Developing Dynamic Web-GIS based Early Warning System for the Communities at Landslide Risks in Chittagong Metropolitan Area, Bangladesh

Landslide Inventory Report

August, 2014

BUET-Japan Institute of Disaster Prevention and Urban Safety (BUET-JIDPUS)
Bangladesh University of Engineering and Technology (BUET), Dhaka-1000, Bangladesh
Email: jidpusinfo@jidpus.buet.ac.bd, Phone: +8802-9662975, Fax: +8802-9662975

Landslide Inventory Report of Chittagong Metropolitan Area, Bangladesh

Submitted to

International Centre for Integrated Mountain Development (ICIMOD)

Submitted by

BUET-Japan Institute of Disaster Prevention and Urban Safety (BUET-JIDPUS); Bangladesh University of Engineering and Technology (BUET), Dhaka-1000, Bangladesh

Authors

Bayes Ahmed
Md. Shahinoor Rahman
Sonia Rahman
Ferdous Farhana Huq
Sharmin Ara

ABSTRACT

Landslides are one of the most significant natural damaging disasters in hilly environments. Chittagong Metropolitan Area (CMA), the second largest city of Bangladesh, is vulnerable to landslide hazard with an increasing trend of frequency and damage. Devastating landslides have hit CMA repeatedly in recent years. Landslide events occurred at a much higher rainfall amount compared to the monthly average. Moreover, rapid urbanization, increased population density, improper land-use, cutting of hills, indiscriminate deforestation and agricultural practices are aggravating the landslide vulnerability in CMA. Against this backdrop, it is essential to develop an early-warning system for the hilly communities of CMA incorporating local knowledge. The first step of developing early warning system is to prepare an inventory of all landslide locations. This report shows detailed information of all landslide locations of CMA.

A landslide inventory has been prepared for the CMA area. To prepare inventory three steps have been followed. At first, existing achieves of landslide have been studied. Some information that could not have been found from existing achieves were collected from field survey. Participation of local people in field survey was a big part of field survey. Some other data that could not have been collected from field survey were collected through image interpretation.

To prepare landslide inventory different factors have been studied, such as: landslide classification, landslide dimensions (different widths and lengths, area), landslides activity and its distribution (advancing, enlarging, moving, widening etc.), potential causes of landslides (geological, morphological, physical, human induced etc.), landslide triggering mechanism (excessive rain, water level change, earthquake, human activities), factors influencing slope stability (gradient, slope geometry, stress, vegetation, disturbance etc.). Study results on each factor have been discussed in this inventory report.

This inventory report also covers different social and physical aspects of landslide vulnerable people. This report gives a glance of road network, housing pattern, drainage condition of the adjacent areas of landslide locations. Socio economic condition of people living in landslide vulnerable areas has also been studied and presented in this report. This report presents detailed landslide conditions and possible risk that may arise from it in CMA area.

ACKNOWLEDGEMENT

The project, 'Developing Dynamic Web-GIS based Early Warning System for the Communities at Landslide Risks in Chittagong Metropolitan Area, Bangladesh', is funded by SERVIR, a regional visualization and monitoring system that integrates earth observations such as satellite imagery and forecast models, with in situ data and other information for timely decision-making. SERVIR is a joint initiative of USAID (United States Agency for International Development) and NASA (National Aeronautics and Space Administration). SERVIR-Himalaya is implemented in partnership with ICIMOD and works towards establishing itself as a regional resource centre in the Hindu Kush Himalayan (HKH) region by developing relevant geospatial applications, and increasing access to data and decision-support tools on different thematic areas.

The authors express their gratitude to International Centre for Integrated Mountain Development (ICIMOD), an implementing partner of SERVIR-Himalaya for their all time guidelines, comments and support.

The authors are also grateful to Md. Zafar Alam, Director, Department of Environment (DOE); Md. Samiul Masud, Assistant Commissioner (Land) of Chittagong Sadar Circle; Architect Rezaul Karim, Chief City Planner, Chittagong City Corporation (CCC); Shahinul Islam Khan (Deputy Chief Town Planner), M.A. Issa Anshary (Town Planner), Syed Fuadul Khalil Al Fahmi (Assistant Town Planner) and Md. Abutalha Talukdar (Assiatant Town Planner), Chittagong Development Authority (CDA); Major Aftab, Chittagong Cantonment; Professor Dr. Khan Towhid Osman, Dean, Dept of Soil Science (University of Chittagong); and Muhammad Muhibbullah, Assistant Professor and Chairman, Dept of Geography & Environmental Studies (University of Chittagong) for their cordial help and support regarding different issues.

Last but not the least, the authors are cordially thankful to the local people of the study areas for their kind cooperation and help during the field work of this research.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1.1 PROJECT DESCRIPTION

The hilly areas of Bangladesh are vulnerable to landslide as like as the other hilly regions of the world. Every year landslide occurs in the port city of Chittagong in south-eastern part of Bangladesh. Heavy rainfall during monsoon season causes single and multiple landslides that destroy the houses as well as lives of slum dwellers around the hilly areas. To mitigate the death loss, it is necessary to develop a warning system for the people of those areas so that they can move to other places when there is possibility to a landslide.

This project is named 'Developing Dynamic Web-GIS based Early Warning System for the Communities at Landslide Risks in Chittagong Metropolitan Area, Bangladesh'. The aim of this project is to create a dynamic website that will warn the landslide vulnerable communities of Chittagong Metropolitan Area (CMA) in advance. To achieve this goal it is necessary to understand the mechanisms of landslides, litho logy, the human ecology to landslides, decision-making process, preparing the predictive susceptibility maps, and analyze the rainfall pattern of CMA. The website will incorporate all the relevant information and apply advanced geospatial technologies. This will help in reducing the impact of landslide risks on the people of Chittagong city.

The project is funded by SERVIR-Himalaya, a joint initiative of USAID (United States Agency for International Development) and NASA (National Aeronautics and Space Administration). The International Centre for Integrated Mountain Development (ICIMOD) assists the project.

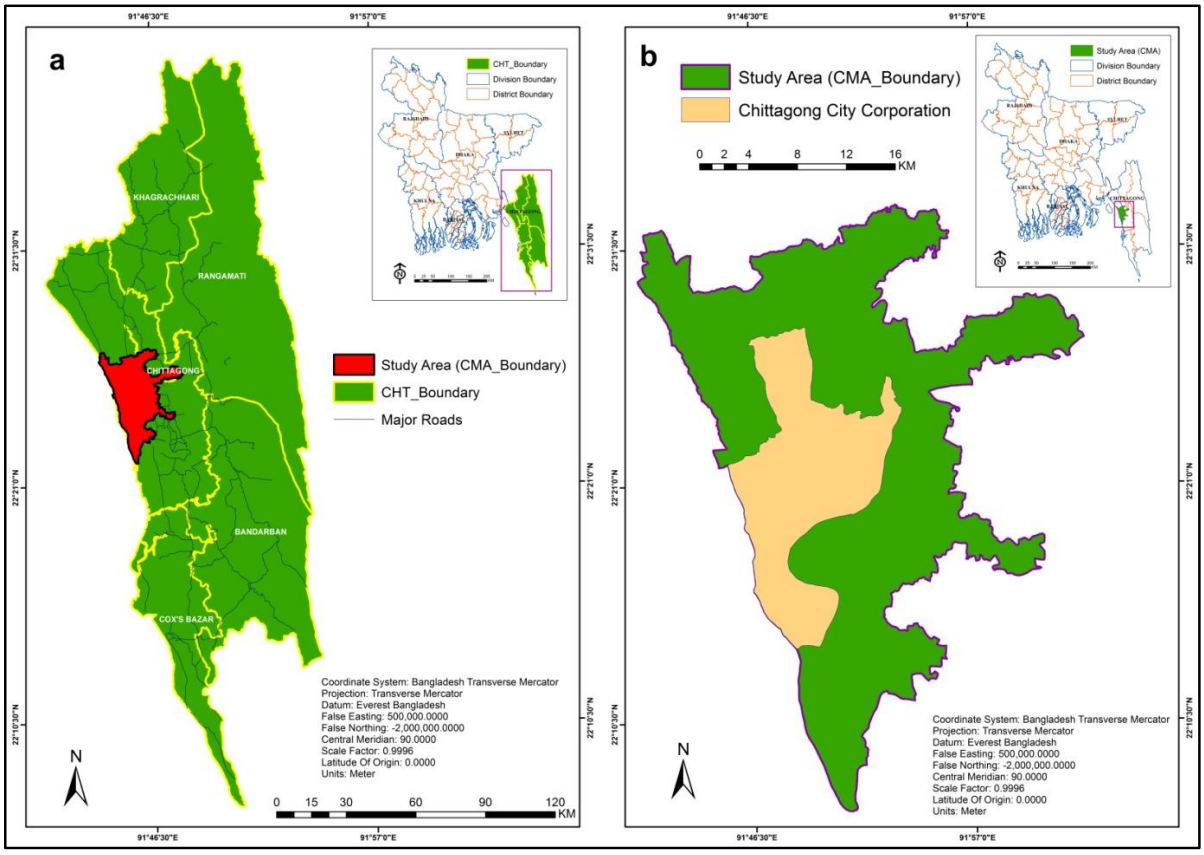
1.2 BACKGROUND OF THE STUDY

Landslides are one of the most significant natural damaging disasters in hilly environments. Social and economic losses due to landslides can be reduced by the means of effective planning and management (´ntara, Esteban and Parrot, 2006). Moreover, land-use and land-cover changes have been recognized as world's one of the most important factors stirring rainfall-triggered landslides (Yalcin, 2008). Land cover changes (e.g. urbanization, deforestation) cause large variations in the hydro-morphological functioning of hill-slopes, affecting rainfall partitioning, infiltration characteristics and runoff production. All these factors trigger landslides in hilly areas (Chau, Sze, Fung, Wong, Fong, Chan, 2004). On the other hand, worldwide heavy one or multiple-day precipitation events have increased alarmingly due to climate change (Cities and climate change: global report on human settlements, 2011).

The rapid land-cover change (e.g. unplanned urbanization in steep slopes, hill cutting), coupled with the increased intensity and frequency of adverse weather events (e.g. heavy rainfall in short time span), is causing devastating effects (e.g. landslides) in Bangladesh, which also has lower capacities to deal with the consequences of climate change (Cities and climate change: global report on human settlements, 2011). Particularly in Chittagong Metropolitan Area (Figure 1.1), where many urban dwellers and their livelihoods, quality of life, property and future prosperity are being continuously threatened by the risks of rainfall triggered landslides that climate change is expected to aggravate.

In addition, there is no strict hill management policy within CMA. This has encouraged many informal settlements along the landslide-prone hill-slopes in Chittagong. These settlements are being considered as illegal by the formal authorities. Besides, the settlers demand themselves as legal occupants while they have no valid documents of possession. Yet they can rent out such vulnerable houses because of their political power or ties with government officials. This is how; there is acute land tenure conflict among the formal authorities, the settlers and the local communities over the past few decades. This kind of conflict has also weakened the institutional arrangement for reducing the landslide vulnerability in CMA.

Figure 1.1: (a) Location of the study area in Chittagong hill tracts and **(b)** location of CMA



Devastating landslides have hit Chittagong repeatedly in recent years. Landslides triggered by heavy rains in Chittagong claimed at least 185 lives in the last seven years and 127 in 2007 alone. The disasters took place in Lalkhan Bazar, Motijharna, Tankir Pahar, Batali Hill, Akber Shah and Pahartali areas. After the disaster the Divisional Hill Management Committee was formed. Recent news says that the committee listed around 2,500 people for rehabilitation but many of them have been left out and returned to the previous places as they have no other cheaper and suitable places to live in. An estimated 10,000 people are currently living in such vulnerable areas. Patenga Met Office forecasts that light to moderate rain may continue over the coming weeks as the monsoon persists from June to September (Chakraborty and Uddin, 2014).

