


The Strategic Design Approaches for Chittagong Hill Areas to Reduce Risks of Landslides and Exploring the Opportunity of Tourism Development

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ABSTRACT

 Chittagong is the largest port city and second largest city of Bangladesh and contributes substantially to the economic development of Bangladesh. Chittagong is quite an attractive location. Surrounded by the rivers, hills and the sea, Chittagong possess the opportunity to uphold its image as a fascinating, multiple tourism destination where visitors can enjoy both the sea and hills. Chittagong has boundless opportunities for thousands of people living in the hilly areas. But unfortunately the hillsides are highly vulnerable to frequent and damaging landslides. Recent major landslides were caused by an extreme, higher than average, rainfall within a short period of time. 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 land and contributing to landslides. The aim of this study is to assess the area's potential for landslides and explores different strategic designs measures based on assessment of risks, uncertainty, possible consequences, constructability, environmental impacts and costs. While proposing specific measures to take to prevent landslides, it is best to match the physical characteristics of the hills and the availability of materials. This study makes an effort to contribute to the development of a comprehensive design solution that can be adapted to reduce landslides and to ensure the residents' immediate safety and at the same time promote tourism development.

Keywords: *landslide, vulnerable area, sustainable, tourism development, hill slope*

BACKGROUND

Chittagong, the second largest city of Bangladesh, is a busy international seaport. Surrounded by rivers, hills and the sea, Chittagong possess the opportunity to uphold its image as a fascinating multiple tourists' destination. Its green hills and forests, local cultures and cuisine, its broad sandy beaches and its fine cool climate has always attracted holiday-markers. Described by the Chinese traveler poet, Huen Tsang (7th century A.D) as "...a sleeping beauty emerging from mists and water.", and was given the title of "Porto Grande" by the 16th century Portuguese seafarers. Even today, Chittagong remains true to both descriptions. It combines the busy hum of an active seaport with the soothing quiet of a charming hill town. The spectacular scenic beauty and the nerve racking experience of travelling along the road has attracted the imagination of thousands of travelers from home and abroad. Chittagong has opened boundless opportunities for thousands of people living in the hilly area with enormous potential it now offers the tourism sector. The scenarios' of converging air, clouds, hills, rivers, people of different ethnic communities, their lifestyle, their rich and diverse heritage is really original and natural. But one of the major constraints and threats to tourism in Chittagong's hilly areas is the risks of landslides.

Landslides are a common phenomenon in Bangladesh. Every year many people die due to landslides in the hilly regions, especially in Chittagong. The term 'landslide' includes all varieties of mass movements of hill slopes and can be defined as the downward and outward movement of slope forming materials composed of rocks, soils, artificial fills or combination of all these materials. This constitutes surfaces separation by falling, sliding and flowing, either slowly or quickly from one place to another. Landslides can be initiated by storms, earthquakes, fires, erosion, volcanic eruptions and by human modification of the land. However, rapid urbanization and human development activities such as, building and road construction through deforestation and excavation of hill slopes have increased landslides in densely populated cities located in mountainous areas (Galli and Guzzetti, 2007; Schuster and Highland, 2007). In fact, low-income people in the cities of poor countries often occupy government or privately owned lands both legally and illegally and informal settlements along unstable hill slopes without following any existing building codes, standards or regulations (Boulle et al., 1997; Payne 2001; Nathan, 2005). Chittagong city has already been recognized as one of the most

vulnerable city to experience landslides. Different studies shows that more than 500,000 impoverished people are living in informal settlements on the risky foothills of Chittagong city (Islam, 2008; Khan, 2008). In the hilly areas, are vulnerable to landslides almost every year.

Ineffective hill management policy at the national level and weak enforcement by local authorities has created space for many informal settlements along landslide prone hill slopes and foothills in Chittagong city. However, there is no institutional assessment of those informal settlements' damage from potential landslides. Little research focuses the issues of landslides and cutting into the hills. Nor has there been research that resulted in an explanation to the informal settlers of the role of formal institutional arrangements in reducing risks of landslides. Neither organizations at the national nor local levels or NGOs have planned and executed any proper structural and non-structural mitigation measures other than conventional stabilization (simple retaining walls) of foothills and relocation respectively. Although being more affected by landslides, the informal settlers are less willing to adapt risk reduction measures, like relocation. Mostly land tenure conflict, trust, socio-economic status (education, income) and powerlessness inhibit these populations to accept new institutional arrangements. The population's growing distrust and conflict has negated any pre-landslide institutional arrangements for reducing vulnerability. This study explores how strategies are developed to maintain tourism potential despite risk of a significant natural hazard. The discussion will include a systematic exposure of problems and environmental contexts explaining the situation.

LITERATURE REVIEW

Landslides represent a major threat to human life, property, constructed facilities, infrastructures and natural environments in most mountainous and hilly regions of the world. Statistics from The Centre for Research on the Epidemiology of Disasters (CRED) show that landslides are responsible for at least 17% of all fatalities from natural hazards worldwide. The socio-economic impact of landslides is underestimated because landslides are usually not separated from other natural hazards, such as extreme precipitation, earthquakes or floods. This underestimation contributes to reducing the awareness and concern of both the authorities and the general public about landslide risk.

Population pressures are increasing in most of the world today and will certainly accelerate in the future. These pressures have resulted in rapid urbanization and development, much of it on hillsides. The world's urban population was estimated at 3 billion in 2003 and is expected to rise to 5 billion by 2030 (United Nations 2004). This increase in urban population will require considerable expansion of urban boundaries. As a consequence of this urban expansion, housing development and the construction of industrial structures, urban transportation facilities and communications systems will disturb large volumes of geological materials. Much of this disturbance will be on hillsides that are susceptible to slope failure. In addition to the pressures created by population growth, people are attracted to building on hillsides because of the natural beauty and the views from their property. As noted by Olshansky (1996, p. 1):

"Hillsides pose unique problems for the construction and maintenance of human settlements. They are prone to natural hazards, and they topographically constrain the design of settlements. For these reasons, hillside lands often remain vacant long after adjacent valley floors are urbanized. Despite the constraints, they are attractive places to live because of the views and because of the sense of being close to nature."

