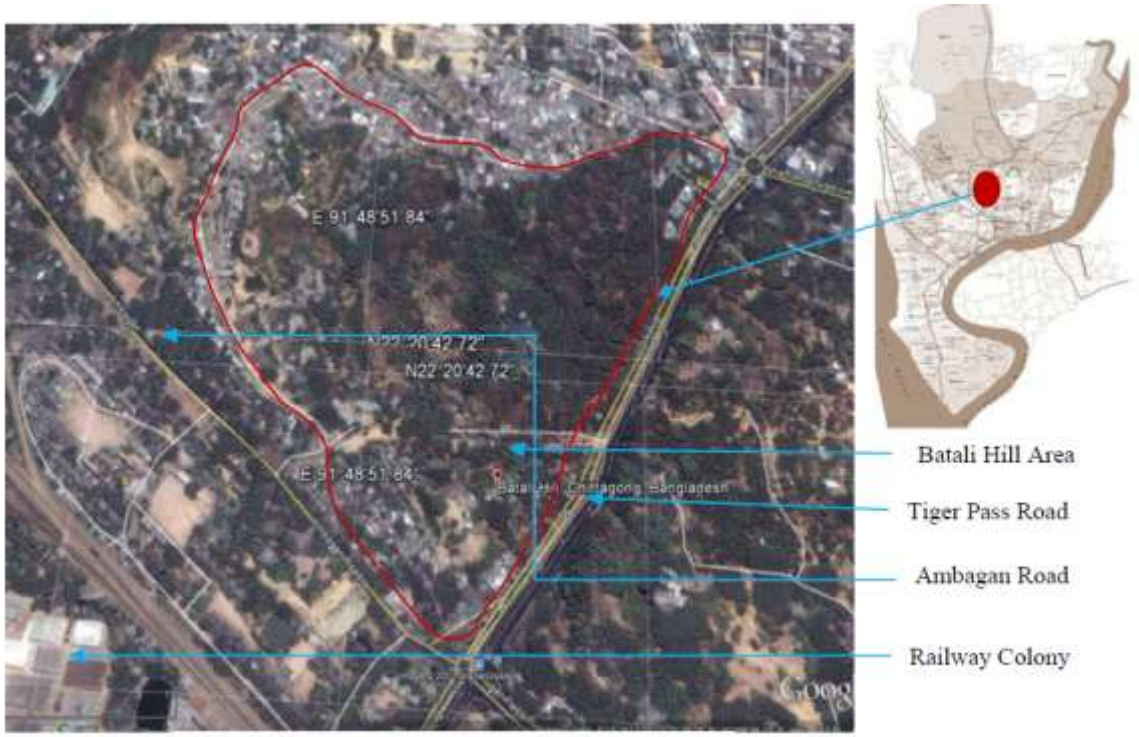

Figure 1: Location map of Batali Hill area, Chittagong City Corporation

Figure 2: Location map of Motijharna area, Chittagong City Corporation

Secondary data collection: The planning for collection data, preparation of data sheets, analysis and interpretation of data and finally the reporting of research work are directly dependent on knowledge and information gained from publications. To find out available materials on the topics, different data sources were surveyed properly: Books, magazines, scientific journals, different university studies, personal communication with different researcher, project papers and review papers on the related field, Government documents and different published Bangladeshi newspapers.

Methods for data collection: The study was carried out in Motijharna and Batali Hill using random sampling and open handed questionnaire**.** At the beginning, a reconnaissance survey was carried out to observe the field condition for efficient study. A map of the CCC was collected to find out existing landslide vulnerable areas. A questionnaire Survey was done for the purpose of the study.

Data analysis- Calculating the LVI (Livelihood Vulnerability Index): composite index approach: LVI includes seven major components: Socio-Demographic Profile, Livelihood Strategies, Social Networks, Health, Food, Water and Natural Disasters and Climate Variability. Each is comprised of several indicators or sub-components.[21] These were developed based on a review of the literature on each major component, for example studies on Motijharna water sector as well as the practicality of collecting the needed data through household surveys. The LVI uses a balanced weighted average approach where each sub-component contributes equally to the overall index even though each major component is comprised of a different number of sub-components. It was intended to develop an assessment tool accessible to a diverse set of users in resource-poor settings. LVI formula uses the simple approach of applying equal weights to all major components.