It is, therefore, essential to develop an early warning system for the hilly areas of Chittagong Metropolitan Area (CMA) incorporating local knowledge to reduce the loss of lives and property. The aim of this project is to create a dynamic website that will warn the landslide vulnerable communities of CMA in advance. This will help to enrich the landslide mitigation strategies for sustainable mountain development.

From the very beginning of this project, it is important to understand the process and pattern of landslides of a particular area from the records of landslide events of previous years. But there is no such record for vulnerable hills in Chittagong Metropolitan Area. Only the landslide events with casualty to death take attention through newspaper and media. At this stage, a detailed inventory of the landslide areas will be prepared and will be helpful while preparing the susceptibility map using data driven model.

1.3 OBJECTIVES OF THE STUDY

The main objective of this inventory is to prepare an informative report to understand the process and mechanism of previous landslide events occurred in Chittagong Metropolitan Area (CMA). For this, following factors will be studied:

(a) Landslide classification (using different available schemes)
(b) Landslide dimensions (different widths and lengths)
(c) Landslides activity and its distribution (advancing, enlarging, moving, widening etc.)
(d) Rate of movement of landslides (extremely slow to extremely rapid)
(e) Potential causes of landslides (geological, morphological, physical, human induced etc.)
(f) Landslide triggering mechanism (excessive rain, water level change, earthquake, human activities)
(g) Factors influencing slope stability (gradient, slope geometry, stress, vegetation, disturbance etc.)

1.4 LITERATURE REVIEW

Landslide is a term generally used to describe the downward movement of soil, rock, and organic materials under the effects of gravity and also the landform that results from such movement (Highland & Bobrowsky, 2008). It is a common geographical phenomenon in the mountainous areas includes movement of ground with rock, debris; mud etc. This is a complex type of natural phenomenon either caused by geophysical or hydrological processing. The frequently used terms to address landslide are mass movement, mass wasting, slope movement. A landslide might be shallow or deep seated. Landslides are mostly sporadic, localized and dispersed in nature that's why these not receive maximum media attention like other hazards which hit instantaneously and cause widespread losses and human suffering, such as earthquakes, floods, cyclones and hurricanes. But statistics shows that this is one of the most catastrophic geological hazards causing extensive economic losses, physical damages and fatalities all over the world. According to EM-DAT(2014), between 2000 and 2014 landslides killed approximately more than6000 people in South Asian country whereas in the America and Caribbean region the death toll is 519 for twenty landslide events within this period. A landslide or slope failure may be initiated by natural processes or by human intervention. The natural process involves the slope topography, relief, geological condition, material etc.

1.4.1 Landslide worldwide

According to EM-DAT (2014), landslide killed about 7612 people all over the world with massive economic damage. **Table 1.1** shows the spatial distribution of landslide events occurrence in the period of 2000 to 2014. The number of reported natural disaster in 2013 is 324 among them twelve were landslide events in different countries. In this year Asia accounted nine devastating landslide which killed 238 people whereas America accounted three landslide events.

The six Asian countries share the top 10list in terms of number of people killed due to landslide hazard with 53.4% of global reported disaster fatality, while the other countries are located in Europe, Africa, Southern and Northern America (EM-DAT, 2014; Guha-Sapir et al., 2013).

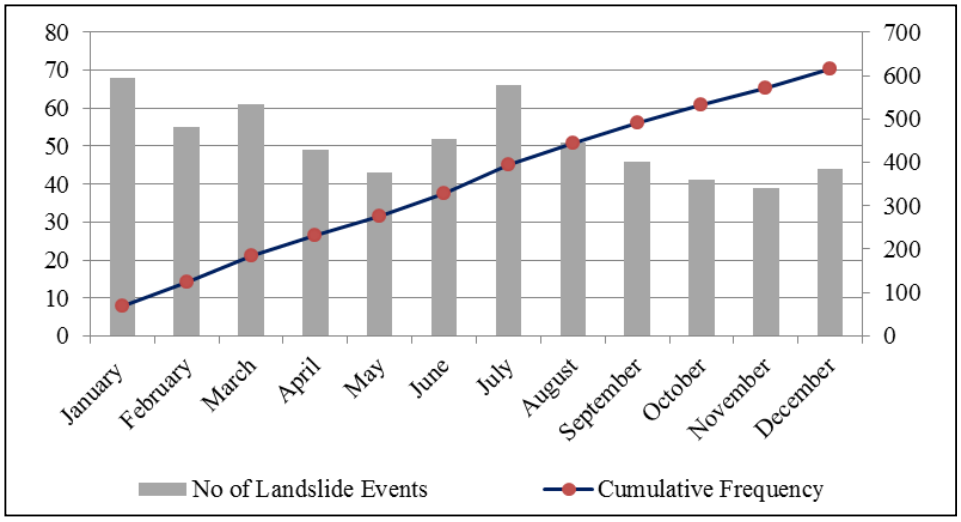
Among the reported landslide in 2013, four of them were in China where the loss of life was about 157. In terms of economic damage, Peru shows highest loss of about 200,000 million US dollar and China in second position. The landslide of Yunnan province in China alone caused total economic loss of 8000 million US dollar. Apart from the population and economic damage, landslides threaten some of the world's most precious cultural sites, including Egypt's Valley of the Kings and the Inca fortress of Machu Picchu in Peru. Landslides are considered as the most destructive hazards in developing countries, particularly where urbanization rate and population growth rate is high, intensive land use and deforestation or mining practices. For example on 17th February 2006, a huge landslide on the island of Leyte in the Philippines caused about two hundred deaths and about 1000 people disappeared in the debris flow. Very recently on 20thAugust 2014, at least 36 people were killed by torrential rainfall triggering landslide which including number of children in the Hiroshima city of Japan(ADRC, 2014). The temporal distribution of landslide occurrence shows similar pattern and July shows the highest number of total landslide events. **Figure 1.2** shows the frequency of the landslide occurrence in all over year from 1950 to 2014.

Table 1.1: Worldwide distribution of devastating Landslide occurred between 2000 and 2014
Source: EM-DAT,2014

Area	**No of landslide events**	**No of fatalities/killed**	**No of affected people**
Africa	21	710	34850
Central Asia	11	142	31605
East Asia	47	3468	2184428
Western Asia	8	204	849
South Asia	30	1543	650222
Central America	17	395	63127
South America	36	1150	163782
Total	**170**	**7612**	**3128863**

Figure 1.2: Temporal occurrence of landslide events between 1950 and 2014

Source: *(EM-DAT, 2014)*

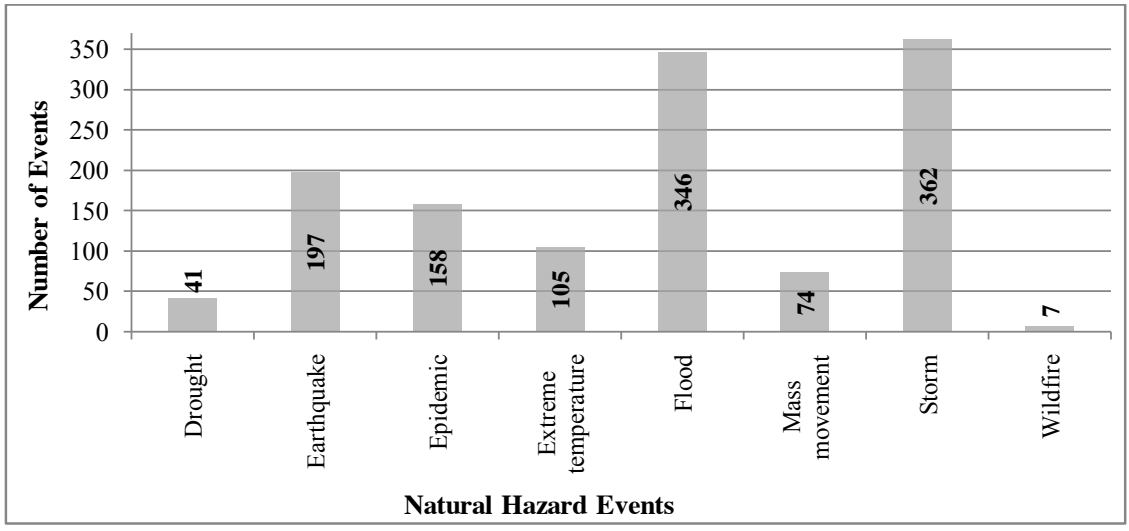


1.4.2 Landslide in South Asia

Landslides cause substantial damages and injuries to the Himalayan regions of Pakistan, Afghanistan, India, Nepal and Bhutan. Some other parts of India, Bangladesh and Sri Lanka also suffer from it. It is estimated that 30 per cent of the world's landslides occur in the Himalayan region(SAARC, 1992). Li (1990) estimates that the annual economic loss due to landslide damage alone in the Himalayan region exceeds one billion US dollars along with the loss of hundreds of human lives. Mass movements mainly occurs in four principle geographical settings: in Hindu Kush- Himalaya including Outer/ Sub Himalaya (Siwalik Hills), Lesser and Higher Himalaya; hill tracts of north-east India and Chittagong (CHT) of Bangladesh; Western Ghats of India and hill tracts and central high land of Srilanka (Chapagai, 2011). The Himalayan Mountains constitutes with youngest and most dominating mountain system in the world. The total landmass covered by this mountain range is approximately 50 million hectares(SAARC, 1992). Because of its distinctive nature, there are no other mountains in the world having the history of landslide like Himalaya. The main contributing factors for the mass movement in South Asia can be divided into natural and human induced factors. Natural factors include its tectonic settings, strength of rock, climatic variation, topographic and geomorphological conditions etc. The human intervention e.g. unscientific exploitation of the Himalaya,

deforestation, unplanned construction and settlement, mining and quarrying activities combined with its complex geological and heavy rainfall makes the slope instable(Dahal & Pathak, 2011).The most common triggering factor in the South Asian region is prolonged and intense monsoon rainfall. Besides this, in some cases earthquakes induced landslide in India and Pakistan during 2005 which causes about 26500 human casualties. The Asian Disaster Reduction Center (ADRC) has started a new disaster database for worldwide and the data available from 1990's. This database shows that about 96 landslide and mudslide occurred in Asia among them 12 in South Asian country (ADRC, 2014) whereas the Emergency Event Database (EM-DAT) recorded 74 disastrous landslides in South Asia since 1948 which killed more than 10 people (see Figure 1.3).

Figure 1.3: Natural disaster occurrence in South Asia
Source: *(EM-DAT, 2014)*



Among the eight South Asian countries, the statistics of EM-DAT shows that India severely affected by devastating landslides which killed 3479 people and millions of injuries between the year of 1950 to till date. The Himalayan belt of India: Darjeeling, Sikkim, Nilgiris, and southern India mainly susceptible for the landslide hazard. A valley in the Nilgiri hills is called "Avalanches Valley". This range of hill has loose cover of debris consisting of boulders and lateric caps which is susceptible to mass movement. Most of the landslides were either fresh or

reactivation of the old one. In the recent years (2009) about 21 peoples were killed in Darjeeling hills. This landslide triggered by cyclone Aila which causes heavy rainfall. Another devastating landslide triggered in Mumbai which killed at least 11 people and injured more than 10 people. Landslides are major natural disaster in Nepal because of its geographical location, geological characteristics, unpredictable climatic variation (intense rainfall), and human intervention in unplanned settlement development, agricultural activity in the fragile hill slope and landslide vulnerable area. The average annual rainfall in the central region of this country is 2000 mm to 3000 mm. In addition to these, stone-quarrying, improper mining and dam construction also aggravates landslides events in Nepal. The major landslide prone in Nepal is Siwalik range which is composed of weak sedimentary rocks, Lesser Himalaya and part of Higher Himalaya. Majority of the landslide events found in the eastern, central and western part of Nepal. This distribution of landslide mainly varies due to the topography and amount of rainfall. On 2nd August 2014, a massive devastating landslide triggered by incessant rainfall Sindhu palchowk District. This landslide killed 33 people and fully or partially damaged 171 houses in the affected area (SDMC, 2014).