With much urban expansion taking place in hillside areas, ground failure by land sliding will be one of the most significant geological hazards affecting these new developments. Along with the development of homes in residential subdivisions comes the entire fabric of infrastructure, such as streets, sidewalks, water and sewer lines and utility lines (Schwab et al. 2005). Such facilities require large amounts of grading, excavation and paving and the addition of significant areas of impervious surface. In addition, lawns and vegetation will require landscape irrigation. All of these modifications may contribute to slope instability. Particularly in developing nations, this pattern is being repeated, but with even more serious consequences.

CHITTAGONG CITY, STUDY AREA

Chittagong is the second largest city of Bangladesh with 185 square kilometers (60 Sq. Miles) and contains 41 wards and 285 clusters. It has a total population of 25, 63,293 people in the area (BBS,

2011). The Karnafuli River lies to the south, the coastal plane to the west and flood plane 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. Chittagong district is the hub of natural resources and beauties. (Figure 1)

Most of the hilly areas are found in the Chandgaon, Double Mooring, Pahartali, Khulshi and Bayezid Bostami Thanas. Hills around the Foy's Lake area are the most famous hilly area within the city. Besides, Tiger Pass hill, Battali Hill, CRB hill, Moti Jharna Hill, Court hill, DC hill and others are widely known as the hilly areas with attractive places in the city for tourism. According to the Chittagong City Corporation, the hill range from Fauzderhat to Sitakunda is the highest of all. The average height of these hills is 500 feet with maximum height of 1015 feet (Chandranath Hill). The height of the hills within the city is relatively low. Battali hill, situated in the centre of the city, is 281 feet high and a hill near Foy's Lake at the north-west corner of the city is 270 feet (Mohajan, 2011). The soil of the hills is brown and sandy with acidic character. The different categories of hills are given below in Table 1.

Others hills include Intraco CNG Hill in Pahartali and Tigerpass area, Kushumbag R/A Hill in Pahartali, Dampara and GEC circle, Ispahani Hill in Pahartali, South Khulshi, Lake city Hill in Pahartali area. The hills of Chittagong City are owned by different governments, autonomous and private organizations, and elite individuals. Bangladesh Railway is the largest owner of the city hills. Public Works Department, Chittagong City Corporation (CCC), Chittagong Development Authority (CDA), Chittagong Water and Sewage Authority (CWASA), and Bangladesh Army are other large owners. Some large, private companies namely AK Khan Group, Ispahani Group, James Finley and some elite individuals have also owned a portion of the hilly lands (Islam, 2008); (Murshed, 2013). Battali Hill is over populated and inhabited by slums; Intraco CNG Hill is inhabited by Bamboo type structures along slopes; Kushumbag R/A Hill and Lake City Hill are also over populated with Moderate high & low rise structures .

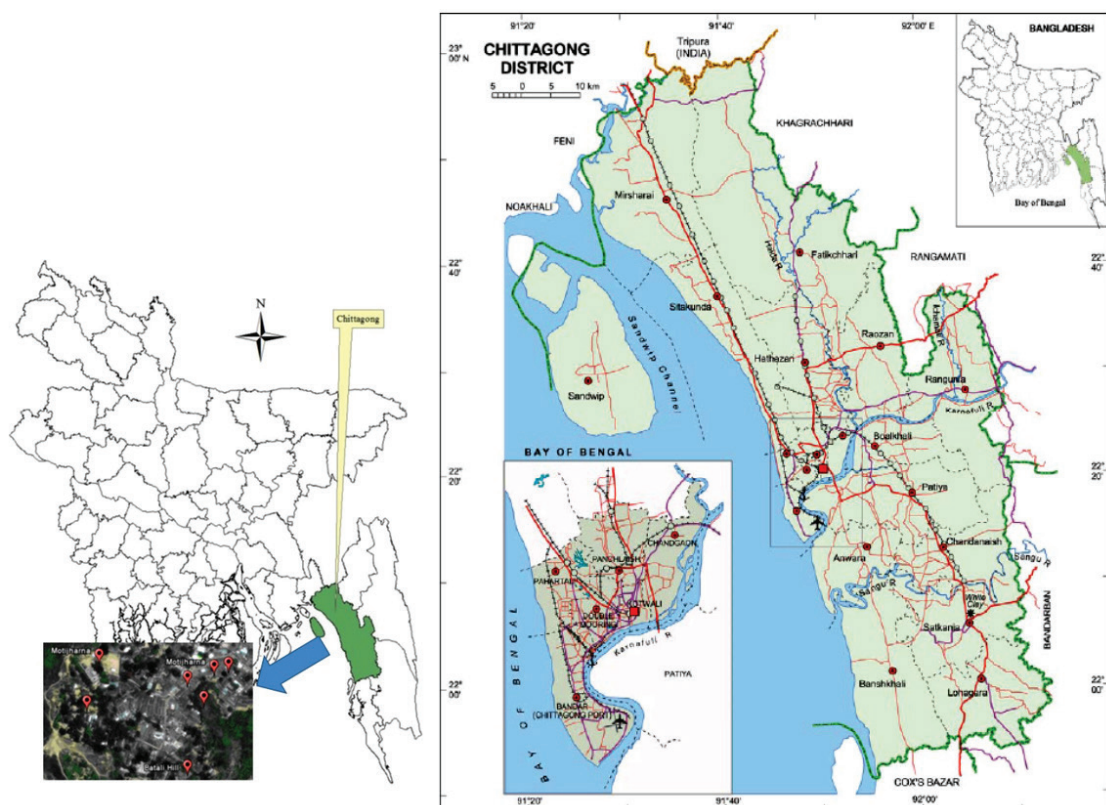


Figure 1:
Location of Chittagong city

Table 1:

