

Assessing Social Vulnerability to Landslide Disasters in Chittagong City, Bangladesh

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ABSTRACT

Landslides have emerged as recurring natural hazards in the hilly districts of Bangladesh. Chittagong, the port city of Bangladesh, has been on the record for devastating landslide events causing the loss of lives and properties. This study aims to investigate the socio-economic aspects, risk perception, and coping mechanisms to landslide disasters of the local inhabitants in Chittagong. Golpahar community, one of the most landslide vulnerable sites of the city, has been selected as a case study. Both quantitative and qualitative techniques were applied, namely household-based questionnaire survey, participatory rural appraisal techniques, and expert opinion survey. The community people of Golpahar identified the vulnerable locations inside their locality and suggested potential ways to reduce landslide vulnerability. Results show that social vulnerability was high because of a large number of poor people living in temporary housing constructed near risky slopes of the hills. Landslides may be triggered by heavy rainfall during monsoon on slopes already rendered vulnerable by hill cutting and deforestation.

Keywords: landslides, participatory rural appraisal, social vulnerability, Bangladesh.

1. INTRODUCTION

Bangladesh is a low-lying floodplain area of Ganges-Brahmaputra delta in South Asia. Although most portion (82%) of it is flat land (flood plains), a significant part (18%) of it in the North-East and South-East contains hills. Because of the geographical location, Bangladesh experiences a significant amount of monsoon rainfall (~4000 mm/year) among the South Asian countries (Shahid, 2010). Bangladesh is highly vulnerable to different natural hazards including flood, cyclone, landslide, drought, and earthquakes. 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. Although earthquakes are not that frequent, the earthquake risk is also high (Al-Hussaini et al., 2012). Such earthquakes can also trigger landslides.

In recent years, rainfall-induced landslides have become one of the regular geological hazards in the Chittagong Hill Districts region causing loss of lives and property (Sultana and Tan, 2021; Alam, 2020). Chittagong is the largest port city and second largest city of Bangladesh, playing a major role in the economic development of Bangladesh. Landslide occurs frequently in the hilly regions of Chittagong (Figure 1) due to extreme uninterrupted monsoon rainfall and existence of other social vulnerabilities among the hilly communities (Ahmed, 2021). The devastation aggravates along with weak structure, unplanned and erratic use of hills and settlement development (Ahmed et al., 2018; Alam and Ray-Bennett, 2021; Rahman et al 2016). Because of its favorable geographical location and easy accessibility for regional and international trade, the city has developed as an important commercial hub for the country. As a result, population density has been increasing at a fast pace and demand of land is going up. To meet the housing demand of the increasing population, a section of people has occupied vacant government and privately owned land both legally and illegally; and built informal settlement without following any rules and regulation (Engineer Ali Ashraf, Expert Opinion Survey, 2014). A significant number of landslide hazard locations exist in those urban areas which may result in severe damages and socio-economic losses in the event of a landslide (Rahman et al, 2017, Rabby and Li, 2020). The characteristics of soft sedimentary and unconsolidated rocks in the hilly terrains, soil structure, steep slopes created by hill cutting, and indiscriminate deforestation across the hilly areas make the slope unstable as a consequence causing fatal landslides during heavy rains (Ahmed et al, 2018, CDMP-II, 2012).

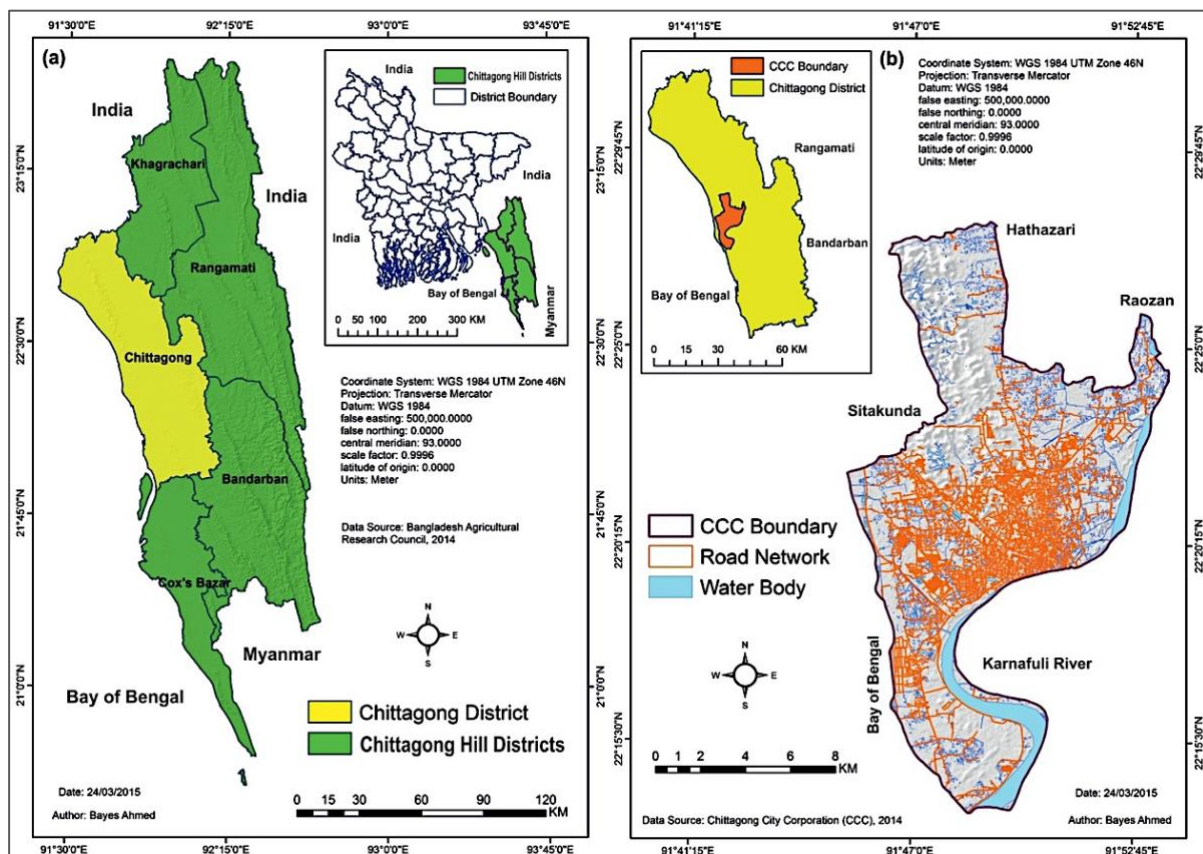


Figure 1. Location of the (a) Chittagong Hill Districts in Bangladesh, and (b) Chittagong City Corporation (CCC) where landslides occur frequently. *Source: The authors, 2015.*

Every year a number of landslides occur 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. Statistics show that since 2000 landslides have

caused death of more than 300 people in Bangladesh, with loss of hundreds of houses and million dollars of properties (Ahmed et al., 2018, Sarwar, 2008; Sultana, 2020). The rapid and unplanned urbanization with adverse climatic variation (more intensive rainfall) increases the landslide risk in this region (Sultana 2020, Huq et al., 2017). Comprehensive Disaster Management Programme-II (CDMP-II, 2012) has identified the major probable causes for landslide in Bangladesh which involves: removal of lateral support, increase of load on the slope, earthquake, removal of underlying support, and anthropogenic activities such as jhum cultivation.