This weighing could be adjusted by future users as needed. Because each of the sub-components is measured on a different scale, it was first necessary to standardize each as an index. The equation used for this conversion was adapted from that used in the Human Development Index to calculate the life expectancy index, which is the ratio of the difference of the actual life expectancy and a pre-selected minimum and the range of predetermined maximum and minimum life expectancy.[21]

$$index_{s_d} = \frac{s_d - s_{\min}}{s_{\max} - s_{\min}} \quad (1)$$

where sd is the original sub-component for areas d and s min and s max are the minimum and maximum values respectively for each sub-component determined using data from both districts. For example, the 'average time to travel to primary water source' subcomponent ranged from 1 to 40 min in the two areas. These minimum and maximum values were used to transform this indicator into a standardized index, so it could be integrated into the water component of the LVI. For variables that measure frequencies such as the 'percent of households reporting having heard about conflicts over water resources in their community,' the minimum value was set at 0 and the maximum at 100.

After each was standardized, the sub-components were averaged using eq. 2 to calculate the value of each major component.

$$M_d = \frac{\sum_{i=1}^{n} index_{sdi}}{n} \quad (2)$$

where M_d = one of the seven major components for d [Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Networks (SN), Health (H), Food (F), Water (W) and Natural Disasters and Climate Variability (NDCV)], $Index_{sdi}$ represents the sub-components indexed by i, that make up each major component and n is the number of sub-components in each major component. Once values for each of the seven major components for a area were calculated, they were averaged using eq. 3 to obtain the district-level LVI:

$$LVI_d = \frac{\sum_{i=1}^{7} w_{M_i} M_{di}}{\sum_{i=1}^{7} w_{M_i}} \quad (3)$$

which can also be expressed as

$$LVI_d = \frac{w_{SDP}SDP_d + w_{LS}LS_d + w_{SN}SN_d + w_H H_d + w_F F_d + w_W W_d + w_{NDC}NDCV_d}{w_{SDP} + w_{LS} + w_H + w_{SN} + w_F + w_W + w_{NDC}} \quad (4)$$

where LVI_d is the Livelihood Vulnerability Index for district d and equals the weighted average of the seven major components. The weights of each major component W_{Mi}, are determined by the number of sub-components that make up each major component and are included to ensure that all sub-components contribute equally to the overall LVI.

In this study, the LVI is scaled from 0 (least vulnerable) to 0.5 (most vulnerable). For illustrative purposes, a detailed example of calculating the Natural Disasters major component for the LVI for one of the i is presented.[21]

Calculating the LVI–IPCC (Intergovernmental Panel on Climate Change)- IPCC framework approach: An alternative method was developed for calculating the LVI that incorporates the IPCC vulnerability definition. Table 2 shows the organization of the seven major components in the LVI–IPCC framework. Exposure of the study population is measured by the number of landslides that have occurred in the past 6 years, while climate variability is measured by the average maximum and minimum monthly temperatures and monthly precipitation over a 6-year period. Adaptive capacity is quantified by the demographic profile of a district (e.g. average income of the households), the types of livelihood strategies employed (e.g. percent of family member work in different community) and the strength of social networks (e.g. average borrow: lend money).

Table 2
Categorization of major components into contributing factors from the IPCC (Intergovernmental Panel on Climate Change) vulnerability definition for calculation of the LVI-IPCC.

IPCC contributing factors	Vulnerability major components
Exposure	Landslide vulnerability and climate variability
Adaptive capacity	Socio-demographic Profile Livelihood strategies Social networks
Sensitivity	Health Food Water

Sensitivity is measured by assessing the current state of a areas food and water security and health status. The same subcomponents outlined in table 2 as well as eqs (1) and (3) were used to calculate the LVI–IPCC. The LVI–IPCC diverges from the LVI when the major components are calculated. Rather than merge the major components into the LVI in one step, they are first combined according to the categorization scheme.[21]