Hilly Area in Acre	No of Hill		Area (Acre)	
	No	%	No	%
Lowest Through 4 acres	33	38.78%	65	0.53%
4.0 Acres – 11.9 Acres	20	23.13%	146	1.18%
12.0 Acres – 36.9 Acres	19	21.77%	410	3.27%
36.0 Acres – 107.9 Acres	9	8.88%	443	3.40%
Through Highest 108 Acres	7	7.48%	2854	91.62%
Total	88	100.00%	3918	100.00%

(Source: UNDP, 1995)

LANDSLIDE VULNERABILITY IN CHITTAGONG CITY

In a landslide or rock fall, the movements of materials depend on the slope, and are caused by

the slope's instability. This is commonly observed in Chittagong and its adjacent areas of Bangladesh. Several geological, morphological, and human induced changes cause these slopes' instabilities. Chittagong hills are the part of tertiary hills. The

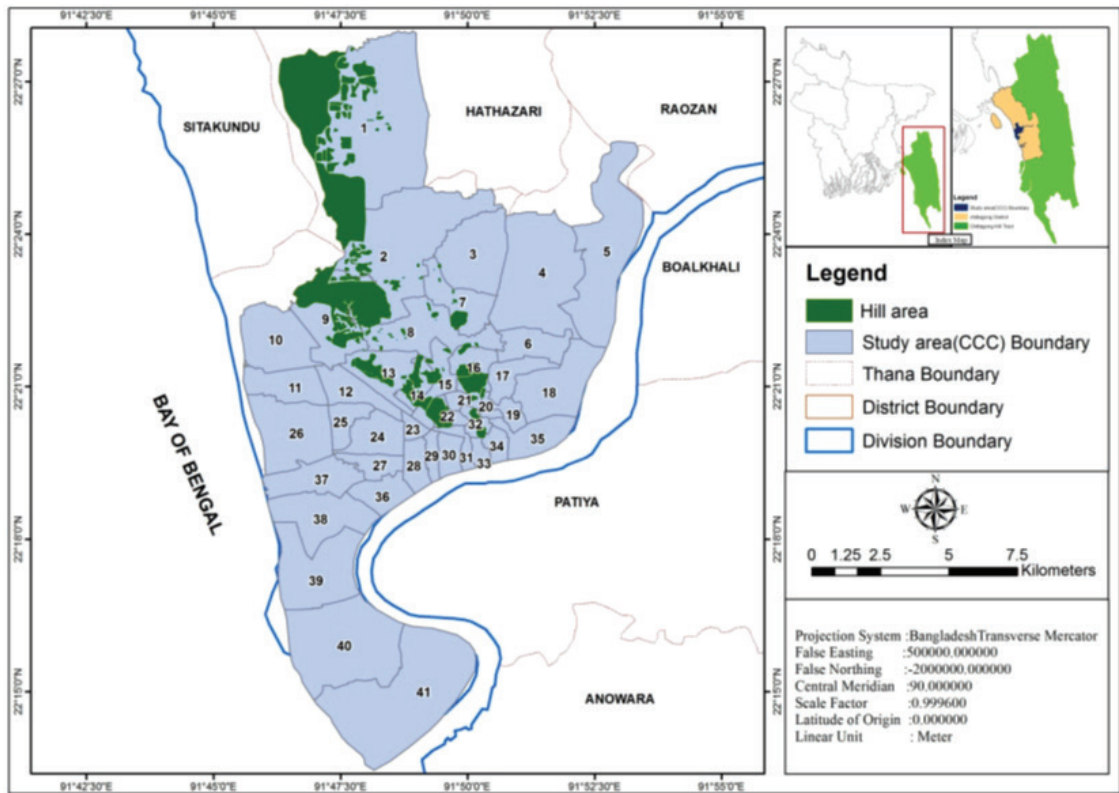


Figure 2:
Existing Hilly Area in Chittagong City Corporation (CCC)
(Source: Chittagong Development Authority)

geological structure and soils of these hills are weak and the hills also have steep slopes which increase the risk of landslides. Risk is higher where settlements exist on the foothills where poor people live. Over the last few decades landslides have become an increasingly serious hazard, with much of the city's expansion utilizing the hills. As a result the hills are being cut for unplanned urban development. The development authorities of Chittagong have identified 30 risky hills, namely Matijhorna, Lalkhan Bazar, TankirPahar, Batali Hill, GolPahar, AK Khan Pahar, etc(Chakraborty & Uddin, 2014). Here people are living at the foot and on the slopes of hills with the high risk of landslides and associated damage.

Landslides frequently occurred due to extreme, uninterrupted monsoon rainfall. In 2007, the monsoon started with unprecedented heavy rainfall that was intensified by a storm from the Bay of Bengal on 9–10 June. The heavy rain caused mudslides, which overwhelmed slums in the foothill on 11th June 2007. The death toll was reported to be

at least 128, including 59 children, and more than 150 people were injured (SDMC, 2007).