Figure 1.4: Devastation scenario of the Hiroshima Earthquake, Japanin, 20 August, 2014
Source: *SDMC, 2014*

Figure 1.5 Rescuers search for victims after a landslide, triggered by rainfall which buried 18 primary school children in southwest China's Yunnan provincein October 2012
Source: *The DAWN*.

Figure 1.6 :Nepal landslide blocks the river
Source: *AFP Kathmandu, 2014*

Figure 1.7: Landslide 2008 in Nepal
Source: *AFP Kathmandu, 2014*

Figure 1.8: Fetal landslide event in 2010 at Kashmir, India which destroyed the buildings completely
Source: *AFP, 2014*

Mass movement is very common phenomenon in Pakistan, especially in the mountain region of the north and northwest. During the rainy season, landslides take place in the Northwest province, Kashmir, Punjab and Baluchistan. Mass wasting in the form of soil creep (as slow as a fraction of a millimeter per year) is also common in Baluchistan and the hilly areas of the Sindh province. Petley (2006) estimated the earthquake induced landslides in Kashmir killed over 20,000 people. Furthermore, in 2007 two devastating landslides hit the mountainous villages and

blockade the roads which hampered the rescue activities in the remote area. This landslide caused by four day long heavy rainfall and killed at least 40 people in several areas in Kashimir region. According to EM-DAT, in 2010 a landslide killed at least 19 people and affected 26700 people in the northern part of Pakistan.

The fragile geological condition, rock material, steepness of the slope, heavy precipitation and poor drainage makes Sri Lanka vulnerable to landslide. Besides this, haphazard and unplanned land use, inappropriate construction method, hill cutting leads Sri Lanka susceptible to landslide. The extent of the landslide area in Sri Lanka is about 30% of its total land area(Bandara, 2005). The statistical data shows that the number of landslide events has been increasing from 2003 but the fatalities is relatively less than other South Asian countries. The recorded landslides are high in the month of May and June and again in November to January(DMC, 2009).The spatial distribution of landslide shows that most of the events occurred in the Southern, Uva and Central province. On 11th January 2007, the Ritiella landslide occurred in Walapanesub division of Nuwara Eliya district which completely destroyed nine houses and affected almost 86 families (SDMC, 2007). This area consists of colluviums soil materials deposited by old landslides in the past. The government of Sri Lanka has been working to reduce the landslide vulnerability of the people. The National Building Research Organization (NBRO) under the Ministry of Disaster Management is mainly working for all kind of landslide related studies and services.

1.4.3 Landslide in Bangladesh

Bangladesh is a low-laying floodplain area of Ganges delta in South Asia. Geologically it is part of the Bengal Basin which has been filled by sediments washed down from the highlands on three sides of it, especially from the Himalayas. Because of the geographical location Bangladesh experiences highest amount of monsoon rainfall and annual average rainfall among the SAARC countries (Ahasan et al., 2011). The whole country has two different distinctive geographical features with flat land (82%) and hilly regions (18%) in the North, North-East and South-East part. According to geological data, hilly region of Bangladesh developed in tertiary age. Bangladesh is highly vulnerable to different natural hazards: flood, cyclone, landslides,

drought, earthquakes are very frequent. As per the statistics of EM-DAT from 1950 to 2014, total 306 natural disasters occurred in different portions of this country which affects more than 40 million people and stranded about more than 14 million people. Landslide is becoming one of the regular geological hazards especially in Chittagong, Chittagong Hill tracts, Cox's 12azaar region. A significant number of landslide hazard locations exist in those urban areas that make many communities vulnerable to slide which may result in severe damages and socioeconomic losses. The characteristics of soft sedimentary and unconsolidated rocks in the hilly terrains, soil structure across the hilly area makes the slope instable as a consequence caused fatal landslides(CDMP-II, 2012).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 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.

The statistics shows that landslide caused death of more than 300 peoples in Bangladesh since 2000, with a loss of hundreds of houses and millions of dollars of properties(Sarwar, 2008).The rapid and unplanned urbanization with adverse climatic variation (intensive rainfall) increases the landslide risk in this region. CDMP-II (2012) identified the major causes of landslide in

Bangladesh which involves 1) removal of lateral support: a) erosion by rivers, b) previous slope movements such as slumps that create new slopes, c) human modifications of slopes such as cuts, pits, and canals; 2) increase of load to the slope: a) accumulation of rain water, b) increase in vegetation, c) construction on fill, d)weight of buildings and other structures, e) weight of water from leaking pipelines, sewers, canals, and reservoirs; 3) earthquakes; 4) removal of underlying support: a) undercutting by rivers and waves; b) swelling of clays; 5) anthropogenic activities as jhum cultivation. Government of Bangladesh has taken many initiatives to reduce the landslide risk from the vulnerable area.

1.4.4 Landslide in Chittagong

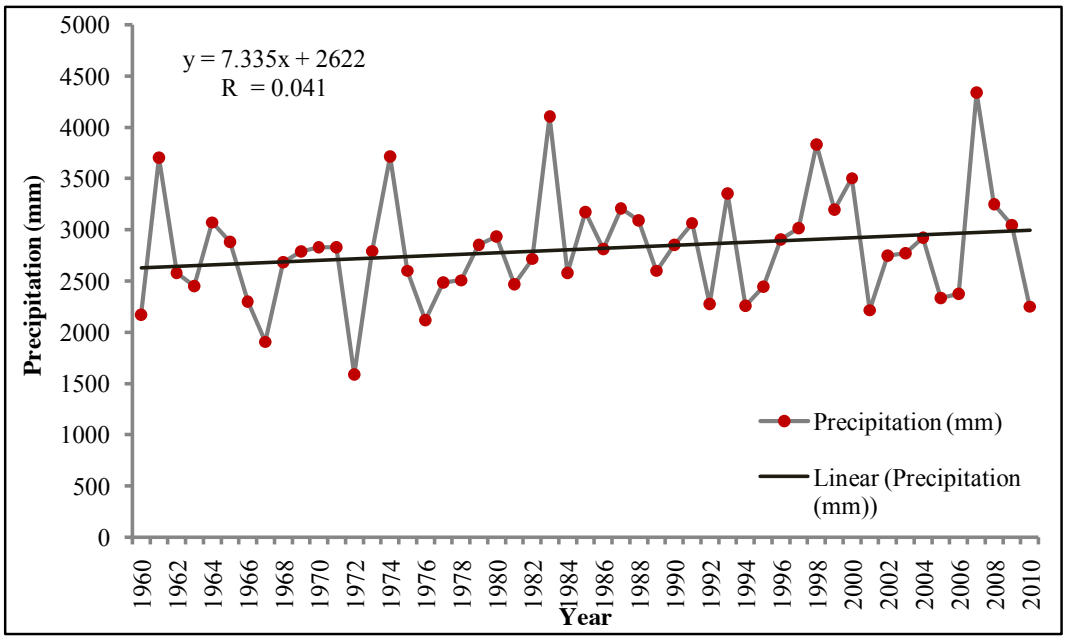
In Bangladesh landslides events mainly occur in the Chittagong and Chittagong hill tracts area. Chittagong is the largest port city and second largest city of Bangladesh which contributes substantial role in the economic development of Bangladesh. Landslide occurred frequently in Chittagong hilly region due to extreme uninterrupted monsoon rainfall. The devastation aggravates along with weak structure, unplanned and erratic use of hills and settlement development. 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(Ahammad, 2011). As a result population density is increasing and demand of land going up. Thereby people in the urban area occupied the vacant government and privately owned land both legally and illegally and built informal settlement without following any rules and regulation. The development authorities of Chittagong have identified 30 risky hills in this city namely Matijhorna, Lalkhan Bazar, TankirPahar, Batali Hill, GolPahar, AK Khan Pahar, etc(Chakraborty & Uddin, 2014).Here people are living at the toe and on the slopes of hills with high risk of landslides and associated damage. In 2007 monsoon started with unprecedented heavy rainfall, intensified by a storm from the Bay of Bengal on 9–10 June. The heavy rain caused mudslides, which overwhelmed slums in the foothill areas of the large city of Chittagong on 11thJune 2007. The death toll was reported to be at least 128, including59 children, and more than 150 people were injured (SDMC, 2007).

Figure 1.9 illustrates the average annual rainfall distribution pattern over the time period of 1960 to 2010, where it is clear that a highest pick of precipitation was in 2007 with 4340 mm. Another landslide event occurred on 18 August of 2008 in Matijhorna area of Lalkhan Bazaar and killed 11people of the two whole families. Furthermore in June 2010 a rain-induced massive slide occurred and killed about 66 people including army personnel and injured 100 people (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 slum area of Lalkhan Bazar. The victims were buried at their home while they were sleeping and the houses were made of tin. In this event the mostly effected were women and children. 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 of occurrence. Due to this heavy and intensive rainfall about 90 people killed in different areas of the city (Lebu Banagn, Foy's lake) and surroundings (BBC, 2012; Rubel & Ahmed, 2013).

Figure 1.9: Trend of annual average rainfall pattern of Chittagong
Source: *Rubel & Ahmed, 2013*



Different studies identified the reason of landslide in the Chittagong area. The main causes can be summarized as follows:

- **Rainfall:** The rainfall characteristic in Chittagong district is different from the other districts in Bangladesh because of its geographical location. Usually in the monsoon period the rainfall shows highest precipitation. Most of the landslide in this region

occurred due to the incessant and prolonged rainfall. A heavy rainfall during a shorter period of time leads to a fatal landslide events in this hilly area. A study by Yalcin(2007)

showed that an intense rainfall of greater than or equal to 70mm per hour is conducive to occur a landslide. Rainfall in Chittagong is second highest in the country with an annual average of approximately 2500 mm per year, with maximum recorded rainfall in monsoon period (June-July). The month of June and July shows most landslide frequency in Chittagong and shows strong correlation between heavy rainfall and landslides in the country (Sarwar, 2008).

- **Indiscriminate Hill cutting:** In Chittagong city and its surrounding area hills are indiscriminately flattened and diminishing by the reckless people. They cut the hill for building construction, residential development, road network development, clay and sand mining. Because of hill cutting, the slopes become instable. The hill slopes are being steeped day by day and where hill cutting exist the slopes varies from 70-80 degrees. The recent landslide in Chittagong city was the result of hill cutting and steep slopes of the hills. The most affected areas because of indiscriminate hill cutting are Khulshi, Panchlaish, BaizidBostami, Kotowali, Lalkhan Bazar, Sholoshahar, Foy's Lake, Pahartali and Polytechnic area. The hilly areas are located in the heart of the city. Because of rapid urbanization in the Chittagong city the land value is rising. Informal, low class residential settlement, high class residential area and commercial buildings are being established in the hill cutting area which threatens lots of families and life to landslide. Besides the erosion and landslide susceptibility hill cutting deteriorates the natural drainage system, biodiversity (Alam et al., 2005).

- **Soil structure of the hills:** Soils mainly consist of fine grained silt (90%) and rests are the sand and clay. During the monsoon and heavy rainfall water dissolves the constituents of the soil of hills and creates pore water pressure thus loosen its compaction. The steep land shows impervious characteristics of soil and uninterrupted rain runs off its surface

instead of seeping into ground(Lynch & Hack, 1988). The steep slope of the hill cannot allow the weight of the wet soil or mud which results the landslide or mudflow.

- **Deforestation in the hilly area:** Deforested areas of hills are easily exposed and top soils are eroded by surface run-off or by wind erosion. The vegetation covered areas are less vulnerable to landslide than deforested area (Sarwar, 2008).Plant cover protects earth surface from erosion and roots of tree stabilizes the strength of soil compaction thus reduce soil erosion.

- **Other cause:** Seismic activity and abnormal tidal flow in the city might have contributed to landslide in Chittagong; in addition to heavy precipitation and hill cutting(Sarwar, 2008). Seismic activities destabilize the soil structure which triggered massive landslide. Besides hill in the Chittagong city its one third areas are covered by low land that experience abnormal tidal flow during monsoon period. The tidal water level flowed at a higher level of one and a half to two meter higher than the average tidal height. As a consequence the soil of hill saturates and loses its compaction.