The development authorities of Chittagong have identified 30 risky hills in this city, locally known as Motijharna, Lalkhan Bazar, Tankir Pahar, Batali Hill, Golpahar, AK Khan Pahar, etc. (Chakraborty & Uddin, 2014). In these areas, people are living at the toe and on the slopes of hills with high risk of landslides and associated damages. For example in June 2007, monsoon started with unprecedented heavy rainfall, intensified by a storm from the Bay of Bengal. The heavy rain caused mudslides, which overwhelmed slums in the foothill areas of the large city of Chittagong on 11th June 2007. The death toll was reported to be at least 128, including 59 children, and more than 150 people were injured (Sultana, 2020).

In most cases, landslide disasters have been scrutinized in physical science perspective (Emberson et al., 2021; Ahmed et al., 2018). However, the implications of landslides on social life of people are essential to look at, to reduce the social vulnerability to landslide events. Social vulnerability refers to the socio-economic and demographic factors that affect the resilience of communities (Cutter et al., 2003). Studies have shown that in disaster events the socially vulnerable are more likely to be adversely affected, i.e., they are less likely to recover and more likely to die. Effectively addressing social vulnerability decreases both human suffering and the economic loss related to providing social services and public assistance after a disaster (Barry et. al., 2021).

Inventory of landslides under Chittagong City Corporation (Rahman et al, 2016) reveals 57 landslide locations in 30 years. Golpahar is one of them with high population density compared to other areas (Ahmed et al 2014). It is important to understand human adaptation to landslide risks under the condition of rapid urbanization. A socio-economic survey was conducted in the Golpahar area to assess the social vulnerabilities of the population living with landslide risk. This chapter presents the results of the survey and its implications.

2. SURVEY METHODOLOGY

This survey aims to understand the socio-economic context of people living in the landslide vulnerable areas, causes and effects of landslide vulnerability on their life, community's real-life experience with the landslide disaster and land slide risk management strategies followed by the community. A vulnerable hilly site Golpahar in Chittagong city has been selected for the socio-economic study. The study has two broad objectives: (a) to study the socio-economic aspects of the people in the Golpahar area, and (b) to analyze the landslide risks, vulnerability and the coping strategies followed by the local people. This study used both quantitative and qualitative data which were gathered from primary and secondary sources. The fieldwork was conducted between July and September 2014. The trained survey team maintained all the necessary ethics approval, local level permissions, consent, translations and risk assessment. Quantitative information is collected by applying a household questionnaire survey based on a random sampling survey method. A total of 114 households were selected for standardized questionnaire surveying. All the respondents of the survey were above 18

years old. To collect the qualitative information, participatory rural appraisal (PRA) methods (Chambers, 2008; Kumar, 2002) and expert opinion survey techniques were used. Five PRA tools namely Social and Resource map, Timeline, Venn diagram, Vulnerability Map, and Dream map were applied to gather the qualitative information. Expert opinion survey was conducted to triangulate the results found from surveys. Secondary data were collected from different organizations like the Department of Environment, Chittagong Development Authority, and Ward Commissioner's Office.

3. STUDY AREA PROFILE

3.1 Historic profile of the Golpahar area

Golpahar area became populated in the 1970s and 1980s. In this period, commercial activities significantly increased. A remarkable fire hazard took place in this period. Later, NGOs and other organizations came to this area raising awareness among people on different health issues and hazard management. Landslide event was first experienced by the people of this area in the 90s. After this incident, utility facilities and roads in this area were improved. After 2000, schools and NGO's were established in this area (PRA Survey, 2014).

3.2 Socio-physical characteristics

Socio-physical characteristics of the Golpahar area are studied by analyzing its social and geographical contexts. Figure 2 presents a social and resource map of the area. This area is surrounded by hills and people use these hills for vegetation and wood. There are some open spaces and big grave yard in this area. Water bodies are at some distance. These resources are useful for the communities during any type of disaster.

There is a retaining wall along the side of the hill to protect a part of the area from landslide hazards. There are some social institutions in this area, two schools, one mosque, and one madrasha. One pharmacy is located along the side of the main road. There is a water tank at the side of the main road to provide water to the local people. A few commercial shops are seen along the side of the main road. There are residential settlements located around every portion of this area and these settlements are weakly constructed with materials like bamboo, tin, and brick.