Following equation:

$$CF_d = \frac{\sum_{i=1}^{n} w_{M_i} M_{di}}{\sum_{i=1}^{n} w_{M_i}} \quad (5)$$

where CF_d is an IPCC-defined contributing factor (exposure, sensitivity, or adaptive capacity) for district d, M_{di} is the major component for district d indexed by i, W_{Mi} is the weight of each major component and n is the number of major components in each contributing factor. Once exposure, sensitivity and adaptive capacity were calculated, the three contributing factors were combined using the following equation

$$LVI - IPCC_d = (e_d - a_d) * s_d$$

where $LVI–IPCC_d$ is the LVI for district d expressed using the IPCC vulnerability framework, e is the calculated exposure score for district d (equivalent to the Natural Disaster and Climate Variability major component), a is the calculated adaptive capacity score for district d (weighted average of the Socio-Demographic, Livelihood Strategies and Social Networks major components) and s is the calculated sensitivity score for district d (weighted average of the Heath, Food and Water major components). The LVI–IPCC scale was from 0 (least vulnerable) to 1 (most vulnerable).[21]

Results

LVI- Motijharna versus Batali hill: Maximum and minimum values of the vulnerabilities sub-components for both Motijharna and Batali hill area were calculated for the index standardization in eq. 1. Table 3 presents the LVI sub-component values for four major components e.g. Socio-demographic profile, Livelihood strategies, Water and Health for each area as well as the minimum and maximum values for both combined. Average number of family member for both areas is 6 ±1.31 for Motijharna and 5.77 ±1.44 for Batali hill. Percentage of head of the households who did not attended school in Motijharna is 25 and 33.33 for Batali hill. The average reported age of Motijharna household heads was 42.533 ± 11.65 and 40.317 ± 11.47 for Batali hill.

Percent of households with family member working in a different community is 65 in Motijharna and 58.33 for Batali hill found for the sub-components of livelihood strategies. In Motijharna, 70% of households use ground water and 30% reported WASA for their water consumption. On the other hand in Batali hill, 85% used ground water and only 15% used water supply. About 65% people in Motijharna reported water conflicts in their community and 71.67% for Batali hill area. Average time to reach water source in Motijharna is 5.15 ±3.29 minutes and 7.68 ±4.55 minutes for the Batali hill. Average number of liters of water stored per household in Motijharna is 78.25 liters and 65.08 liters for Batali hill.

Motijharna households reported traveling an average of 20.58 ± 6.19 min to a health facility while Batali hill households reported an average of 29.25 ±6.04 min. Chronic illness was reported by 20% of households in Motijharna compared to 21.67% in Batali hill. About 30% of Motijharna households said that a family member missed work due to illness in the past 2 weeks compared to 35% of Batali hill households.

Maximum and minimum values of the vulnerabilities sub-components for both Motijharna and Batali hill area were calculated for the index standardization in eq. 1. Table 4 presents the LVI sub-component values for four major components e.g. Social network, Food and Landslide vulnerability and Climate variability, each area as well as the minimum and maximum values for both combined.

The social networks indicators were similar for the two areas. Over 86.67% of Motijharna and Batali hill households said that they had not approached their local government for assistance in the past month. Batali hill households reported borrowing money more frequently and receiving more in-kind assistance from family and friends relative to the number of times they lend money or provided assistance in the past month than Motijharna households (borrow: lend ratio: Motijharna 0.733, Baali hill 0.887).

Average number of months households struggle to find food in each year is higher in the Batali hill than Motijharna 1.35 and 0.95 respectively. The sub-components variables for this major components are percent of households not aware of landslide as 0.067 in Motijharna and 0.150 for Batali hill. Average number of landslide past 6 years in Motijharna is 0.337 and 0.838 for Batali hill. Average number of landslide past 6 years is 0.020 for Motijharna and 0.053 for Batali hill. Average monthly minimum temperature (years: 2008-2014) for Motijharna and Batali hill is 0.746. Average monthly maximum temperature (years: 2008-2014) for both areas are 0.542. Monthly average precipitation (years: 2008-2014) for both areas is 0.229.

After each vulnerability, sub-components index standardization values of each sub –components were taken for the overall LVI for both Motijharna and Batali hill area in eq. 3. The major components (Social networks,Food, Livelihood strategies and Landslide vulnerability and climate variability) and the composite LVI for each area are presented in table 5. Overall, Batali hill households were more vulnerable than Motijharna households on the social networks component 0.877 versus 0.800 respectively. Batali hill showed greater vulnerability on the Livelihood Strategies Component 0.583 than Motijharna 0.650. Motijharna. Landslide vulnerability and Climate variability are higher in Batali hill 0.386 than Motijharna 0.289.