Figure 1.10: Neighbors attempting to rescue the victims of the 28 July 2013 Chittagong landslide
Source: *The Daily Star, 2013*

Figure 1.11: Bangladesh Army rescuers search for survivors and bodies following landslides on the outskirts of Chittagong, Bangladesh on June 27, 2012.
Source: *The Daily star 2012*

Figure 1.12: Existing condition in the most landslides prone of Chittagong City: a) Instable slope near Batali Hill b) View from Tankirpahar in Matijhorna area where in foothill informal settlement with high landslide risk c) Residential Buildingsbuilt by cutting hills d) Hill cutting near Batali Hill area. Source: *Field survey, August 2014*

1.4.5: State of Art of Landslide Early Warning System

The United Nations defined Early Warning System (EWS) as "the set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss"(ISDR, 2009). The timely and effective information through institutions allows individuals to be less exposed to a hazard and time for preparation.

In general warnings should be given sufficiently far in advance of the event to enable protection of both life and property. An early warning system includes the following components (Westen et al., 2011):

- Understanding, and mapping the hazard;
- Monitoring and forecasting impending events;
- Processing and disseminating understandable warnings to political authorities and the population, and
- Undertaking appropriate and timely actions in response to the warnings

Different hazards need different monitoring systems. Different techniques either instrument or remote sensing based early warning systems are now-a-days applied. Because of the technological advancement the availability, reliability and accuracy of short term disaster warnings have been increased, particularly in cases of heavy rainfall, storms, floods, wild fires, volcanic eruptions, tsunamis and crop damage etc. All over the world the real-time monitoring and early warning systems are being adopted and implemented which is critical to protect the life of people and property.

In the landslide prone urban area the number of populations and infrastructures are expanding rapidly which is increasing the potentiality of human loss and properties from slides. The early warning system is important for landslide risk management which essentially could reduce the

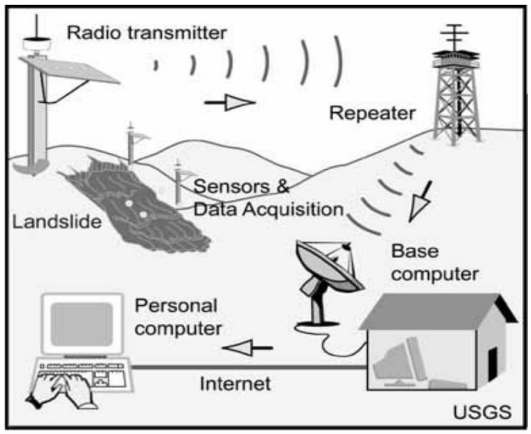
massive social and economic losses. Since a landslide can be triggered by heavy rainfall therefore monitoring is crucial to predict the behavior of landslides and forecasting which storms can cause large numbers of landslides. Landslide Hazards Program of USGS monitored some selected landslides prone areas and hillsides in United States in order to learn more about the physical processes that triggers sliding or to control their movement (USGS, 2013). Figure 1.13 shows a typical components of the employed EWS includes field sensors, field data acquisition system, remote communications (here via radio telemetry), data processing (on a base computer) and data dissemination (via the Internet).

Advancement of instrumentation increases the capability to detect the precursor activity before a landslide or debris flow from the scale of a single landslide to regional level. This can be incorporated in the hazard mapping and real-time monitoring. The monitoring and investigation of landslide process can be done by the advance digital photogrammetry, multi-temporal Synthetic Aperture Radar differential interferometer (DInSAR), high resolution airborne or terrestrial LIDAR data, optical and radar satellite imagery. The data from radar sensors integrated with GPS, laser scanner and in situ information can improve significantly the capabilities to detect, characterize and monitor ground deformations and also infrastructure instability. Besides remote sensing, the geophysical data are frequently used to assess the seismic reflection, surface wave analysis and seismic/electrical tomography. Since most of the landslides are triggered due to intense rainfall, the monitoring of rainfall in the area can be used to forecast the possibility of landslides in the area.In addition to this, contributions of effective institutional structures and integration of local people, including community-based approaches and studies regarding the response of local populations to warning and evacuation makes more efficient.

Effective development and operation of debris-flow or rapid landslide early warning systems are dependent on creation of several major resources. These include reliable landslide susceptibility or hazard maps, geographically specific warning thresholds, meteorological and geotechnical monitoring networks, and the computer and communications networks needed to support the operation. Rain gage, soil moisture, and pore pressure monitoring networks and expanded weather radar coverage for landslide prone hillside areas are needed for accurate

warnings, particularly in localities of high or frequent debris-flow incidence (Baum & Godt, 2009).

Figure 1.13 : A ground-based, near-real-time landslide monitoring system implemented by USGS(Reid et al., 2008)



1.4.6 Practices and Implementation of Landslide Early Warning System in South Asia

The researchers emphasized that the future earthquake events in the Himalayan region will continue to create landslide disasters. Despite this threatening environment, there is almost no work on Landslide Early Warning System in South Asian countries. There many researches on landslide hazard mapping in Bangladesh, India, Nepal, and Pakistan. There are almost no researches on landslide early warning system in the Himalayan region which shares 35% of the total fatalities due to landslide in the world.

However, recently under the Comprehensive Disaster Management Program-II, Ministry of Disaster Management and Relief of Bangladesh worked on rainfall triggered landslide hazard zonation in Cox's Bazar & Teknaf Municipalities as well as introducing community-based early warning system for Landslide Hazard Management. In this project the slope modeling was done for those aforementioned areas to identify the susceptible areas to be failed triggered by heavy rainfall. This pilot project on community-based early warning system was also implemented by

this project for managing landslide hazard in Bangladesh (CDMP-II, 2012).Under this pilot project the community people were trained about how the EWS works for landslide and how they will respond during the period of monsoon, how they will communicate with the community people etc.

Sri Lanka has recently installed few community-based early warning systems taking rainfall threshold as a key factor. The NBRO prepared and implemented the landslide hazard zonation map for the 10 landslide susceptible districts, landslide risk investigation and guidelines for land use planning and construction techniques in the landslide prone areas of Sri Lanka. They are also providing the land slide early warning in the landslide prone areas based on rainfall and severity of landslide potentiality.

Since Pakistan is one of the most landslide affected areas, to reduce the devastating effects an early warning system for landslides was set up by JICA. For landslide EWS two sites were selected in Muzaffarabad which are mostly prone to hazard. Ten wooden battens, two digital extensometers along with two rain gauges were installed to monitor the slope movements. The extensometer installed in Ranjata area was then connected to a siren to warn the community. The system is working as: the installed instrument observe the ground movement more than the specified one, then it sent signals to the alarm unit, which would then activate the revolving light and the siren to warn the community of the danger of landslide. Necessary settings were made in order to prevent false alarms due to contact by animals or human error. The instruments were installed in the wooden boxes to protect them from water and direct sunlight, as well as from security point of view. All the wood used in the installation had properly been painted in order to protect it from severe weather conditions (GSP, 2014).

1.4.7: Landslide mechanism

Vast literatures have been reviewed to understand the landslide mechanism. A summary of landslide mechanism has been given below.

Type of Movement

Fall: Falls comprises a detachment of slope materials from a steep slope or cliffs and more or less free and extremely rapid descent of the material (Figure 1.14) (Dahal and Pathak, 2011).

Topples: A topple is a forward rotation of slope materials out of the slope about a point below the center of gravity of the displaced mass. The titled mass subsequently falls by bouncing or rolling down the slope (Figure 1.14) (Dahal and Pathak, 2011).

Slides: Slides refer to the movements of soil or rock along a distinct surface of rupture or slip surface, which separates the unstable materials from more stable underlying material (Dahal and Pathak, 2011)

Lateral spread: Spread is an extension of a cohesive soil or rock mass combined with a general subsidence of broken mass of cohesive material in to underlying materials (Dahal and Pathak, 2011)

Flow: Material near surface runs at a higher velocity than the underlying material (Figure 1.17). Two types of flow (Dahal and Pathak, 2011).

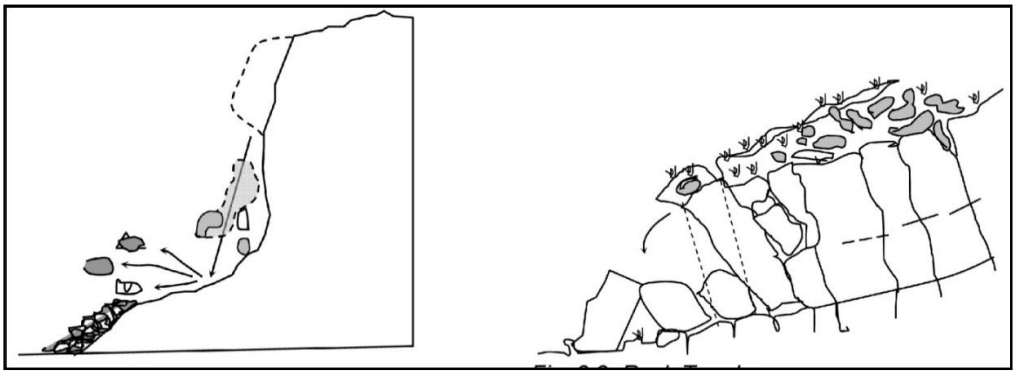
Surry flow: Sediments contain 20%-40% water

Granular Flow: Sediments contain 0%-20% water

Creep: Creep is the slow down slope movement of the soil mantle where the long term gravitation shear stress is large enough to produce permanent deformation (Dahal and Pathak, 2011)