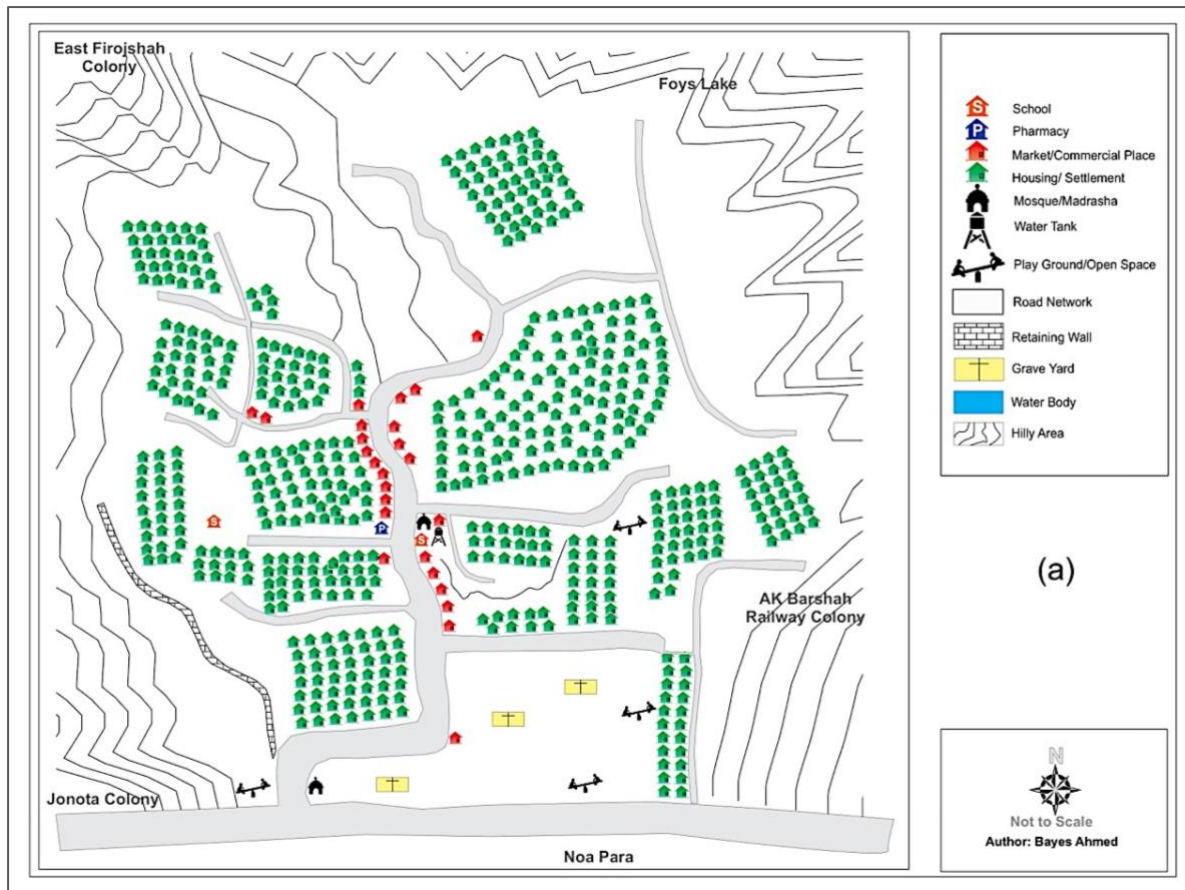


Figure 2. Social and resource map of Golpahar community in Chittagong City Corporation.
Source: Community people, fieldwork, July–August 2014.

To understand the landslide vulnerability of the Golpahar area from its geographical perspective, the physical characteristics of this area have been investigated by a strong PRA tool: Transect Walk. The findings from this tool suggest that in the West-East direction houses are located on the slope of the hills. Many houses are located on the top of the hills (Figure 3a). Stairs (by cutting hills) are used for the movement of people. Along with residential settlements, commercial structures are also seen in both directions. Structures' height varies from single to three stories (Figure 3b). The development of multi-storied buildings at different levels of the slope of the hills makes this community highly vulnerable to landslide disaster which may have multifaceted effects on the life of people.

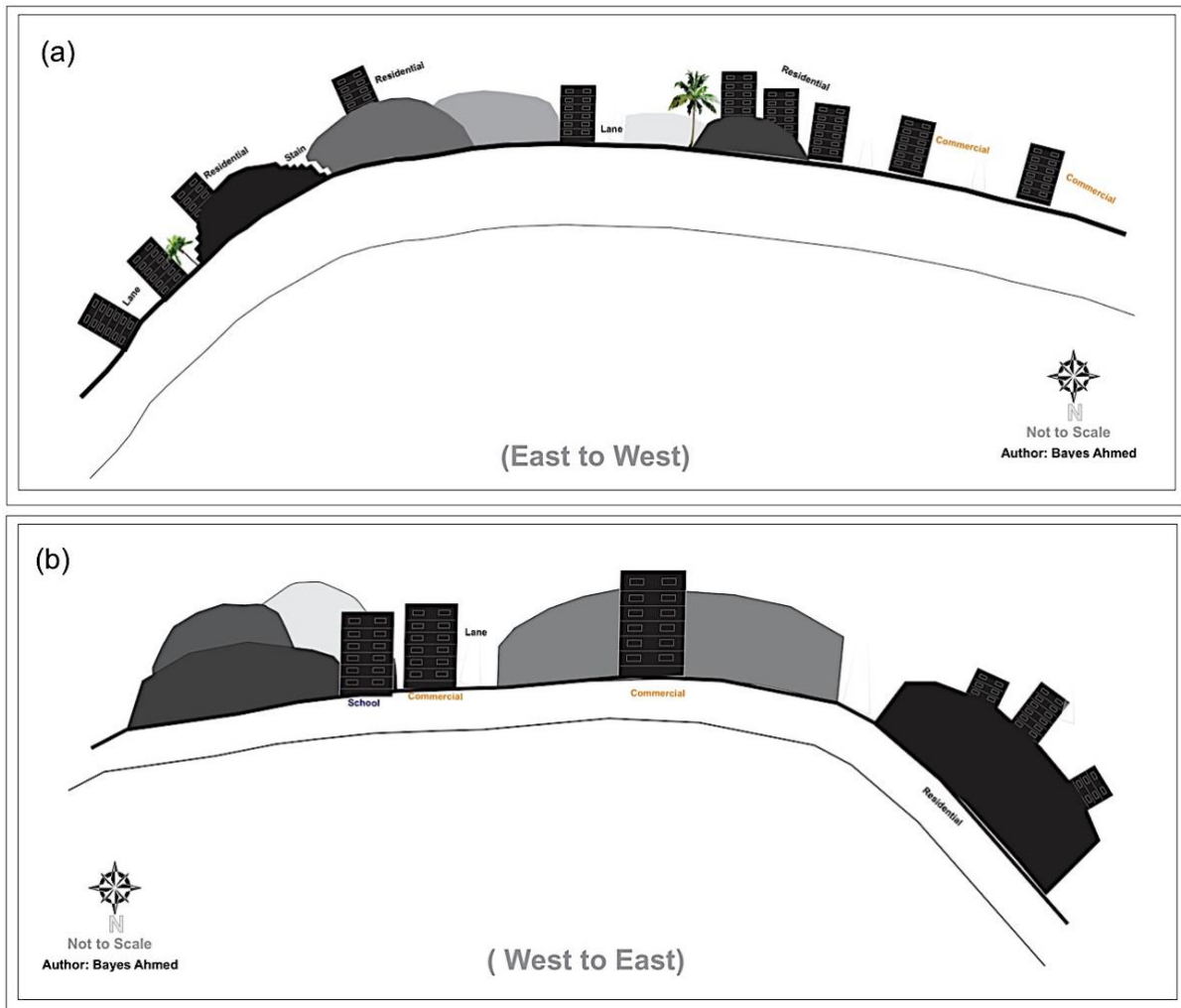


Figure 3. Transect map of Golpahar community, Chittagong City Corporation. *Source: Community people, fieldwork, July–August 2014.*

Therefore, it is evident from the socio-physical characteristics of the Golpahar area that the geographical attributes of this site make this community primarily vulnerable to landslides. Additionally, the weak settlement structures, handful of social institutions, and no other important organizational resource in the community make the community socially vulnerable to the landslide disaster.