Batali hill were more vulnerable than Motijharna for food major components and the calculated result was 0.450 and 0.317 respectively. Overall, Batali hill had a higher LVI than Motijharna 0.4878 versus 0.3864 respectively indicating relatively greater vulnerability to climate change impacts. Food vulnerability for both area is 0.317 and 0.450 for Motijharna and Batali hill respectively.

Table 3
Livelihood Vulnerability Index (LVI) sub-components (Socio-demographic profile, Livelihood strategies, Water and Health) values and minimum and maximum sub-component values for Motijharna and Batali hill, Chittagong City Corporation area.

Major component	Sub-components	Units	Motijharna	Batali Hill	Maximum value in both areas	Minimum value in both areas
Socio-demographic Profile	Average number of family member	Count	6	5.733	9	3
	Average income of head of the households	Taka	8700	7058.33	20000	3000
	Percentage of head of the households not attended school	Percentage	25	33.33	100	0
Livelihood strategies	Percent of households with family member working in a different community	Percentage	65	58.33	100	0
Water	Percent of households with water Conflicts	Percentage	65	71.67	100	0
	Average time to collect water source	Minutes	5.15	7.68	15	0
	Average number of liters water stored per household	Liters	78.25	65.08	150	35
Health	Average time to reach health facility	Minutes	20.58	29.25	45	0
	Percent of households with chronic illness	Percentage	20	21.67	100	0
	Percent of household where family member had to miss work for past two weeks	Percentage	30	35	100	0

Table 4
Livelihood Vulnerability Index (LVI) sub-components (Social networks, Food and Landslide vulnerability and climate variability) values and minimum and maximum sub-component values for Motijharna and Batali hill, Chittagong City Corporation area

Major component	Sub-components	Units	Motijharna	Batali Hill	Maximum value in both areas	Minimum value in both areas
Social networks	Average borrow: lend money ratio	Ratio	1.6	1.83	2	0.5
	Percent of households that have not gone to their local government for assistance in the past 12 months	Percentage	86.67	86.67	100	0
Food	Average number of months households struggle to find food	Months	0.95	1.35	3	0
Landslide vulnerability and climate variability	Percent of Households not aware landslide	Percentage	6.67	15	100	0
	Average number of landslide past 6 years	Counts	1.35	3.35	4	0
	Percentage of house affected by landslide	Percentage	8.33	13.33	100	0
	Average number of households with an injury or death as a result of recent landslides	Counts	0.06	0.16	3	0
	Average monthly minimum temperature (years:2008-2014)	Celsius	21.65	21.65	26	8.9
	Average monthly maximum temperature (years:2008-2014)	Celsius	30.96	30.96	36	25
	Monthly average precipitation (years: 2008-2014)	Milimeters	291.31	291.31	1268	1

LVI–IPCC- Motijharna versus Batali hill: LVI-IPCC for Batali hill showed least vulnerability to climate change. The calculated result shows the adaptive capacity, sensitivity and exposure level for Batali hill area. The adaptive capacity found in Batahi hill was 0.5605 and sensitivity found in both areas was 0.4976 for Batali hill. The exposure level of the IPCC contributing factors Batali hill was 0.386 .

Batali hill is vulnerable than Motijharna for the seven major components overall LVI framework. The major vulnerability components presented in figure 3 show the vulnerability spider diagram for the both areas respectively.

From the spider diagram, it was found that Batali hill is more vulnerable for the health major components than Motijharna. Socio-demographic profile and water major components for the both areas are almost the same although Batali hill is slightly vulnerable than Motijharna. Batali hill is also vulnerable for the landslide vulnerability and climate variability. Food, social networks and livelihood strategies are major components for both areas. Batali hill is vulnerable than Motijharna. The scale of the diagram ranges from 0 (less vulnerable) at the center of the web, increasing to 0.5 (more vulnerable) at the outside edge in 0.1 unit increments. A vulnerability spider diagram is given for the two areas.

Adaptive capacity, sensitivity and exposure are the major IPCC contributing factors for both areas. The major IPCC contributing factors are present in figure 4 that indicates Batali hill is vulnerable to climate change than Motijharna.