Figure 1.14: (a) Rock fall and (b) topple

Source: *Dahal and Pathak, 2011*



(a) **(b)**

Figure 1.15: Earth slide

Source: *Dahal and Pathak, 2011*

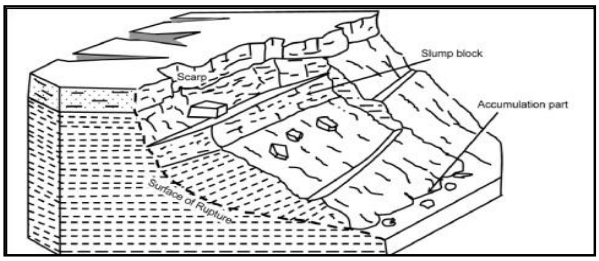


Figure 1.16: Rock spreading

Source: *Dahal and Pathak, 2011*

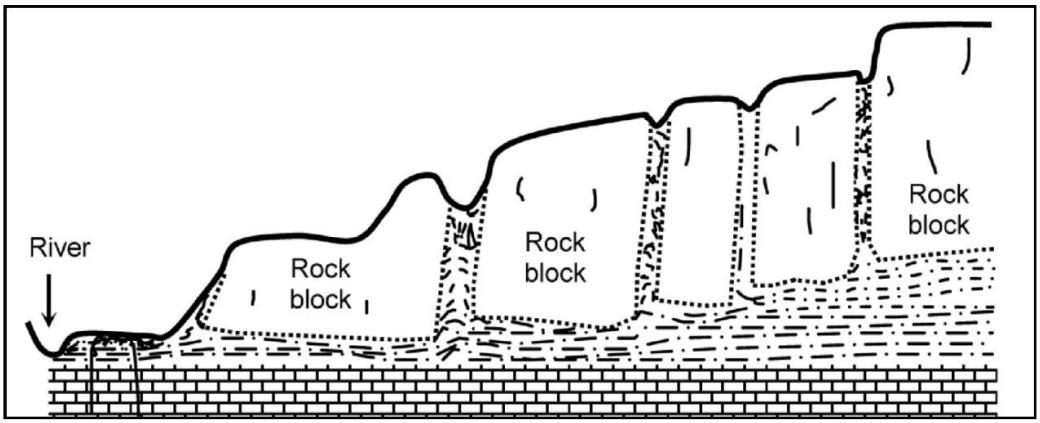


Figure 1.17: Flow

Source: *Dahal and Pathak, 2011*

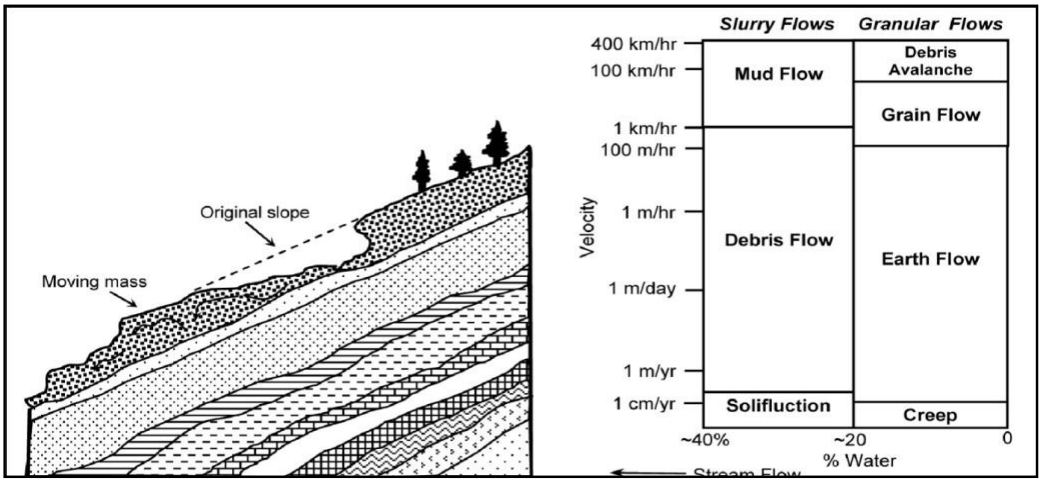
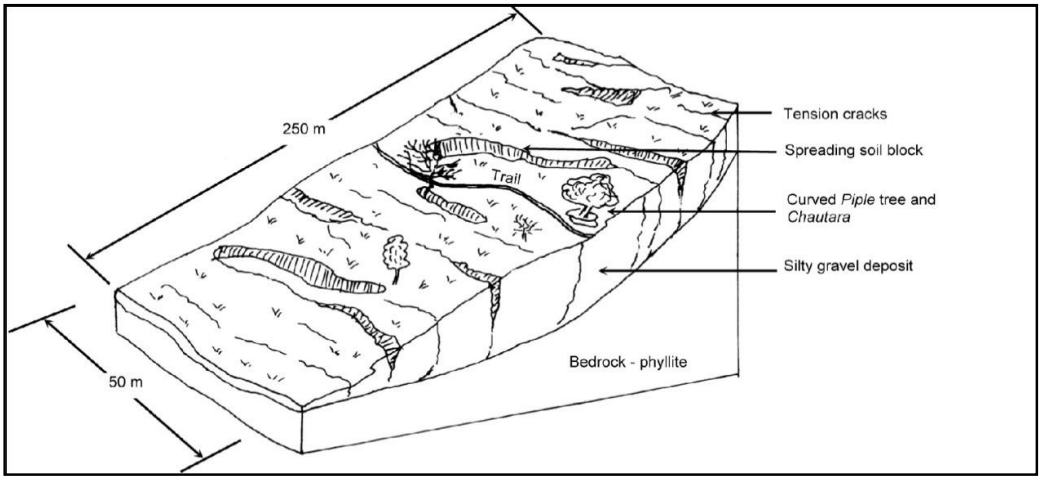


Figure 1.18: Sketch of soil creep

Source: *Dahal and Pathak, 2011*



Distribution

Advancing: If the surface of rupture is extending in the direction of the movement, the landslide is advancing (Cruden and Vandine, 2013)

Retrogressive: If the surface of rupture is extending in the direction opposite to the movement of the displaced material, the landslide is retrogressive (Cruden and Vandine, 2013).

Widening: If the surface of rupture is extending into one or both flanks of the landslide, the landslide is widening (Cruden and Vandine, 2013).

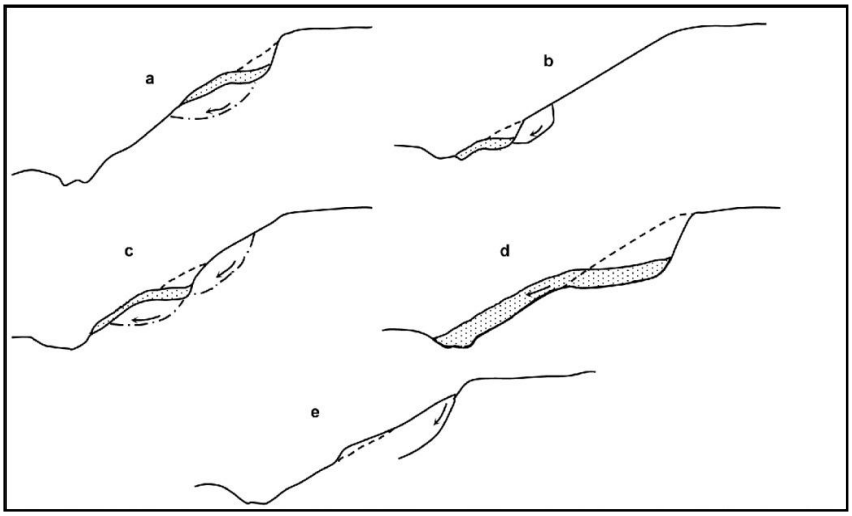
Confined: If the surface of rupture is not visible and there is a scrap only at the foot of displaced mass, the landslide is confined (Cruden and Vandine, 2013).

Diminishing: If the volume of the displacing material is decreasing, the landslide is diminishing.

Moving: A landslide in which displaced materials continue to move but whose surface of rupture show no visible changes is named as moving (Cruden and Vandine, 2013).

Figure 1.19: Displacement of landslide in different states of activity

Source: *Cruden and Vandine, 2013*



Type of material

Rock: Rock is a natural aggregate of minerals that cannot be readily broken by hand and that will not disintegrate on a first wetting and drying cycle (Cruden and vandine, 2013).

Soil: Soil is an aggregate of solid minerals and rocks that is either fragmentary or can be readily separated by agitation in water (Cruden and vandine, 2013)

Debris: the distinction between earth and debris is usually made by comparing the percentage of coarse grain size fractions. If the weight of the particles with a diameter greater than 2 mm is less than 20%, the material will be defined as earth; in the opposite case, it is debris (Landslide classification, (Cruden and vandine, 2013)

Water content

Dry: No moisture visible (Cruden and vandine, 2013).

Moist: Material has some water but no free water; the material can behave as a plastic solid but does not flow (Cruden and vandine, 2013).

Very wet: Material contain enough water to flow as a liquid under low gradients (Cruden and vandine, 2013).

Style of Activity:

The manner in which different movements of the displaced mass contribute to a landslide is referred to as the style of activity (Cruden and vandine, 2013).

Single: A single movement refers only one mode of movement often as an unbroken mass of displaced material (Cruden and vandine, 2013).

Successive: Two sequential identical modes of movement that do not share displaced material or a rupture surface (Cruden and vandine, 2013).

Multiple : repeated movements of the same type that share displaced material or a larger rupture surface an occurrence that typically follows the enlargement of the rupture surface (Cruden and vandine, 2013).

Composite: Composite refers to different modes of movements in different areas of the displaced material, sometimes simultaneously; sometimes sequentially the movement that occurs at a higher elevation is considered the first movement (WP/WLI, 1993 b)

Complex: sequential different modes of movement. (Cruden and vandine, 2013).

State of Activity:

State of activity describes the status of landslide movement (Figure 1.20)

Active moving: Moving at present season (1 of Figure 1.20) (Cruden and vandine, 2013).

Suspended: Landslide occurred at last cycle of seasons, but not currently occurring (2 of Figure 1.20)

Reactivated: Earth is moving again after being inactive; typically because of similar causes and on a pre-existing rupture surface (3 of Figure 1.20) (Cruden and vandine, 2013).

Inactive: Landslide last moved more than one cycle of seasons ago (Cruden and vandine, 2013).

Dormant: It seems that no movement would take place but the causes of movement remain (5 of Figure 1.20) (Cruden and vandine, 2013).

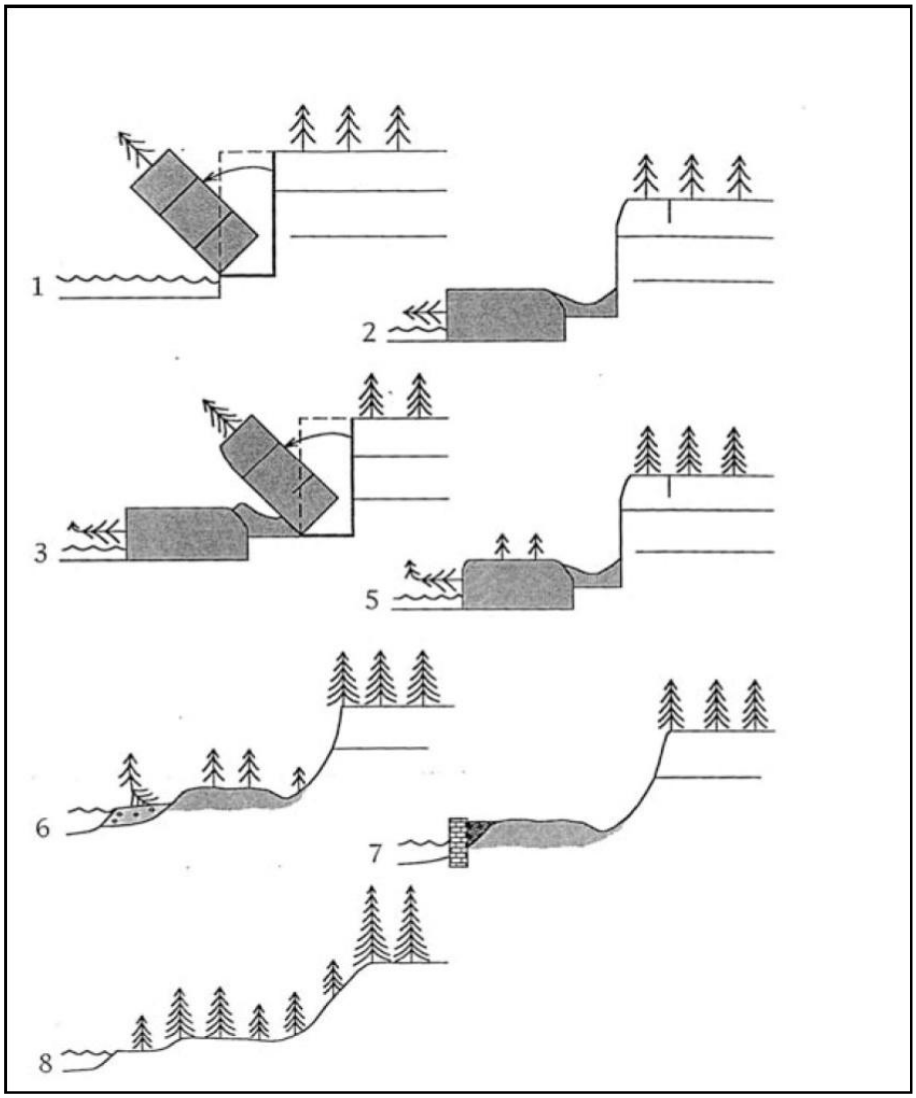
Abandoned: Causes of movement changed naturally; for example, an eroding river has shifted its channel away from the toe of the landslide; typically long term (6 of Figure 1.20) (Cruden and vandine, 2013).

Stabilized: causes of movement removed naturally (for example, natural armoring or buttressing) or by human endeavors; typically long term (7 of Figure 1.20) (Cruden and vandine, 2013).

Relict: Slope developed under different geomorphologic or climatic conditions (Cruden and vandine, 2013).