3.3 Institutional context associated to landslide vulnerability

During any landslide event, it is of crucial importance to get immediate assistance from the local institutions and such help from institutions reduces the landslide vulnerability of a community. To identify such institutions and to understand the relationship between various institutions and the Golpahar community with a view to assessing the social vulnerability of the Golpahar community, the Venn Diagram tool is applied (Figure 4). The findings from this tool are categorized as following according to the nature of the relationship between the institutions and the community.

Institutions having two-way strong interaction: Venn Diagram study suggests that UNDP school, Golpahar Baitul Mamur Jame Mosque, and UNDP office are the institutions that have a great influence on the Golpahar community. These institutions have two-way strong

interaction with the community. Occasional health campaigns are organized by UNDP in the school premises and through this events, local people get socially connected with the school. Two-way strong interaction between this community and the school exists. These health campaigns are supported by Al-Amin Hospital. There exists a one-way strong interaction between UNDP School and Al-Amin Hospital. Golpahar Baitul Mamur Jame Mosque is located 0.2 km away from the community. People attending the mosque get mike-announcement of probable landslide from the mosque and this is why people find mosque an important institution of the community that helps before and after the landslide. UNDP representatives visit this area and make people aware of hazards and diseases.

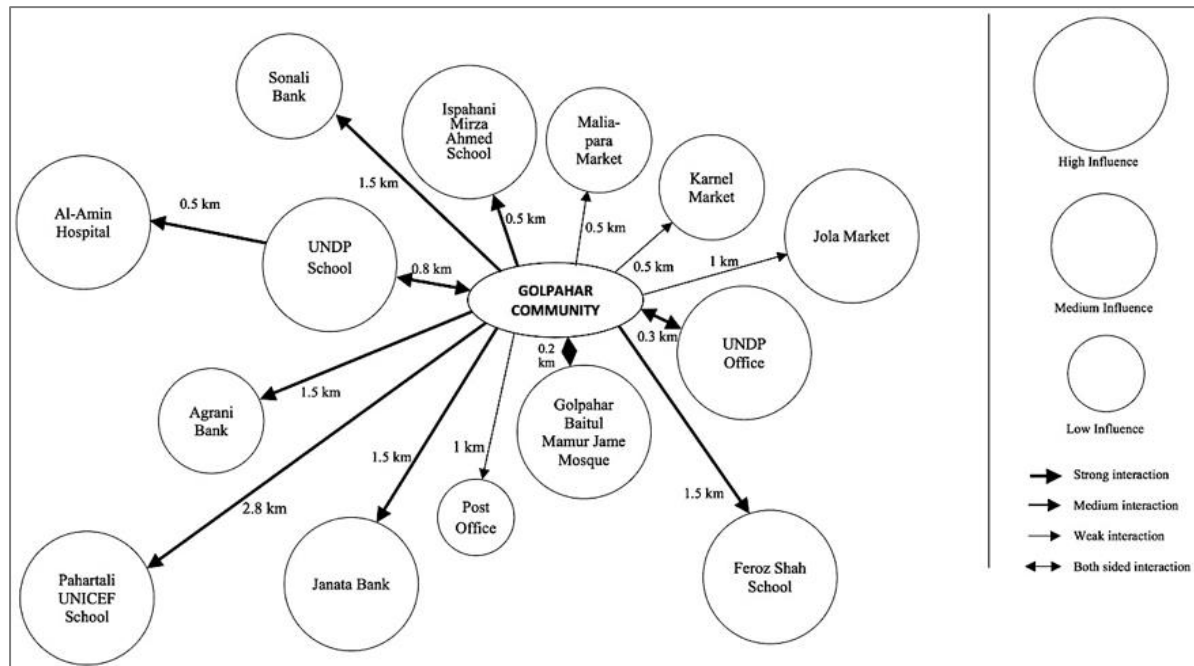


Figure 4. Interaction between institution and the community people of Golpahar area, Chittagong City Corporation. *Source: Community people, fieldwork, July–August 2014.*

Institutions having one-way strong interaction: Janata Bank, Agrani Bank, UNICEF School, Ispahani Mirza School, and Feroz Shah School are some institutions that have one-way strong interaction with the community. Both Janata Bank and Agrani bank is located within 1.5 km of the Golpahar community. Janata Bank has a higher influence on the community people than Agrani bank. These banks provide local people access to a financial resource which is highly essential after any landslide event. Schools such as UNICEF School, Ispahani Mirza School, and Feroz Shah School have a high influence on the community. These schools are located 0.5-1.5 km from the community.

Institutions having one-way weak interaction: Post office, Malia para haat, Karnel haat, and Jola haat are few institutions that have one-way weak interaction with the community. The post office is located within 1 km in this area. But people use this post office rarely. Malia para haat, Karnel haat, and Jola haat are used as commercial market places. Interaction of community with these institutions is one-way and weak. People of the Golpahar have the least opportunity to get benefited from these institutions during any landslide event.

4. SOCIO-ECONOMIC ASPECTS

In this study, the social context of the inhabitants in the Golpahar area has been investigated, which has a significant influence on the landslide vulnerability of the people. To investigate the intensity of landslides, their effect, social vulnerability, and coping strategy of the people, an intensive survey has been conducted in the form of individual household surveys and PRA tools. The findings discussed in this part is based on the respondents' opinion who reside in the Golpahar hilly area.

A large portion (about 40%) of the respondents in the Golpahar area are illiterate. Besides, a significant number of respondents have education only up to primary or secondary school level. Due to lack of education, they work as a day laborer, employee, shopkeeper, rickshaw puller, or garments worker. According to the individual household survey in 2014, the average monthly household income of the inhabitants is between BDT 5001- BDT 15000 (1 USD $\approx$ 80 BDT). But they need to spend all their earnings to survive in the Golpahar area. Because of the poor economic condition, the people have no choice but to live here. Most of them work in nearby areas. According to the statistics, approx. 47% of people do not need to travel for work as they have a job inside the Golpahar area (Figure 5a).

In Golpahar, most of the inhabitants have migrated from other areas for better living. The migrated people make their houses on the slopes and top of hills (Figure 6). Analysis shows that more than 95% of people use the hills for their shelter (Figure 5-b). Among them, 57% do not pay the rent as they live in illegal housing. However, most of the inhabitants in the Golpahar area suffer due to poor condition of roads, drainage and gas facilities (Figure 7). According to the residents, roads are narrow and muddy. 97% of people claimed that they had no gas supply in their houses. On the other hand, they were satisfied with the existing sanitation and electricity facility (Figure 7b). According to the people, the school, market, and bank are located within 1km of the area. But unfortunately, there is no playground or health care center in this area. From their socio-economic perspective, it is obvious that low living cost is the main factor which attracts the poor people to reside in the vulnerable hilly areas in Golpahar. The soil in Golpahar is mostly sandy, therefore, it becomes very unstable and highly susceptible to landslides during heavy rain (Engineer Ali Ashraf, Expert Opinion Survey, 2014).