Another landslide occurred on 18 August of 2008, in the Matijhorna area of Lalkhan Bazaar and killed 11 people of two families. Furthermore in June 2010, a rain-induced massive slide occurred and killed 66 people, including army personnel and injured 100 others (EM-DAT, 2014), in the Chittagong, Cox's Bazar and Bandarban districts of Bangladesh. In 2011, another rain induced landslide hit the same localities as of 2008, in the slum area of Lalkhan Bazar. The victims were buried in their tin homes while they were sleeping. In this disaster women and children were the most affected. Multiple landslides occurred in the Chittagong and its surrounding areas in June 2012, due to the three day long torrential rainfall. The Chittagong port received 40cm (15.75in), of rain in a single 12-hour period on the prior day. Due to this heavy and intensive rainfall about 90 people were killed in different areas of the city (Lebu Banagn, Foy's lake), and its surroundings (BBC, 2012; Rubel & Ahmed, 2013).

After the massive landslide of 2007, a technical committee was created consisting of government agencies, Chittagong City Corporation (CCC), Chittagong Development Authority (CDA), researchers, engineers and NGO workers. The committee's goals are identifying priorities for action, land use vulnerability assessment and zoning. The committee divided the city into three zones to consider the risky issues of landslide.

GENERAL FEATURES OF LANDSLIDE AREA OF CHITTAGONG

The hilly areas of Chittagong have some common features which make the people vulnerable to landslides. The common features of the landslide prone areas are presented below:

The nature of hill slopes: The hill slopes determine the degree of landslide. In the present study, the hill slopes are divided into three categories including low steep ($> 80^\circ$), medium steep ($80-85^\circ$), and very steep ($85-90^\circ$). Most of the respondents (47%), reported low steep slopes followed by 23% medium steep slopes, and 13% very steep slopes. According to Mahmood and Khan (2008), hill cutting in Chittagong is occurring on slopes of $70-80$ degrees. This makes the dwellers highly vulnerable to landslides.

Establishment of settlement: According to the survey, the majority (90%), of the respondents reported that some influential persons (powerful people called *Matobbar* locally), who established the settlements built houses legally and illegally in the study area. Migrant people rent these houses due to the low costs of living. The low costs creates competition among the migratory people to settle in the landslide prone area.

Hill Cutting: Hill cutting is a common scenario in Chittagong because the majority of the settlements developed through cutting into the surrounding hills. The majority (93%) of the respondents reported that hill cutting occurred due to house construction. About 60% of the respondents reported road construction as one of the important causes of hill cutting. An earlier study reported that the unplanned hill cutting occurred due to road construction, sand collection and administrative infrastructure development (Sultana, 2013).

De-vegetation and deforestation: In the hilly areas de-vegetation and deforestation means cutting small plants and forests. In the study area, de-vegetation and deforestation was reported by 75% and 63% respectively. Prior to a few decades ago enriched vegetation cover was a prominent feature of the hilly areas. Vegetation protects the soil and makes slopes stable which reduces the risk of landslides. Large trees provided strong structures in the earth that anchored the soil and protected it from any erosion (Sultana, 2013). The de-vegetation and deforestation is increasing day by day due to various human interventions. A number of hills in the study area were found with no vegetation coverage. (Figure 3)

INSTITUTIONAL FACTORS TRIGGERING LANDSLIDE VULNERABILITY

Several researchers have argued that vulnerability to any hazard is not only the outcome of natural forces; but also, depends on institutional settings that determine the social and economic possessions of affected communities and their ultimate coping capacity (Adger 2000, Wisner et al. 2003). Landslides as a natural hazard not only occur due to natural factors like heavy rainfall, earthquake and volcanic eruption, but are also triggered by human interventions like unplanned hill cutting for informal settlements and deforestation. Vulnerability to landslides depends on the strength of existing institutional arrangements in pre, during and post disaster situations.

Feeble hill management policies

Bangladesh has neither specific hill cutting nor hill management policies in place at the national level that can be carried out at the local level. Only, according to the section 3(C), Bangladesh Building Construction Act, 1952 (amended in 1990), hill cutting has been allowed (not prohibited) with the permission of the authorized government department under certain terms and conditions. As per section, the authorized officer allows hill cutting when satisfied that the cutting or razing of hills is necessary for public housings and could be done without seriously damaging the original hill ecosystems, adjacent human lives, property and infrastructure or increasing siltation of water bodies (Ahammad 2009).



*Figure 3:
Features of landslide area of Chittagong city*

However, with the rapid urbanization in Chittagong city, the laws could not ensure the effective guidelines for where and how housings should be established. So, most of the government administration, who responded to the study, understand that landslide vulnerability is an ultimate result of weak hill management policies.

Most of the informal settlements were built in a haphazard manner by private hill owners and illegal occupants without following building rules and consequentially became vulnerability to landslides. No one from either CDA or DoE was there to assess the vulnerability of those settlements. CDA does not go into the field to monitor whether the proposed structures will destroy the hill's ecosystems or increase harm to adjacent property or human lives. Although DoE has filed 20 police cases against illegal hill cuttings, these could not stop cutting into the hill or the inhabitation of the informal settlers along risky slopes. Basically weak hill management policies and lack of co-ordination between CDA & DoE triggered vulnerability risks.

Conflict of Hill Ownership

For over 20 years, Bangladesh railway has been having a land tenure conflict concerning hill resources with local people in the informal

settlements. Chittagong claims that the informal settlement area was Bangladesh Railway's property.

On the other hand, the informal settlers claim that they are the legal occupants of those hills. They have legal documents as the original owners. However, officials of the Railway complain that those houses were built with the support from corrupt lawmakers, CCC, local politicians and fake land registration officials.

Rural-urban migration plays a vital role in building the informal settlement on government owned hills. After entering the city, many poor people have no chance to rent safe and expensive housings. So, over the last years, corrupt, local people built cheap housing on unused railway and government owned hills to rent to low-income people.