Adaption capacity for both areas are almost the same. For the sensitivity and exposure level of IPCC contributing factor for both areas, Batali hill is more vulnerable to climate change than Motijharna. A vulnerable triangle for the IPCC contrisbuting factors figure is given.

Table 5
Indexed sub-components, major component (Social networks, Food, Livelihood strategies and Landslide vulnerability and climate variability) and overall LVI for Motijharna and Batali hill.

Sub-component	Motijharna	Batali hill	Major component	Motijharna	Batali hill
Average borrow: lend money ratio	0.733	0.887	Social networks	o.800	0.877
Percent of households that have not gone to their local government for assistance in the past 12 months	0.867	0.867			
Average number of months households struggle to find food	o.317	0.450	Food	0.317	0.450
Percent of Households not aware landslide	0.067	0.150	Landslide vulnerability and Climate variability	0.289	0.386
Average number of landslide past 6 years	0.337	0.838			
Percentage of house affected by landslide	0.083	0.133			
Average number of households with an injury or death as a result of recent landslides	0.020	0.053			
Average monthly minimum temperature (years:2008-2014)	0.746	0.746			
Average monthly maximum temperature (years:2008-2014)	0.542	0.542			
Monthly average precipitation (years: 2008-2014)	0.229	0.229			
Percent of households with family member working in a different community	0.650	0.583	Livelihood strategies	0.650	0.583
Overall LVI for Motijharna=0.3864 Overall LVI for Batali hill =0.4878					