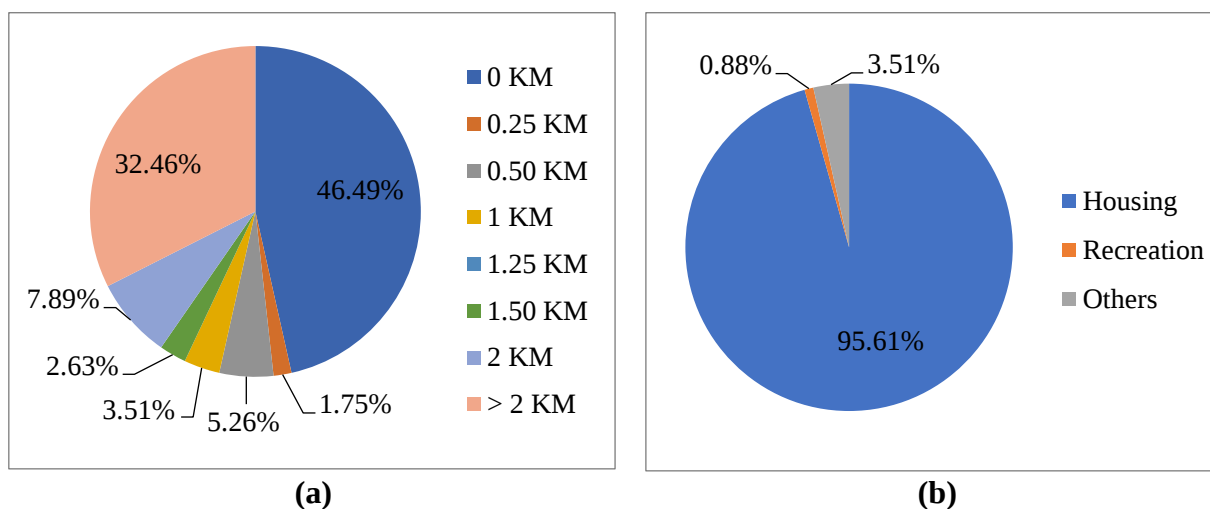


Figure 5. (a) Distance to workplace from home, and **(b)** usage of hills for different purposes in Golpahar community, Chittagong City Corporation. *Source: Field Survey, 2014.*



Figure 6. Housing of the local inhabitants in Golpahar area under Chittagong City Corporation, Bangladesh. *Source: Field Survey, 2014.*



(a)



(b)



(c)

Figure 7. (a) Roads and drainage, (b) sanitation, and (c) and social organizations in Golpahar hill community under Chittagong City Corporation. *Source: Field Survey, 2014.*

5. LANDSLIDE SCENARIO AND PEOPLE'S RESPONSE

Landslide is an everyday challenge for the people residing in the Golpahar area. In this study, the real-life experience of the inhabitants of the landslide has been investigated. The respondents have shared their experience of landslides and their coping mechanisms with it. They also identified the causes and effects of landslides through cause-effect diagram which is a useful PRA tool to identify the causes and effects of an event.

5.1 Experience of previous landslides

During the individual questionnaire survey, the respondents have been asked about their last landslide observance. Most of the respondents (approx. 60%) have observed last landslide in recent years 2005 to 2014 (Figure 8). There are several causes behind landslides in the Golpahar area and negative consequences of the disaster in the life of the people residing here. Through using the PRA tool: Cause-effect Diagram, a group of local people identified the causes and effects of landslide vulnerability in their life (Figure 9). The respondents identified high precipitation and illegal hill cutting as the main triggering factors of landslides.

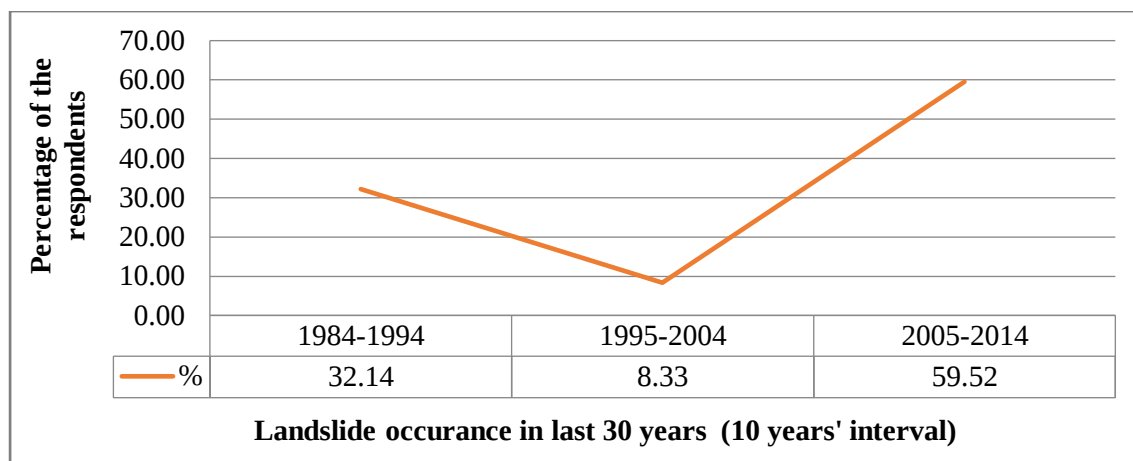


Figure 8. Respondents' landslide observance in the past 30 years. *Source: Field Survey, 2014.*