Figure 1.20: Different states of activity

(Source: *Cruden and Vandine, 2013*



1.5 Instruments used during field survey:

(a) Measuring Tape:

The displacement of mass has been measured using long fiberglass measuring tape. (Figure 1.21)

Figure 1.21: Survey Instruments (a) Measuring tape, (b) GPS device, (c) Camera

(a)

(b)

(c)

(b) GPS Instrument: Garmin map 62s has been used to collect the GPS values in selected points. (Figure 1.21)

(c) Camera: The photographs of study locations have been captured using Samsung WB100 digital camera. (Figure 1.21)

1.6 Methodology

A methodology has been followed to prepare landslide inventory for Chittagong Metropolitan Area. Methodology has been described below.

Search for information of landslide:

At first, the project team searched for the information of previous landslide events occurred in CMA and their intensity, damages, etc. from newspapers and websites/online documents. Different information related to this study was found. But some other information necessary for

Conducting this project could not be collected from existing achieves. To overcome this reconnaissance survey was conducted.

Reconnaissance survey:

A reconnaissance survey was conducted to gather initial information of the project area/ locations. During this survey, some documents/ information were collected from different stakeholders namely Department of Environment (DOE), Chittagong Development Authority (CDA), Chittagong City Corporation (CCC), Assistant Commissioner (Land) of Chittagong Sadar Circle, Dept. of Soil Science and Dept. of Geography & Environmental Studies in University of Chittagong (CU). A list of vulnerable hills to study was made with the help of the information from DOE and CDA. A draft questionnaire was prepared to gather landslide information (Appendix-A). During reconnaissance survey a field visit was made to justify the contents of questionnaire. On the basis of the feedback found from field interview, the questionnaire was modified later.

Field Survey

Project team conducted the field survey for inventory in the areas of listed hills. During the field survey, it was difficult to identify the exact location of the landslide occurrence. In some cases, the areas were demolished/ lost in such a way that even local people never heard the name of the areas (Chittagong Cantonment, University of Chittagong). After asking so many of the local people, the team found the locations (Appendix-B). Total 57 locations have been identified and classified into 10 clusters (Chapter 2, section 2.3) where landslide events occurred in the previous years and also vulnerable to landslide in near future (Chapter 3).

In this field visit information on location name, coordinates (latitude, longitude), datum and elevation, area of displacement mass, rainfall, landslide mechanism (type of movement, state, distribution, style, water content, material), existing land cover/ use type, causes of movement, landslide history (date of occurrence, duration of rainfall), consequences (casualties, injuries, damages, impacts) and future risk of landslide were collected.

Figure 1.22: Field Survey (a) Taking GPS values, (b) Measuring displacement of mass, (c) Taking Photographs

Source: *Field Survey, August, 2014*

(a) (b) (c)

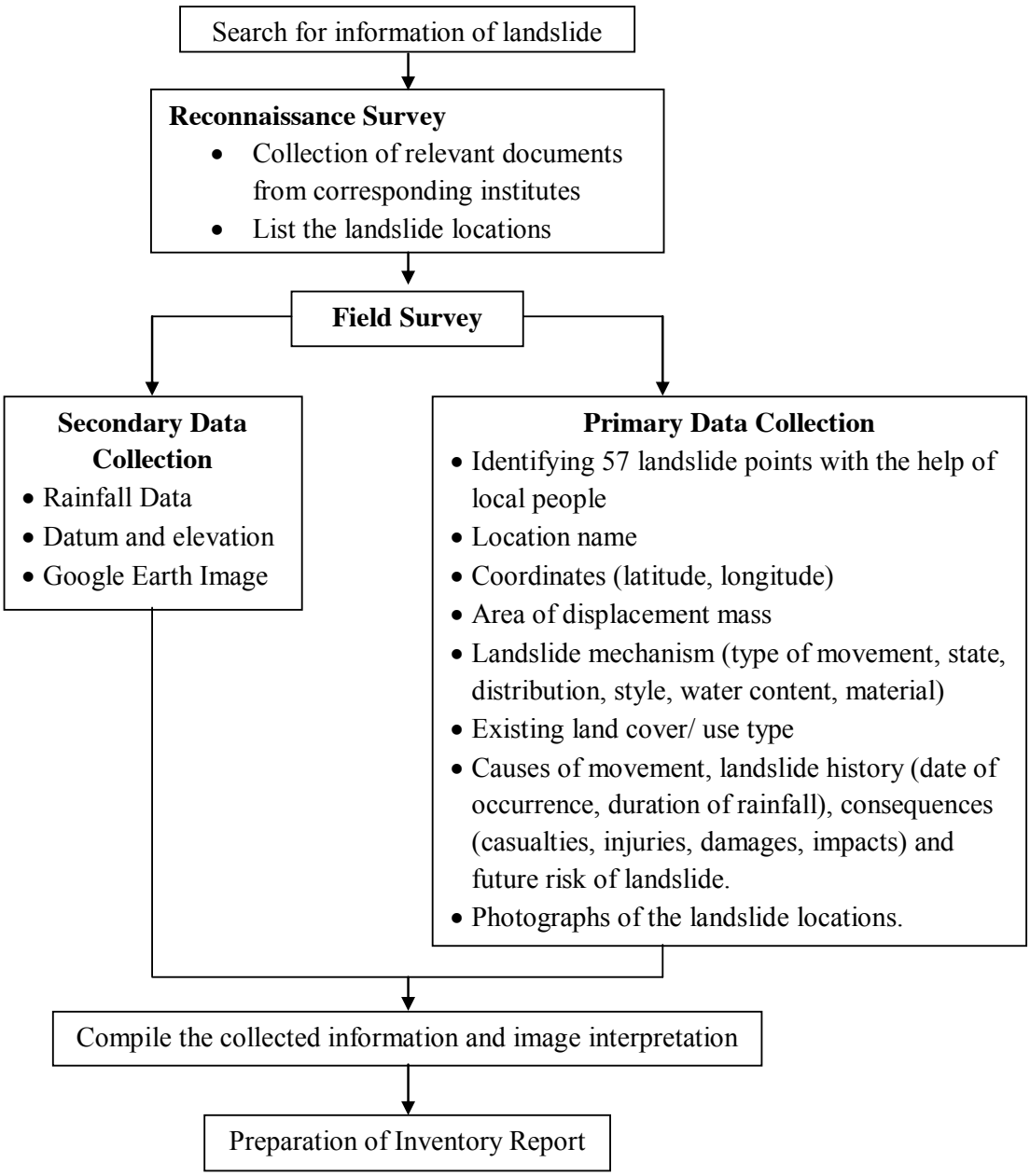
Location name was collected by interviewing people. Coordinate values of landslide locations was collected by using GPS (Figure 1.22-a). In case of some restricted/unreachable places information was collected through interpreting the Google earth image. The displacement of mass has also been measured (Figure 1.22-b). Besides, landslide mechanism, causes of movement, landslide history and consequences have been collected from the local people and the affected people to some places as the collected documents could not provide us with those information. The daily rainfall data have been collected from Bangladesh Meteorological Department up to the year 2010. However, as the exact date of some landslide events could not found from archive or the local people, the rainfall data could not be provided for those landslide events in the detailed inventory report. The future risks have been determined after over viewing the previous consequences of landslide and the opinion of the local people. Throughout the field survey photographs of the landslide areas considering different issues were collected by the project team (Figure 1.22-c).

Preparing landslide inventory:

Finally GPS values have been used to prepare a landslide inventory location Map has by using GIS software. Related information to landslide of different locations has been organized into a report format. Lastly, a detailed landslide inventory has been prepared for the listed 57 landslide points in Chittagong Metropolitan Area.

The process of methodology has been shown in the following diagram:

Figure 1.23: Flow chart of the Methodology



CHAPTER 2: STUDY AREA PROFILE

2.1 CHITTAGONG METROPOLITAN AREA

Chittagong Metropolitan Area (CMA) is located towards South-East of the Capital city of Dhaka which is around 280 KM. Chittagong city is situated on the bank of Karnaphully River and the city is surrounded by rich natural resources like the green Hilly Terrain (Figure 2.1-a) and the Bay of Bengal on the west (Figure 2.1-b). Chittagong is the second largest city, prime sea port and the heart of all commercial and business activities in Bangladesh. Accordingly, the government of the country has already declared Chittagong as the "Commercial Capital" of the country by this time. After the independence of Bangladesh in 1971, Chittagong has earned a significant status of the second important City because of the Chittagong Port, diversified Economic activities, Natural Beauties, Industrial activities and because of its suitable Geographical Location factor in the regional Map (City report of Chittagong, 2006).

Topographically Chittagong is a Hilly City surrounded by Karnaphully River and the Bay of Bengal from different sides contributing the friendly urban growth. At the very beginning, Chittagong Town started to grow as a small Municipality in 1863 that was inhabited by 25,000 people only. In 1864 (the town area 4.5 sq. Miles) the city was reconstituted as Chittagong Municipality. It was further upgraded to Chittagong Municipal Corporation CMC) in 1982 and finally as Chittagong City Corporation (CCC) in 1990. The Chittagong Metropolitan Area (CMA) is administered by the Chittagong City Corporation (CCC) and the Chittagong Development Authority (CDA). At present, CMA area is approximately 775 square kilometres (Bangladesh Transverse Mercator projection) (Yiaser and Bayes, 2013). Chittagong City is inhabited by approximately 6.6 million people (BBS, 2011).

Chittagong is a land on huge Natural Beauty; here there are Natural Gifts like Virgin Hilly region, the Bay of Bengal and the Karnaphuly River. These Beautiful Natural features can be potentially developed with modern Tourist Facilities, which can attract local as well as foreign tourist in the city and surrounding areas. This would obviously enhance the Tourist Industry along with small and medium size Industrial Activities in the whole region, where huge Employment Opportunities could be generated at the same time.

Figure 2.1 (a): Panoramic view of Chittagong city area from the top of Ispahani hill

Figure 2.1 (b): Location of Chittagong metropolitan area (CMA). Source: Banglapedia, National Encyclopedia of Bangladesh, 2012.

2.2 LITHOLOGY AND GEOMORPHOLOGY OF THE STUDY AREA

2.2.1 Soil Characteristics of landslide vulnerable hills

The Chittagong Hill Tracts is originated as a result of the collision between India and Asia. After the breakup of Gondwanaland, Indo-Australian plate combinedly moved southeasterly of about 1750 km at a drift rate of 6 cm/yr. Later India broke apart from Australia and started to drift north northeasterly. That is the time when the history began for the Chittagong Hill Tracts (Chowdhury, 2013).

Central Burma or Irrawaddy Basin represents the back-arc basin and Arakan-Yoma folded belt and its western extension up to Chittagong-Tripura hills, a part of which is the Chittagong Hill Tracts, representing the fore-arc basin. The thick sediments deposited in the Irrawaddy Basin during Miocene and Lower Pleistocene time are exposed in the Chittagong and Tripura hills (Chowdhury, 2013).

In the Chittagong Hill Tracts the Upper Tertiary sandy-argillaceous sediments have been folded into a series of long submeridional (NNW-SSE) anticlines and synclines represented in the surface topography by elongated hill ranges and intervening valleys. The folded structures are characterized by en-echelon orientation with an increasing degree of intensity and complexity toward the east. Accordingly, the folded flank is divided into three parallel almost N-S trending zones from west to east as:

(a) the Western Zone is characterized by simple box-like or similar shaped anticlines with steep flanks and gentle crests separated by gentle synclines, viz Matamuhuri anticline, Semutang anticline, etc;
(b) The Middle Zone is characterized by more compressed structures, other than just simple box-like folds, with ridge like asymmetric anticlines frequently associated with faults and separated by narrow synclines vizSitapahar anticline, Bandarban anticline, Gilasari anticline, Patiya anticline, Changohtung anticline, Tulamura anticline, Kaptai syncline, Alikadam syncline, etc;
(c) The Eastern Zone is characterized by highly disturbed narrow anticlines with steep clipping flanks and mostly associated with thrust faults, vizBelasari anticline, Subalong syncline, Utanchatra anticline, Barkal anticline, Mowdac anticline, Ratlong anticline, Kasalong syncline, Sangu Valley syncline and few others (Chowdhury, 2013).