Exclusion of Landslide Issues at National Level

To a large extent national disaster management policy of Bangladesh focuses on vulnerable communities, who generally live in coastal areas or riverine flood planes. However, the cumulative effects of landslides, in terms of lives, properties and infrastructure have been quiet substantial. There have been instances when many settlements

on hilly slopes have been completely demolished. Many rural and urban settlements have been severely affected due to landslides. Landslides are generally perceived as a local hazard in Chittagong region due to its hilly topography. Therefore, many organizations' respondents claimed that national authorities are less concerned with landslide hazard management.

In 2007, the landslides raised awareness to national levels, incorporating the landslide issue into disaster management. A disaster management committee was formed in Chittagong. The mayor of Chittagong City Corporation chairs the committee that coordinates local government departments; the Chittagong Development Authority, the Bangladesh Water Development Board, and the Meteorological department, the Defense Authorities, the emergency authorities, ward representatives and NGOs. The committee is supposed to sit during the pre-monsoon period to define roles and responsibilities regarding pre and post disaster activities.

Absence of Early Warning System

The local Meteorological Department usually provides forecasts for heavy rainfall and issues a pre-hazard warning to the departments or agencies responsible for disaster preparedness. The highest rainfall (425.2 millimeters in 24 hours) was recorded on 11 June 2007, by the local Meteorological Department; however no specific responses, either before or during the rainfall, were undertaken by any of the agencies in the local disaster management committee because of their undefined roles. There was not any responsible agency to convey early warning to the informal settlers that they needed to move to a safe location. Generally, Bangladesh Meteorological Department (BMD) forecasts weather reports through electronic media (TV, Radio and Web), but the information was not available in time for local people for taking early preparation.

Lack of Structural Measures

Many residential buildings in Chittagong established along hill slopes abide by safety measures, building codes and even guarded with concrete reinforcements and better drainage facilities. However, CDA and CCC could not establish any structural measures along the informal settlements, as the residents are illegal occupants. Though experts on landslide issues kept giving warning to both national and local level authorities about the upcoming hazard and its massive impacts.

Lack of organizational coordination

There was no preparation beforehand from the national level to the local level for emergency recovery of a landslide affected community. At the national level, MoFDM had no communication with the local government agencies to generate an institutional response on an emergency basis before the landslides in 2007. At Chittagong city, there was a disaster management committee (GOB 2008). However, the local community claimed that before the landslide in 2007, they did not find any activity of the disaster management committee raising awareness of people regarding landslide hazard management.

Disaster risk reduction among the low-income groups living in informal settlements is hindered by poorly defined roles for urban government agencies and little coordination between them. This is hardly unique to Chittagong. After the 2007 landslides, vigilance teams were formed under the city's corporation to monitor informal settlements that were at risk and to create awareness of the need to move to temporary safe shelters during rainfall. But these vigilance teams only included city corporation staff that lack training for disaster management and who typically undertakes only routine works.

GOVERNMENT INITIATIVES FOR HILL

The legal base of preventing illegal hill cutting is the Building Constriction Act which was enacted in 1952 with a view to preventing haphazard erection of buildings, excavation of tanks and cutting of hills and hillocks in Bangladesh. But later on, the government amended the 1952 Act twice in 1987 and in 1990 (Rahman, 2012). In the Building Construction (Amendment) Act of 1990, amongst other, section 3C and 3D were inserted into the 1952 Act. As per section 3C of the Act no person is allowed without the previous sanction of the authorized officer to cut or raze any hill. As per this section no such sanction should be granted unless the authorized officer or such other authority as the government may specify is satisfied that-the cutting or razing of the hill shall not cause any serious damage to any hill, building, structure or land adjacent to or in the vicinity of the hill, obstruction to any drain, stream or river, loss of life or property. The Act not only contains the permission procedure and criteria but also contains

specific provisions for punishment and legal actions against the persons transgressing the law (Murshed, 2013). To prevent environmental degradation in the country Bangladesh Environmental Conservation Act 1995 was formulated. But the act contained no provision regarding illegal hill cutting, but later on in 2010 the Act was amended giving additional power to the law enforcers. Nobody is allowed to cut and/or raze hills/tillas without prior permission of authorized officer, otherwise according to law he will be punished 10 years imprisonment or 10-lakh taka [\$15,400] monetary punishment or both. In addition to that the Ministry of Forest & Environment issued a circular against hill cutting in 2002. It is yet to be framed into an Act. This government directive is now being used to prevent hill cutting (GoB, 2010).

In 1995, Chittagong Development Authority prepared a comprehensive Master Plan for the city with the technical assistance from United Nations Centre for Housing and Settlement (UNCHS). One of the components of this plan is the Structure plan. In this plan, six guidelines have been stated considering the issues of environmental degradation related to manufacturing activities, solid waste disposal, noise and air born pollution, hill cutting and loss of vegetation coverage to enhance the environmental quality of the city (UNDP, 1995). In the Master plan of Chittagong City prepared in 1995, particular attention has been given for the protection and improvement of urban environmental quality.

Chittagong Development Authority has prepared a set of detailed development guidelines for Chittagong city called Detailed Area Plan for Chittagong City 2007 (Rahman, 2012). In this planning report, the whole city has been divided into 12 zones named Detailed Planning Zone (DPZ). Of these 12 zones, 6 are within the City Corporation Area. Out of them only 3 zones consist of hilly areas (Mohajan, 2011). The detailed Area Plan has classified the hills in to several categories depending on the level of their destructions and forest covering. Consequently the guidelines or the suggestions given in the report regarding hills are predominantly about protection of lives and property of the city people.

Case study (Foy's Lake, Chittagong)

As already discussed earlier, Chittagong is considered by many as the most beautiful district of the country due to its natural beauty comprising of the seaside, hills, rivers, forests and valleys.