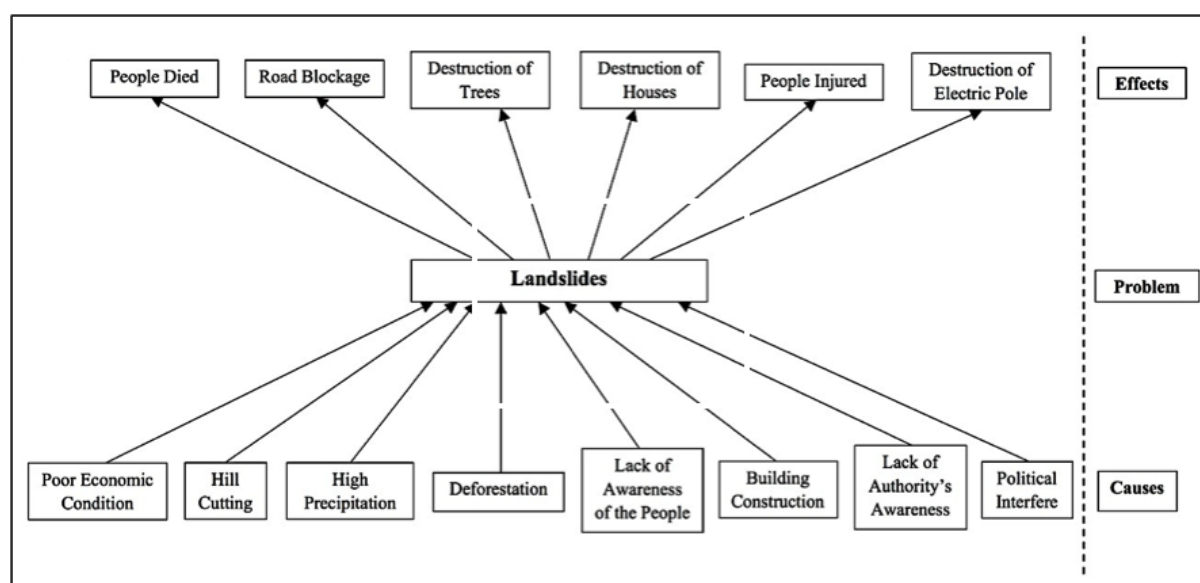


Figure 9. Cause effect analysis for landslide vulnerability in Golpahar area under Chittagong City Corporation. *Source: Community people, fieldwork, July–August 2014.*

Besides, they have also pointed out some severe negative impacts of landslides on the community people. According to the respondents, landslides have been occurring in this locality since 1992 and it has caused severe damages to the lives and properties of the inhabitants (Table 1).

Majority of (approx. 53%) respondents have mentioned the landslide as a serious problem (Figure 10a). About 45% of the respondents think that the most vulnerable to landslides are the one who live near the hills (Figure 10b). The respondents also noticed that most of the previous landslides have occurred in the early morning and at that time most of the people (89%) were inside their houses (Field Survey, 2014). During landslide occurrence, most of the respondents (74%) did not take any step to help the landslide victims. According to the field survey, only 25% of the residents participated in rescuing people. Interestingly, it has been found that 14 respondents were affected by the previous landslides, but still living in the same place for low living costs.

Table 1. Intensity of causes and negative impacts of landslides in Golpahar area.

Causes of landslide	Number of respondents	%	Negative impact of landslide	Number of respondents	%
Hill cutting	11	9.82	House destroyed	7	6.42
Deforestation	1	0.89	Property damaged	3	2.75
High precipitation	50	44.64	Road blocked	6	5.50
construction of road/structure	2	1.79	People died	3	2.75
Hill cutting and high precipitation	33	29.46	People injured	1	0.92
Hill cutting and residential use	2	1.79	Damage of utility facilities	0	0.00
High precipitation and residential use	2	1.79	House destroyed and property damaged	16	14.68
Hill cutting, high precipitation and residential use	9	8.04	House destroyed, property damaged and people died	35	32.11
Others	2	1.79	house destroyed, property damaged, people died and people injured	35	32.11
-	-	-	Others	3	2.75
Total	112	100		109	100

Source: Field Survey, 2014.

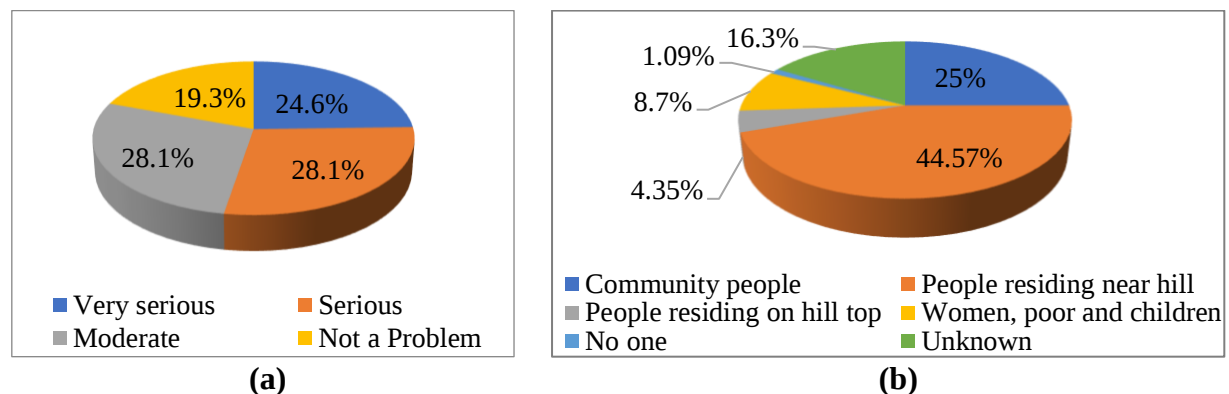


Figure 10. (a) Intensity of landslide as a problem, and **(b)** people vulnerable to landslides in the Golpahar community. Source: Field Survey, 2014.

5.2 Landslide risk management and coping mechanism

According to Engineer Ali Ashraf (Expert Opinion Survey, 2014), heavy rain for consecutive 4-7 days during the monsoon season is one of the main triggering factors of landslide occurrence. The respondents have their opinion about the positive and negative impacts of monsoon rain in their day-to-day life. The positive and negative impacts of monsoon rain are shown in Table 2. According to the respondents, the monsoon rain is a blessing to their life in many ways. On the other hand, its adverse effects include damage to roads, waterlogging, landslides, and surface runoff.

Table 2. Respondents' opinion regarding positive and negative impacts of monsoon rain.

Positive impact of monsoon rain	Number of respondents	%	Negative impact of monsoon rain	Number of respondents	%
Water Collection	26	22.81	Damage of road	48	42.11
Washing and Bathing	11	9.65	Water logging	10	8.77
Cleaning of Drain and Road	1	0.88	Landslides	21	18.42
Water collection, washing and bathing	2	1.75	Road damage and landslide	13	11.40
	-	-	Surface runoff	1	0.88
No Impact	73	64.04	No impact	16	14.04
Others	1	0.88	Others	5	4.39
Total	114	100	Total	114	100

Source: Field Survey, 2014.

Whenever there is heavy rain in the Golpahar area, there is a possibility of landslide occurrence. Therefore, people are moved to another shelter for the time being. From the household survey, it is found that only 16% of the respondents are relocated from their usual living places during the monsoon rainfall. The respondents know about the landslide information mainly by announcement through mike from City Corporation authority. More than 94% of respondents stay at their houses even after getting the warning. Around 84% of the respondents do not have the contact number of the nearest fire service/ police station/ volunteer groups/ emergency services/ relevant agencies for emergency purposes. The lack of awareness and preparedness makes them more vulnerable during the landslide. According to the local people, there is a landslide voluntary committee in the Golpahar area. They are Commissioner Group, DSK, and some unknown organizations. During past landslide events, emergency services have been mainly provided by the police, fire service, community groups, City Corporation officials, NGOs, and neighbors (Table 3). Though more than half of the respondents are satisfied with the rescue effort, a large portion of them is dissatisfied with the rescue effort. The causes behind dissatisfaction include late response and shortage of equipment (Table 3).