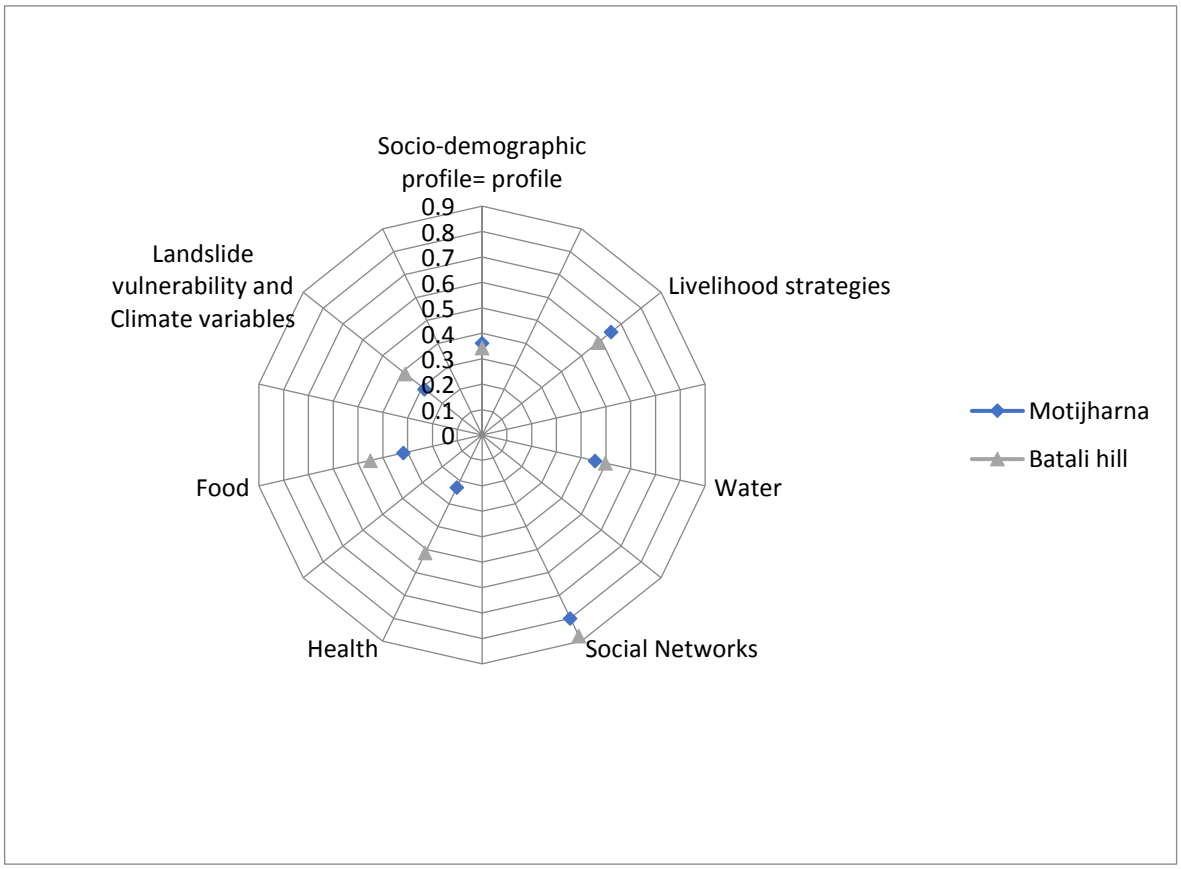

Figure 3: Vulnerability spider diagram of the major components of the Livelihood Vulnerability Index (LVI) for Motijharna and Batali hill areas, Chittagong City Corporation

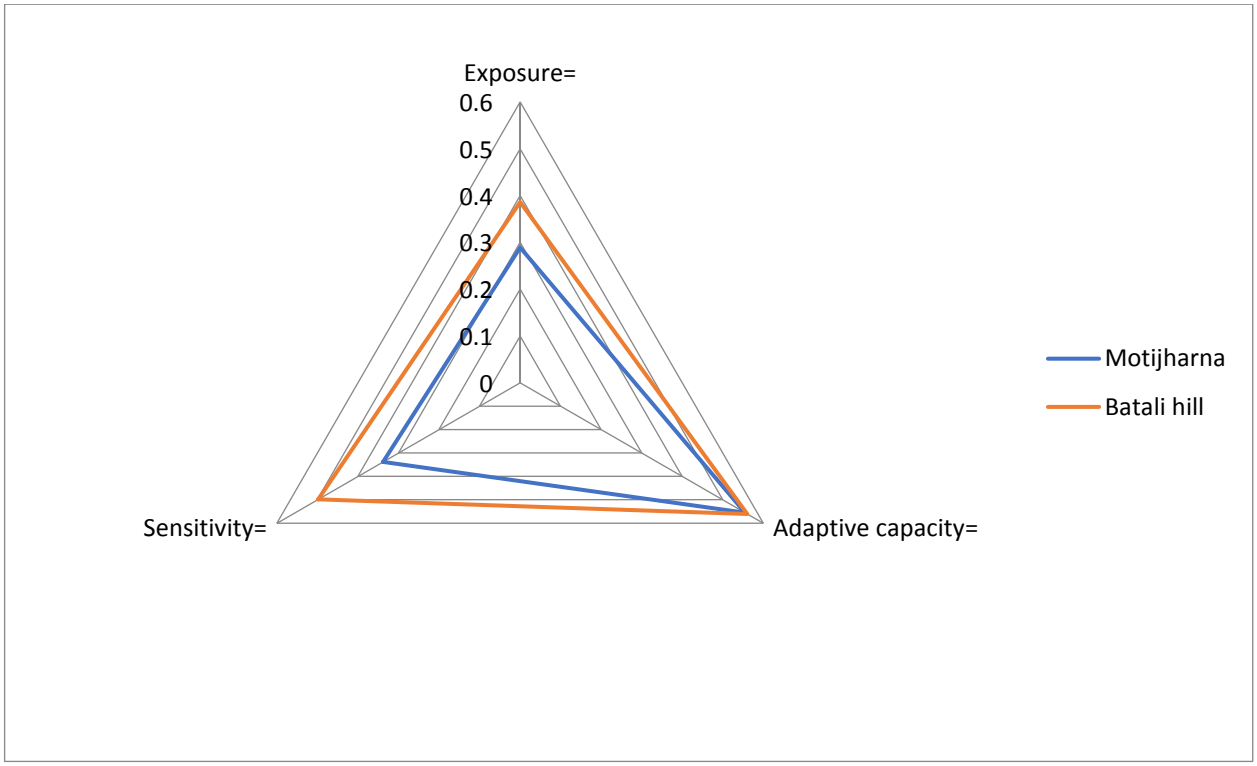

Figure 4: Vulnerability triangle diagram of the contributing factors of the Livelihood Vulnerability Index-IPCC (LVI–IPCC) for Motijharna and Batali hill areas, Chittagong City Corporation

Discussion

Socio-demographic profile is more vulnerable in the Batali hill than Motijharna area.From the survey question it was found that income in slightly high in the Motijharna. Illiteracy rate is high in the Batali hill area. Number of family member is also high in Batali hill area. In both areas, maximum heads of the households have low income and high illiteracy rate than any other place in the CCC area.