Figure 2.2 and figure 2.3 give more ideas about the geological condition.

Figure 2.2: Geological Map of CCC and its surrounding areas

Source: *Geological survey of Bangladesh (GSB), 2013*

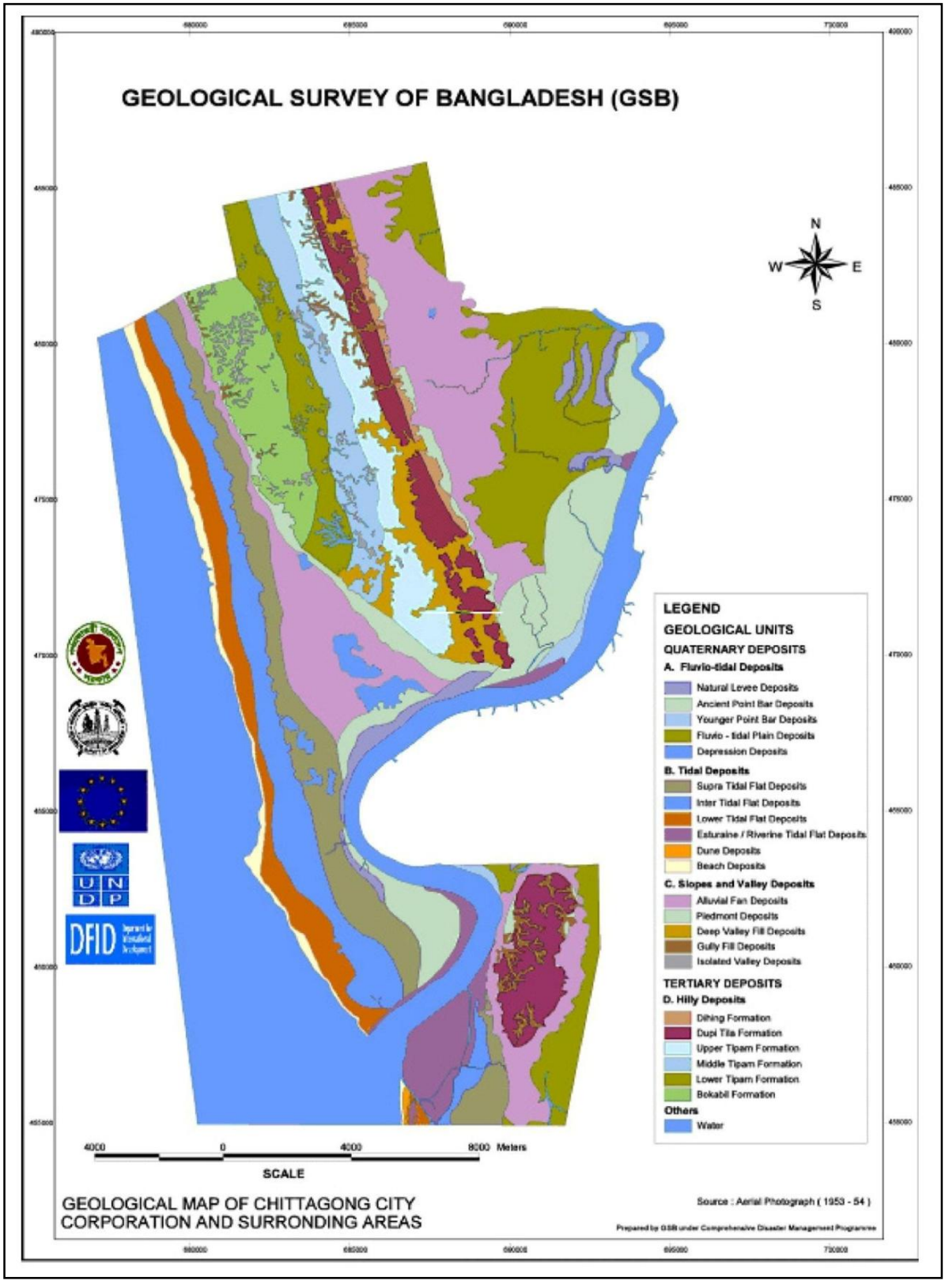
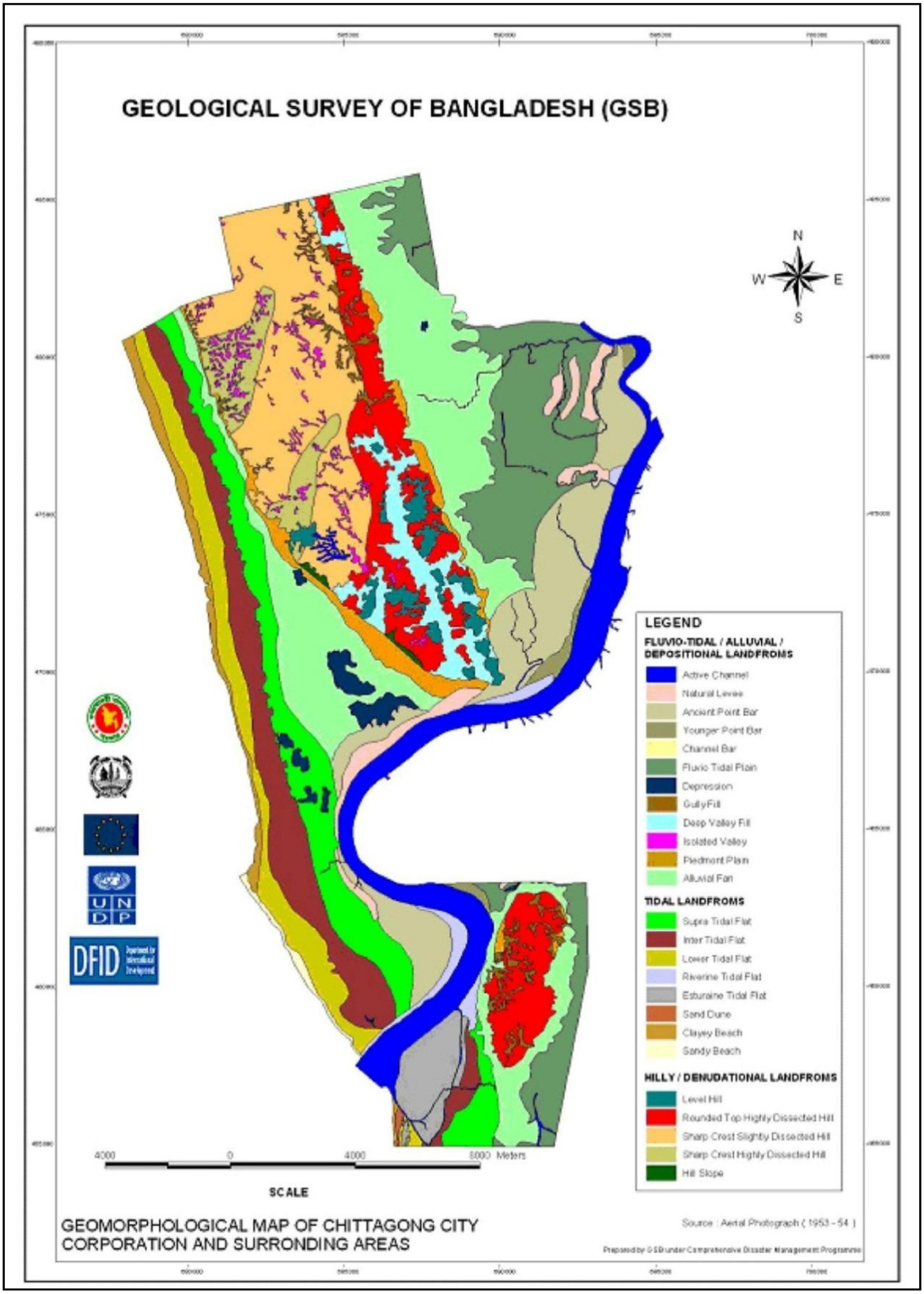


Figure 2.3: Geo Morphological map of CCC and its surrounding areas.
Source: *Geological survey of Bangladesh (GSB), 2013*



2.3 Description of the Clusters

2.3.1 Landslide Location Cluster: From the field survey 57 locations have been found where landslide event occurred in previous years. These locations are organized into ten clusters (Table 2.1). The selection of the clusters was based on the landslide hazard locations, tentative similarity of the surroundings and landslide mechanisms. The locations of the clusters are attached in Appendix-C. Location of each cluster with respect to surrounding places has been described below:

Cluster 1

A Branch of Chanmari Road is at the North side of this cluster. At the South, East and West side there are Tiger pass railway colony, CDA Avenue and Ambagan Road respectively (Figure-1, Appendix-C).

Cluster 2

This cluster is inside the Chittagong Cantonment Area. The Cantonment Area is located at the North side of the major road Bayejid Bostami Road. Chittagong cantonment road is at the west side of Lebubagan and Kaccharghona area. The Bhatiari Hathazari Link Road and Mobarok Road are at North and South side respectively. Chittagong cantonment Railway station is at the East. Besides, Sekandarpara is at North side of Bhatiari Hathazari Link Road. (Figure-2, Appendix-C).

Cluster 3

Nasirabad Properties Limited and Cluster 7 are at the North side of this area. Hazrat Goribullah Shah Mosque is at the East, South Khulshi Mosque is at the West and Lankhan Bazar is at the South of this cluster. (Figure-3, Appendix-C).

Cluster 4

The locations in this cluster are in the Chittagong University Campus. At the North there are Tsunami Garden and Shahjalal Hall. The University Jame Mosque and Mosque of Faculty of Science are at North and West side of this area. The Golpukur is at the South of the cluster. (Figure-4, Appendix-C).

Cluster 5

This cluster is surrounded by North side Foy's Lake, Foy's Lake Road, Zakir Hossain Road and Bara Peer Hazrat Abdul Kader Zilani (R) Masjid at the North, East, South and West side. (Figure-5, Appendix-C).

Table 2.1: Cluster of hills according to areas

Hill Name	Area	Cluster Name
Tankir Pahar 1	Motijhorna	Cluster 1
Tankir Pahar 2		
Tankir Pahar 3		
Motijhorna 1		
Motijhorna 2		
BataliHill 1		
BataliHill 2		
Chanmari Bi Lane		
Tiger Pass Hill		
LebuBagan 1	Chittagong Cantonment	Cluster 2
LebuBagan 2		
LebuBagan 3		
Kaicchaghona 1		
Kaicchaghona 2		
Sekandar Para 1		
Sekandar Para 2		
Sekandar Para 3		
KushumbaghHousing	Kushumbagh	Cluster 3
GoribullahShah Mazar Hill		
Ispahani Hill		
GolachipaHill	University of Chittagong	Cluster 4
Hill beside ShahidMinar		
KharaPahar1		
KharaPahar2		
Akbar Shah MazarHill	Akbar Shah Mazar	Cluster 5
LalPahar		
GolPahar 1		
GolPahar 1		
GolPahar 1		
Observation Tower hill	Foy's Lake	Cluster 6
Foy's Lake Zoo Hill 1		
Foy's Lake Zoo Hill 2		
Foy's Lake Zoo Hill 3		
Foy's Lake Zoo Hill 4		
Holy Crescent 1	Khulshi	Cluster 7
Holy Crescent 2		
Krishnochura Housing 1		
Krishnochura Housing 2		
Nasirabad Housing 1		
Nasirabad Housing 2		
Nasirabad Housing 3		
Zakir Hossain Road, South Khulshi		
AKS brickfield	Chotesshori	Cluster 8
Finley Hill		
Finley Hill		
Dolphin Hill		
Medical Hill (Goachi Bagan) 1	Pachlish	Cluster 9
Medical Hill (Goachi Bagan) 2		
Medical Hill (Goachi Bagan) 3		
Medical Hill (Goachi Bagan) 4		
The King of Chittagong		
The King of Chittagong		
Amin Taxtile	Others	Cluster 10
Blossom Garden		
A.K. Khan's House		

Cluster 6

The Foy's lake is at North side of this cluster. The Cluster 5 is at the West side of this area. (Figure-6, Appendix-C).