The Foy's Lake area, the most famous hilly area within the city is located in a picturesque setting surrounded by hills, a lake and green forests located in Pahartoli, Chittagong, on approximately 320 Acres of land. The provision of tourism facilities in Foy's Lake hill helps to reduce the vulnerability of landslide through preserving hill slopes, the hill top and foot- hills by taking following precautionary measures:

- Foy's lake tourism area is controlled and managed by one authority (Leased from Bangladesh Railway) to developed tourism facilities in the area, so that they are solely responsible for overall maintenance of the hill. The area has spontaneous use by visitors. As the hills are used only for tourism purposes it helps protect the hills from any kind of unauthorized access of people, illegal hill cutting and settlements in the area.
- Forest, hill and lake creates a soothing environment in Foy's lake area. The hills in the area are covered with trees, shrubs, bushes and grass. All of which helps prevent top soil erosion during heavy rainfall runoff in monsoon season.
- The trees, shrubs, bushes and grass on hill slopes grab the soil creating stability of hill slopes and reduce the scope of landslide.
- Retaining walls have been constructed at critical positions in the hills and contribute to landscaping works such as walkways, a fountain, steps and a platform on the lake. There are also some buildings which are very close to the foothills that are constructed with the support of retaining walls.
- Almost all buildings (used as restaurant, shops, cottage and resorts) have been constructed on flat land, maintaining a distance from the foot hills and on the platform between the hills without disturbing hill slopes' stability.
- Proper drainage systems of slopes have been maintained in Foy's lake hills, even in the case of building construction, most of the buildings are set on stilts to avoid the obstruction of the natural drainage system.

In figure 10 Additional details also show where hills are protected through some measures and provide recreation facilities in those places.

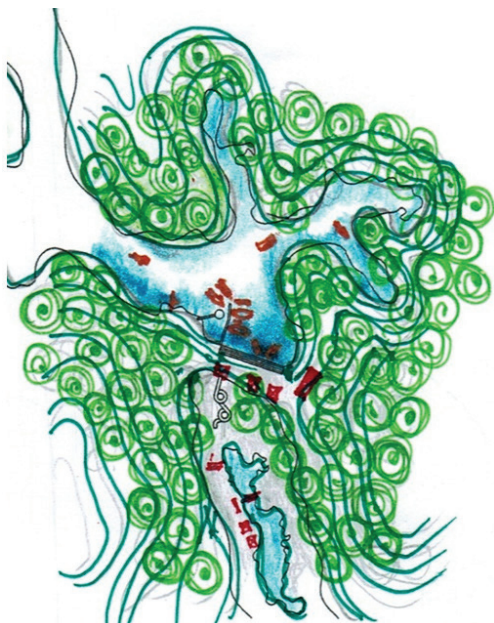


Figure 4:
Site plan of Foy'S Lake with amusement facilities.

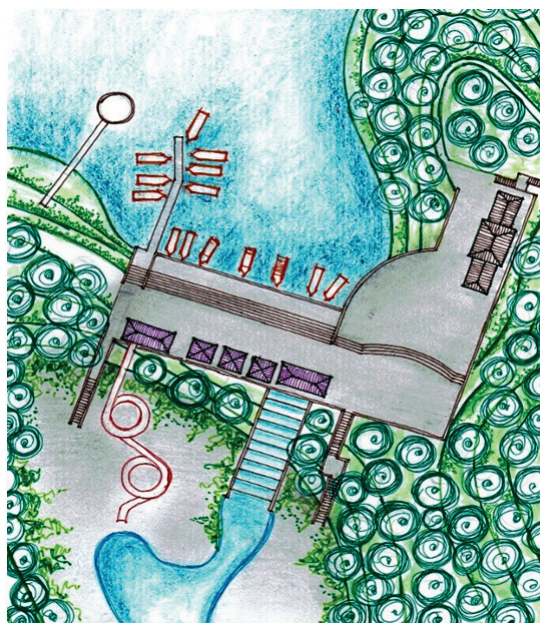


Figure 5:
Amusement facilities on a platform between hills.

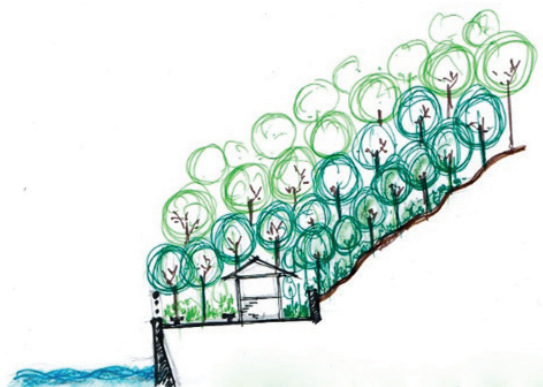


Figure 6:
Retaining wall has been constructed to protect foothill.

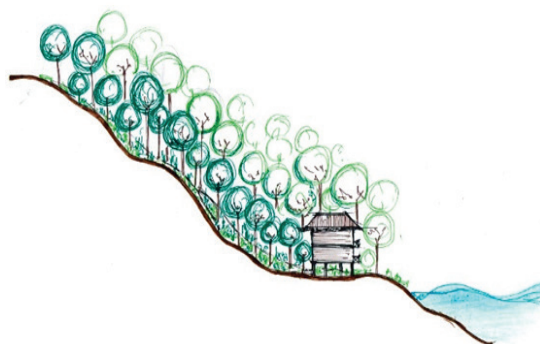


Figure 7:
Slope of hill is remain untouched and building has been constructed on flat land keeping a distance from foothill.