Survey results reveal that majority of relocated people (75%) take shelter in their relative's or neighbour's house and the rest (25%) are relocated to nearby schools provided by the Chittagong City Corporation. The people did not express any objection about the emergency shelter, rather, most of the respondents said that they can stay in the relocation place as long as they wish if there is heavy rainfall. The City Corporation, Government organizations, and Ward Commissioner provide some incentives like money, food, and cloth to the people relocated in the emergency shelter. But still, they struggle to earn their bread and start a new journey from the scratch.

Table 3. Organizations offering the emergency services in Golpahar area and the causes of dissatisfaction to their rescue effort.

Emergency service offering organization	Number of respondents	%	Causes of dissatisfaction to the rescue effort	Number of respondents	%
Neighbors	31	27.19	Inefficient roadway	4	3.7
Community groups	10	8.77	Late response	46	40.74
Volunteers (DSK, Commissioner Group)	2	1.75	Lack of proper attention	8	7.41
Fire service	7	6.14	Low efficiency	4	3.7
City corporation councils	20	17.54	Shortage of equipment	21	18.52
Non-government organization (NGO)	10	8.77	No answer	30	25.93
Police and fire service	1	0.88	-	-	-
Police, fire service, community groups and city corporation	29	25.44	-	-	-
Others	1	0.88	-	-	-
Unknown	3	2.63	-	-	-
Total	114	100			100

Source: Field Survey, 2014.

5.3 Landslide vulnerability and people's aspirations

The people of the Golpahar area have experienced landslide hazards. Many social problems also exist in this area which makes it vulnerable to different natural and manmade disasters. It is necessary to identify vulnerable locations of the area so that the local people can take appropriate measures beforehand to mitigate the risks of landslides and other hazards. For this, a vulnerability map has been prepared by involving the community people through a participatory approach. Hills are located mostly in the northern and eastern portions of the Golpahar area. The settlements located at the downslope of the hills, along the side of the road (on the north-western portion of the area) have been found to be vulnerable to the landslide.

Despite living with many social problems and landslides, the people of the Golpahar area have some hopes and aspirations to improve their social and economic condition. A dream map of the study area has been produced to get an idea about the dreams and aspirations of people regarding their area. They mentioned several facilities which they want to be developed in this area. Establishing a water tank was their first priority as the water crisis is very severe in the Golpahar area. Besides, they proposed to establish schools, madrasa, medical facilities, playgrounds, and a planned settlement in this area (Figure 11). Moreover, the respondents gave some suggestions to reduce the risk of landslides in the Golpahar area, based on their experience of living with a landslide for so many years. They mentioned permanent relocation of people, awareness-raising, stopping hill cutting, constructing retaining walls, tree plantation as the measures to take in this regard (Table 4).

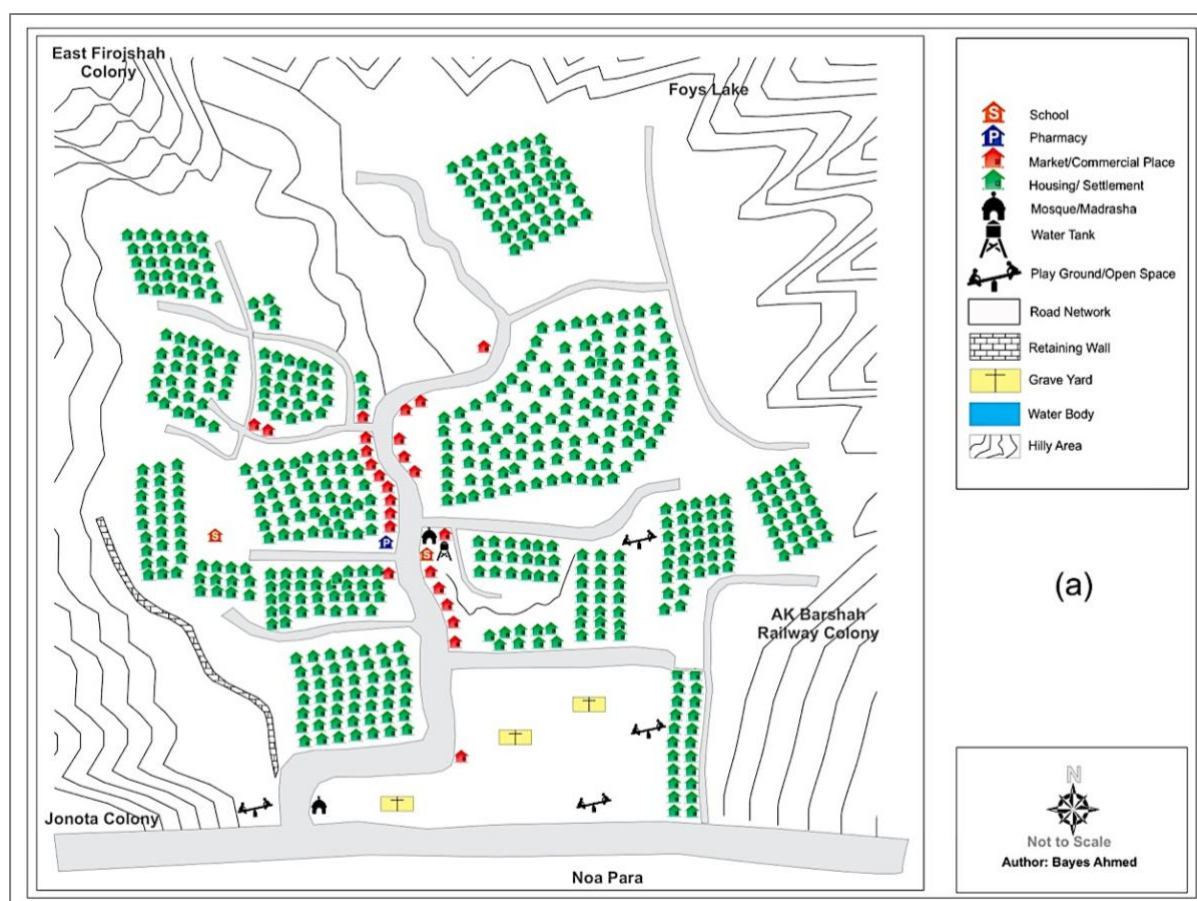


Figure 11. Dream Map of the Golpahar hill community under Chittagong City Corporation.
Source: Community people, fieldwork, July–August 2014.

Table 4. Respondents' suggestion towards landslide risk reduction process.

Landslide risk reduction process	Number of respondents	Percentage
Relocation of people	9	7.89
Tree plantation	3	2.63
Retaining wall	11	9.65
Engineering (constructing retaining wall)	1	0.88
Stop hill cutting	16	14.04
Levelling the hill	24	21.05
Awareness building	14	12.28
No answer	18	15.79
Unknown	12	10.53
Early warning	2	1.75
Others	1	0.88
Government initiatives	3	2.63
Total	114	100

Source: Field Survey, 2014.