Lanslide vulnerability and climate variability are more vulnerable in Batali hill than Motijharna. Landslide awareness is also low in the Batali hill area. Number of landslide occurrence is more in Batali hill than Motijharna. Though landslide occurrence is more in Batali hill, so injury or death rate is vulnerable to Motijharna. Though these two areas are located very closely, their average maximum and minimum temperature are same and precipitation is also the same from 2008- 2014.

Household characteristics contribute most to climate change vulnerability in each respective area. These in turn might be programmed for community assistance. For example, from the field survey it was observed that both areas used plastic container to store water as the water is not available for every day and some people living in these area have to buy water from the owners of the house. From the two areas, water conflicts are more vulnerable in Batali hill than Motijharna.

Livelihood strategies are more in the Batali hill than Motijharna area. From the survey questionnaire, it was found that about 65% people in the Batali hill work in different communities. On the other hand, Motijharna was 58%. Most of the people in these area work in Garments, Community center, Railway, Restaurants and other respective areas.

Food major components are also vulnerable in Batali hill than Motijharna. From the survey question, Batali hill people reported maximum 3 months in a year they struggle to find food than Motijharna. Batali hill households reported a longer average time to health facilities and a higher prevalence of chronic illness. The high percent of people who were so sick in the past 2 weeks that they had to miss work in compared to the percent in Batali hill. These findings suggest that diseases may have a negative impact on household income by limiting the number of healthy work days.

For the social networks major components, the borrow money:lend money ratios were created to measure the degree to which households rely on family and friends for financial assistance and in-kind help. It is found that a household that receives money or in-kind assistance often but offers little assistance to others is more insecure and vulnerable compared to those with excess money and time to help others. The finding that Batali hill households had higher borrow:lend ratios may be related to the higher proportion than Motijharna. Percent of households that have not gone to their local government for assistance in the past 12 months is also vulnerable in Batali hill than Motijharna.

Adaptive capacity, sensitivity and exposure are the major IPCC contributing factors for both Motijharna and Batali hill

area. Due to the low income and high illiteracy, rate adaption strategies are low in both areas. Adaptive capacity of Batali hill households resulting from demographic imbalance and high percent , adaptation practices such as livelihood diversification and food and water storage decreased overall LVI–IPCC score. It is possible that these strategies will only be able to compensate for climate changes within a narrow band of possible climate variation. Although Motijhrnaa households did not report similar adaptation strategies, they also did not report the same demographic pressures, livelihood strategies and social networks. Exposure and sensitivity are also vulnerable in Batali hill than Motijharn where both the areas are less vulnerable to climate change.

Conclusion

Chittagong City is a developing city. Every year a number of people are heading to Chittagong in search of work and a great number of people set their living in the Motijharna and Batali hill area. These two areas are vulnerable to landslide. Every year during rainy season, these two areas are always vulnerable to landslide occurrence. From landslide vulnerability, Batali hill is more vulnerable to Motijharna and landslide occurrence is also more in the Batali hill area. IPPCC contributing factors to climate change are high in Batali hill than Motijharna. Though these two areas are least vulnerable to climate change but in future, vulnerability may be increased if necessary steps are not taken into consideration.

The Government and other NGOs should take some necessary steps to minimize the landslide occurrence from these two areas. Besides for the occurrences of landslides in these areas, the Chittagong City Corporation and The Department of Environment (DoE) are blaming each other. In this circumstance, implementation of some immediate risk reduction measures is suggested to save more lives.

Recommendations

- People living in hills remove soils from the hills to create shelters for their livelihood. The Govt. should take the rehabilitation programmes to remove them from the risky zone of landslide in rainy season.
- Measures to reduce climate-related risks like landslide need to be integrated into urban planning. In this regard, as per the research, urban stakeholders including government departments, private sector organizations and individuals have particular roles for ensuring compliance with land use policy, so that landslide risks are addressed when housing structures are built on hillsides.
- Mass media and print media should increase their encouragement to make people conscious about the adverse effect of landslide.
- Promotion of landslide education as a part of overall disaster awareness, education and training is essential at all levels.
- Law and regulations related to brick burning and building constructions as well as environment should be changed and updated.

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