Measures

By linking the findings of the research questions, relevant literature and case studies, the risk reduction arrangements, light adjustments and relocation, has been found to be incompetent in reducing landslide vulnerability. After considering and analysing all the factors, an immediate mitigation measure and some design measures are proposed on the basis of; risk assessment, uncertainty, constructability,

environmental impacts, and communal use and provide recreation facilities. The final strategic design approach is a creative combination of several methods. The landslide mitigation works are broadly classified into two categories: Control works and Restraint works.

The control works involve modifications of the natural conditions causing landslides such as topography,

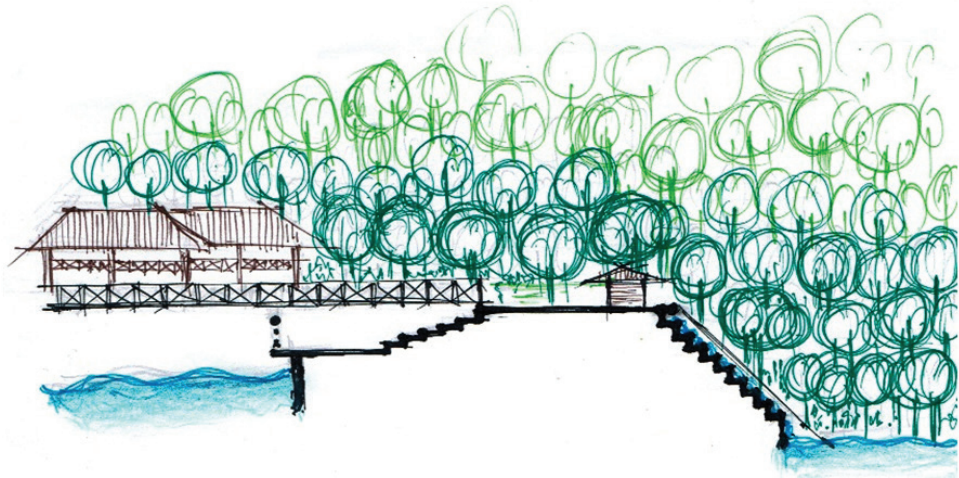
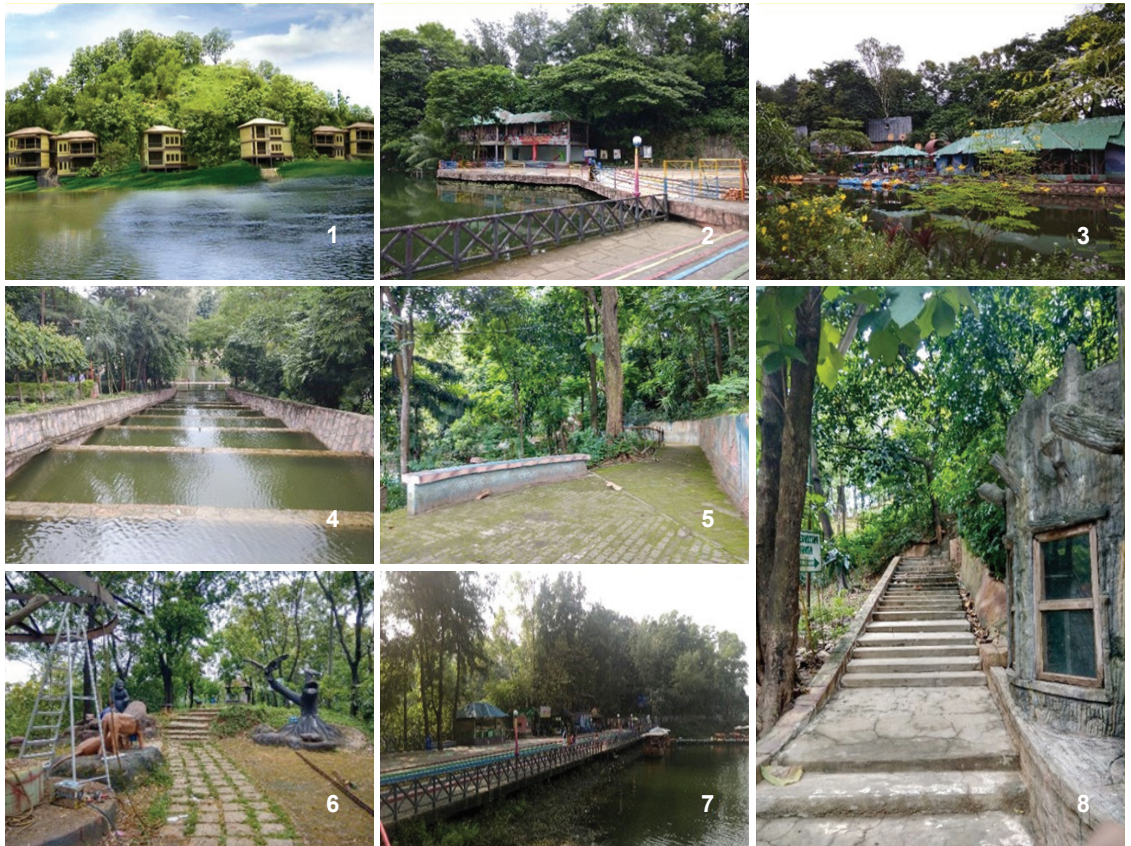


Figure 8:
Slope of hill and bank of lake has been utilized and protected with steps and fountain.



1. Slope of hill is remain untouched and resort has been constructed on flat land keeping a distance from foothill.
2. & 3. Recreational facilities
- 4, 5, 6, 7 & 8. Slope of hill and bank of lake has been utilized and protected with steps and fountain.

Figure 9:
Images of Foy's lake area.