6. CONCLUSION

The study investigates how a highly vulnerable urbanized hilly community deal with landslide disasters by taking a case study area, locally known as Golpahar under Chittagong City Corporation. A mixed-method research strategy was applied by combining both quantitative and qualitative data. Findings show that in Golpahar, most of the residents are low-income people who have migrated (52%) from other areas of the country to have a better life in the city. The people earn their bread by working as day laborers, shopkeepers, etc. They live in unauthorized temporary houses constructed on or near risky hill slopes. As the area is not developed, the roads, drainage, and other facilities are substandard. But still, people live here as the cost of living is low and their workplaces are nearby.

Indiscriminate hill cutting and deforestation for housing settlements and rapid increase of population have resulted in a very vulnerable situation. 53% of the local people consider landslides as a serious problem for them and they are quite aware of the vulnerable situation of the people living near hill slopes. According to 84% of the respondents, high precipitation and hill cutting for different purposes are the main causes of landslide disasters. They also mentioned the damages that occurred due to landslides, such as loss of life, physical injury, destruction of houses and property, damage of utility facilities.

The residents follow a few coping strategies to save their lives and continue living in this area. For instance, most of the inhabitants (75%) move to their relative's or neighbor's house and others (25%) in the emergency shelter as soon as they hear the warning via mega-phone mikes/ announcement before a landslide from the local authority, City Corporation. According to their previous experience, a large number of the respondents (40%) are not satisfied with the emergency response from the organizations that provide assistance following a landslide occurrence, mainly due to their late response.

Most vulnerable locations for landslides have been identified by the local people using PRA techniques. The vulnerability map and the experts' opinion can be useful for further decision-making to reorganize the vulnerable settlement in Golpahar and take some engineering measures to protect the life and property of the vulnerable people.

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REFERENCES

- Ahmed, B. (2021). The root causes of landslide vulnerability in Bangladesh. *Landslides*, 18(5), 1707-1720.
- Ahmed, B., Rahman, M.S., Islam, R., Sammonds, P., Zhou, C., Uddin, K. and Al-Hussaini, T. M. (2018). Developing a dynamic web-GIS based landslide early warning system for the Chittagong metropolitan area, Bangladesh. *ISPRS International Journal of Geo-Information*, 7(12), 485.

- Ahmed, B., Rahman, M.S., Rahman, S., Huq, F.F., Ara, S. (2014). Landslide Inventory Report of Chittagong Metropolitan Area, Bangladesh, BUET-Japan Institute of Disaster Prevention and Urban Safety.
- Al-Hussaini, T.M., Hossain, T.R. and Al-Noman, M.N. (2012). Proposed Changes to the Geotechnical Earthquake Engineering Provisions of the Bangladesh National Building Code. *Geotechnical Engineering Journal of the SEAGS & AGSSEA*, Vol. 43, No.2, 1-7.
- Alam, E. (2020) Landslide Hazard Knowledge, Risk Perception and Preparedness in Southeast Bangladesh. *Sustainability*, 12 (16), 6305. <https://doi.org/10.3390/su12166305>.
- Alam, E., & Ray-Bennett, N. S. (2021). Disaster risk governance for district-level landslide risk management in Bangladesh. *International Journal of Disaster Risk Reduction*, 59, 102220.
- Barry, E.F., Edward, W.g., Elaine, J.H., Janet, L.H., Brian, L (2021). A Social Vulnerability Index for Disaster Management, DOI:[10.2202/1547-7355.1792](https://doi.org/10.2202/1547-7355.1792).
- CDMP-II. (2012). Landslide Inventory and Landuse Mapping, DEM Preparation, Precipitation Threshold Value and Establishment of Early Warning Devices. Report prepared under Comprehensive Disaster Management Programme-II (CDMP-II), Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh.
- Chakraborty, P., Uddin, M. (2014, 23/08). Living in danger of landslide: 10,000 people residing on hill slopes in Chittagong, The Daily Star. Retrieved from <http://www.thedailystar.net/living-indanger-of-landslide-38276>.
- Chambers, R. (2008). PRA, PLA and pluralism: Practice and theory. *The Sage handbook of action research. Participative inquiry and practice*, 2, 297-318.
- Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social vulnerability to environmental hazards. *Social science quarterly*, 84(2), 242-261.
- Emberson, R. A., Kirschbaum, D. B., and Stanley, T. (2021). Landslide Hazard and Exposure Modelling in Data-Poor Regions: The Example of the Rohingya Refugee Camps in Bangladesh. *Earth's Future*, 9(2), e2020EF001666.
- Huq, F.F., Biswas, S. and Al-Hussaini, T. (2017). Exploring the social vulnerability and risks of landslide disaster in Bedbedi and West Muslim para communities of Rangamati city of Bangladesh. Proceedings of International Conference on Disaster Risk Mitigation, Dhaka, Bangladesh.
- Kumar, S. (2002). Methods for community participation: a complete guide for practitioners. Practical Action Publishing.
- Rabby, Y.W., Li, Y. (2020) Landslide Inventory (2001–2017) of Chittagong Hilly Areas, Bangladesh. *Data* 2020, 5, 4. <https://doi.org/10.3390/data5010004>.
- Rahman M.S., Ahmed, B., Huq, F.F., Rahman, S., Al-Hussaini, T.M. (2016). Landslide Inventory in an Urban Setting in the Context of Chittagong Metropolitan Area, Bangladesh, Proceedings of 3rd International Conference on Advances in Civil Engineering, 21-23 December 2016, CUET, Chittagong, Bangladesh.
- Rahman, M.S., Ahmed, B., Di, L. (2017). Landslide initiation and runout susceptibility modeling in the context of hill cutting and rapid urbanization: a combined approach of weights of evidence and spatial multi-criteria. *J. Mt. Sci.* 14, 1919–1937. <https://doi.org/10.1007/s11629-016-4220-z>.

- Sarwar, G. M. (2008). Landslide Tragedy of Bangladesh. Paper presented at the First World Landslide Forum, United Nations University (UNU), Tokyo, Japan.
- Shahid, S. (2010). Rainfall variability and the trends of wet and dry periods in Bangladesh. *International Journal of climatology*, 30(15), 2299-2313.
- Sultana, N. (2020). Analysis of landslide-induced fatalities and injuries in Bangladesh: 2000-2018. *Cogent Social Sciences*, 6(1), 1737402.
- Sultana, N., & Tan, S. (2021). Landslide mitigation strategies in southeast Bangladesh: Lessons learned from the institutional responses. *International Journal of Disaster Risk Reduction*, 102402.