Figure 10:
Hill protection measures in CRB hill area and DC hill area.

geology, ground water, and other conditions that indirectly control portions of the entire landslide movement. The restraint works rely directly on the construction of structural elements. The core idea of the mitigation measure is to reduce risk of the affected area by incorporating both control and restrain works. In the design proposal, a new foot hill is proposed below ground level which will hold maximum amount of landslide debris, an elevated green belt will serve as a buffer for the informal settlement, and the road beside the green will give an easy access.

As hill types and level of damage varies two types of strategic designs are proposed. One is for the hills which are intact or have slightly modified foot hills. Another proposal is for those which have sustained massive hill cutting. In case of intact hill toe, a drainage trench is proposed which will elongate the hill slope downward and contain landslide debris during a disaster. On the other hand, in a deformed hill part of the hill will be retrained with proper structural measures and then the trench will be placed. In this case, immediate flat land of the restored part will be restricted for any type of human intervention but reforestation. (Figure 11 & Figure 12)

The hills have lost their scenic beauty due to unplanned hill cutting and unsustainable land use. To bring back its glorious past, a restoration of hill ecosystem is proposed. The proposal consists of proper reforestation program based on understanding local soil characteristics and plants suitable for the area. Reintroduction of local flora and fauna to the hill will help retrieve lost bio-diversity and balance the ecosystem. Some urban facilities, walkways, a jogging track, and a watch tower will generate a balance between man and nature. By these facilities, other hill areas like Motijharna-Batalihill's informal settlement community may come out of their introvert nature and blend with the rest of the city dwellers. The anti-social activities of the community may also come to an end.

Some policies needs to be considered to avoid detritions of the environment of hills:

- The development work should be kept at a minimum in consideration of the ecology and geo makeup of hills.
- Any development works has to be done after EIA (Environment Impact Assessment) to protect the ecosystem of the area.

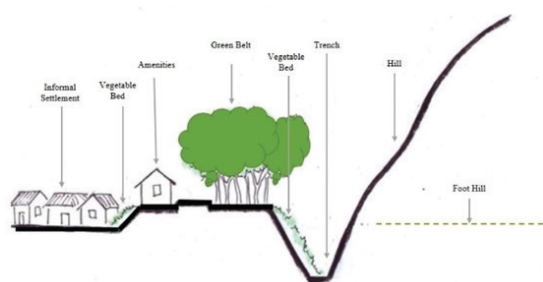


Figure 11:
Strategic design for intact or little modified hill

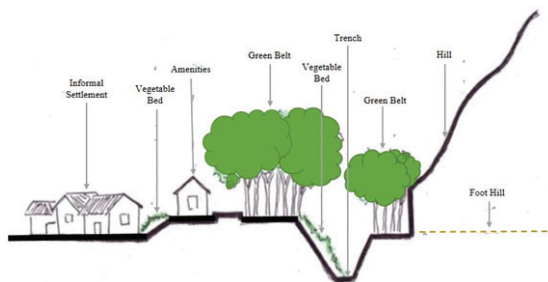


Figure 12:
Strategic design for deformed hill

- Slope stability and soil conditions of the area need to be analyzed through the study of topography, geology, ground water and poor water pressure and external loading of the area.
- Regular maintenance of trees, hill slopes, hill tops and foothills, including natural drainage systems, have to be done.
- The number of visitors and their activities in the sensitive area should be controlled.
- Awareness raising activities for the visitors need to be instituted to increase their knowledge about the relationship between human activity and hill slopes' instability and its consequences on landslide vulnerability.
- Community level disaster risk management institutions are thus essential to be incorporated into the decision making process.

Beside these steps, a few more measures need to be added to tourism development in the hill areas

- The local community should be properly educated to preserve their natural resources.
- The local administration should devote and utilize their funds to maintain the natural beauty.
- Government should take initiatives by organizing several types of training programs for both local male and female workers. Also an awareness of the importance of conserving the hills should be introduced to them.
- In fractural development should be at an international levels but that should not destroy nature, the main attraction for tourist.
- Tourist spots should be calm and natural yet offer fun, exciting, relaxing, educative, and informative experiences and accurate information about the area.
- An effective and participative working network should be introduced between public and private sector as a must. Local people should be involved with public programmes.
- Appropriate infrastructural development, super-structure development and introduction of waste management and sustainability of

the tourist attractions for prosperity are most essential.

- Tourism products can be diversified based on archaeology, culture and monument, river, tea garden, indigenous cultures and etc.

CONCLUSION

Chittagong, a developing city of Bangladesh, is associated with natural disasters that have a substantial impact on the residents of the informal settlements. Landslide vulnerability is an important issue for people living in the hilly areas. In recent years, landslides are occurring with regularly. In the study area, the vulnerability of landslide is more at risk than other landslide vulnerable areas in Chittagong city. The present study indicates that landslides affect the poor people living on the slope of hilly areas. The main reasons identified for landslides were cutting into the hills weak soil structure and de-vegetation. The major impacts of landslides on the local communities were the destruction of natural scenic beauty, economic loss, destruction of lives and environmental problems. The main mitigation strategies suggested by the respondents were the stopping of hill cutting, resettlement of the affected people, re-vegetation and the development of robust policy.

Scientific knowledge and practices are needed to be understood and used proactively by local communities. Their capacities to mitigate landslide risks are thus strengthened, ensuring sustainable risk reduction activities while the sense of ownership is created. Land use planning, as an important landslide push factor in case of unplanned land development, needs to consider landslides in the decision making process, in consultation with civil engineering and local communities.

Monitoring and analysis of natural parameters such as rainfall patterns and water absorption, land movements and slope evolution is critical to landslide risk mitigation. Traditional knowledge can validate evidence of past landslide events, and helps to further understand the landslide perception among the local communities. Traditional technologies are also useful in designing landslide Early Warning System.

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