Cluster 7

Bayejid Bostami Road is at the North-East side of this cluster. Zakir Hossain Road is at the South and the Foy's Lake is at the North-West corner. (Figure-7, Appendix-C).

Cluster 8

Amirbagh Residential Area is at the North side of this cluster. Badshah Mia Chowdhury Road at the West and the Bevery Hill Residential Area is at the East side. The Chatteswari Road is in between the Finley Hill and Dolphin Hill to the East-West direction. (Figure-8, Appendix-C).

Cluster 9

The Bevery Hill Residential Area and Chittagong Medical College Staff Quarter are at South and East side respectively. O R Nizam Road is in between the king of Chittagong and Medical Hill. (Figure-9, Appendix-C).

2.4 EXISTING CONDITION OF THE CLUSTERS

The overall existing condition of the study area has been described in this section. The road network, road condition, housing, Utility, drainage and socio-economic condition of the study area have been described information from the local people and survey team's observation.

2.4.1 Road Network of the Clusters

In Chittagong, Most of the hilly communities are linked to the city centre. The streets in the community are mainly pedestrian walkway. The communities beside the hills are not well planned. The road network does not follow any pattern in those areas. Roads are mainly muddy, sloppy in most of the places. People pass through the community by walking only. No access to vehicle.

The hilly areas in Motijharna (Cluster-1) are well connected to the CDA Avenue through Ispahani Circle, one of the major intersection points in Chittagong Metropolitan Area.

Motijharna lane, Tankir Pahar lane and Chanmari bi lane interconnect the areas in Tankir Pahar, Motijharna Pahar, Batali Hill, Chanmari Lane **(Figure 3.1).** The roads in Tankir Pahar and Motijharna are nearly 5-7 feet in width. The roads are made of clay, sand and brick chips i,e; semi-paved and broken in most of the places. In Tankir pahar there are stairs instead of roads in some places because of sloppy condition (Figure 2.4-a).

Figure 2.4: Internal roads (a) & (b) Tankir Pahar community, (c) Motijharna pahar community. Source: *Field Survey, August 2014*

(a) (b) (c)

On the other hand, the roads in Chanmari Lane and Batali Hill community are paved (material: asphalt) and semi-paved respectively. The road width in both the areas is 8-10 feet.

The areas defined in cluster 2 are mainly in Chittagong Cantonment Area. After the devastating landslide occurred in the year 2007 (Figure 2.6), the areas were taken under the Cantonment Area and no human settlement was further developed here.

Figure 2.5: Roads in (a) Chanmari Bi Lane community, (b) Batali Hill community

Source: *Field Survey, August 2014*

(a)

(b)

Figure 2.6: Scenario after devastating landslide in the year of 2007, (a) Lebubagan (b) Sekandar para

Source: *Director, Department of Environment, Chittagong.*

(a)

(b)

The Kushumbagh area (cluster 3) consists of Lalkhan Bazar, Goribullah Shah Mazar and Ispahani Hill. The roads are unpaved and in very poor condition. During rainy reason they become muddy and in dry season they remain dusty. The average width is 7-9 feet. (Figure 2.7 and 2.8)

Figure 2.7: Road condition in dry season at Kusumbagh, Lalkhan Bazar.
Source: *Field Survey, August, 2014*

(a)

Figure 2.8: Road condition in dry season at Ispahani Pahar.
Source: *Field Survey, August, 2014*

(b)

In Cluster-4 at Chittagong University there are hills in three different places. They are: beside Shahid Minar, Khara pahar and Golachipa Hill near Pritilota Hall. They are located by the side of University Road. There is no human settlement here.

In Golpahar settlement (cluster 5), there are mud roads of 3-4 feet in width. People dump garbage on those narrow roads (Figure 2.9). As there is a very few housing in Akbar Shah Mazar Hill, Red Hill and Nasirakona Hill area, the road network cannot be defined as like as the areas described earlier. People in this community moves along the muddy walkways (Figure 2.10). The settlement in hills at Foy's lake area also has mud roads as like as Akbar Shah Mazar Area.

Figure 2.9: Road at Golpahar community
Source: *Field Survey, August, 2014*

Figure 2.10: Walkway in the community, (a) Akbar Shah Mazar Hill, (b) Red Hill.

Source: *Field Survey, August, 2014*

(a)

(b)

The settlement pattern in different hills of Khulshi area (cluster-7) is not alike. The roads in Kishnochura Housing Area are as same as Akbar Shah Mazar Area and Foy's Lake Area. Besides, Zakir Hossain Road in South Khulshi is semi-paved and 10-12 feet in width (Figure 2.11). The Holy Crescent Hill is a restricted area.

Figure 2.11: Roads in different community, (a) Krishnochura housing, (b) Zakir Hossain Road, South Khulshi.

Source: *Field Survey, August, 2014*

(a)

(b)

There are two hills in Chotteswari Area namely Finley Hill and Dolphin Hill. There are Bungalows for the corresponding officers on both of the hills. The roads in Finley Hills are well planned and made of concrete (Figure 2.12). There is some housing at the bottom of Dolphin Hill but roads are mainly walkways (Figure 2.13).

Figure 2.12: Road in Finley Hill.
Source: *Field Survey, August, 2014*

Figure 2.13: Housing at the bottom of Dolphin Hill. Source: *Field Survey, August, 2014*

The Goachi Bagan Hill and The King of Chittagong hill are located in Pachlaish Area (cluster 9). The roads are muddy in Goachi Bagan (Figure 2.14) and the roads in other hill are made of concrete.

Figure 2.14: Road in Goachi Bagan
Source: *Field Survey, August, 2014*

The Blossom Garden is located at the side of CDA Avenue near GEC Circle, one of the most significant intersection points in Chittagong City. There is no settlement but a restaurant and party centre here. A.K.Khan's House is at Batali Hill and the Amin Textile is a restricted area.

2.4.2 Housing Pattern of the Clusters

Since Chittagong is the Port City and the Commercial Capital, people from the surrounding regions are migrating into the city areas for better income opportunities as well as attractive urban Facilities. As a result, Unplanned and Haphazard Urban Growth of slum areas are taking place at different location of the city which is polluting the urban environment at present (Hashemi, 2006).

Chittagong city is a city of Hills, which is surrounded by the Karnaphuly River and the Bay of Bengal from two different sides. Because of the unplanned Hill Cutting the Greeneries from the hills are being destroyed and the hills are being leveled for developing housing settlements in the concerned areas (Hashemi, 2006).

Housing settlements of study areas have been developed through hill cutting. Though Government is the main care-taker of hills, some people, locally called as Zamindar are illegally developing housing settlements on the slope of the hills through hill cutting. People are allowed to live there on rent (Field Survey, 2014). Though hills are located in different areas of Chittagong area, basic characteristics of housing around the hills are quite similar

General Characteristics of houses surrounding the hills:

From the field observation a general characteristics of housing around the hills has been identified. Most of the houses are of semi built type. Houses are of small sized, single or multiple storied. Tin is used as roofing material. Some houses are made of tin, local material like bamboo and brick (Figure 2.15). These buildings have no foundation. Sometimes plastic sacs filled with sandy soil of hills are used to form the base of the houses (Figure 2.16).

Multistoried buildings are developed without any foundation on the base of the structures. Moreover rendering of the houses is very poor. Most of the buildings lacks proper or minimum plastering (Figure 2.17). Many houses do not have sufficient number of windows and condition of door and windows are very poor (Figure 2.18). Most of the houses lack proper ventilation.

Figure 2.15: Housing Material of study area (Tankir Hill, Motijhorna area)
Source: *Field Survey (August, 2014)*

Figure 2.16: Foundation condition of houses (Akbar Shah Mazar Hill, Akbar Shah Area)
Source: *Field Survey (August, 2014)*

Figure 2.17: Render condition of houses (Motijhorna Hill, Motijhorna area)
Source: *Field Survey (August, 2014)*

Figure 2.18: Condition of doors and windows (Goachi Bagan Hill, Pachlish area). Source: *Field Survey (August, 2014)*

These houses are developed on these hills in different periods. It has been observed that row houses of 3 to 4 rooms form one block. These housing blocks have been established at different time periods. As a result housing blocks are settled in an unplanned manner. 1-2 feet space is kept between two housing blocks (Figure 2.19). Narrow roads of 3 to 4 feet are seen inside the housing settlements. As there is no veranda or corridor in the housing block, these internal roads are used for social gathering, walking and maintaining communication by people living inside the housing settlements (Figure 2.20). Use of steps is a common characteristic of housing of these areas as houses are settled on the slope of the hills. Houses are developed in an unplanned manner, which reflects the characteristics of slum (Field Survey, 2014).

Figure 2.19: Narrow space between two houses (Tankir hill, Motijhorna area) Source: *Field Survey (August, 2014)*

Figure 2.20: Narrow road is used for social gathering (Tankir hill, Motijhorna area)
Source: *Field Survey (August, 2014)*

Housing pattern around the hills of Cluster 1, Cluster 3 Cluster 5 and Cluster 6 is quiet similar to the General Characteristics of housing described above (Field Survey, August 2014). Along with the above mentioned housing pattern many high rise buildings are found to be located in the surrounding areas of these hills. Chanmari bi lane hill site of Cluster 1 can be characterized as area with high rise buildings (Figure 2.21).

Many multistoried buildings along with general housing pattern described are seen around the hills of Cluster 3 and Cluster 5 (Figure 2.22), (Figure 2.23), (Figure 2.24).

Figure 2.21: Highrise buildings in Chanmari bi lane hill
Source: *Field Survey (August, 2014)*

Figure 2.22: Tin shed housing and Multistoried buildings around Red hill
Source: *Field Survey (August, 2014)*

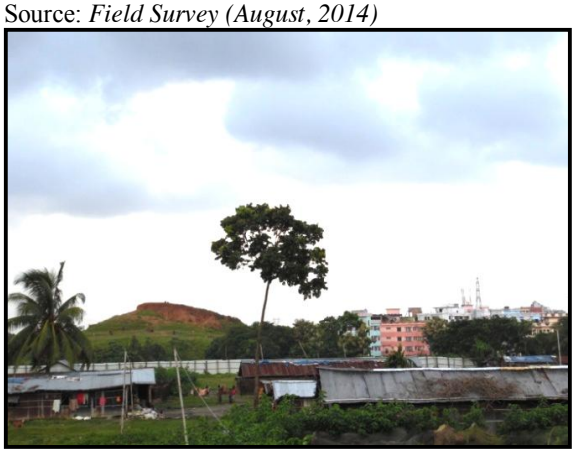


Figure 2.23: Tin shed housing and multistoried buildings around Goribullah shah hill

Source: *Field Survey (August, 2014)*

Figure 2.24: Multistoried housing development around Ispahani hill, Kushumbagh

Source: *Field Survey (August, 2014)*

Khulshi area is a residential area with high rise buildings. Three hills which had undergone with landslide have been found in Khulshi area (Cluster 7). Hill in Zakir hossain society road of Khulshi area is a very significant hill which has been cut for the development of housing areas of South Khulshi area. A big retaining wall has been established to protect the houses from landslide. Houses around the hill of Krishnochura housing of Khulshi area are found to be of tin shed housing pattern. A few houses are found in Krishnochura housing hill area. Houses around the hills of Cluster 10 are also found to be high-rise (Field Survey, 2014).

No housing settlements have been found around the hills of Cluster 2 and Cluster 4 of Chittagong Cantonment Area and Chittagong University area (Field Survey, 2014). Once there was settlement around Lebubagan hill of Cantonment area. A massive landslide took place in Lebubagan hill on 2007, which destroyed many houses. After the disaster occurred people left that place (Figure 2.25 and Figure 2.26).

Figure 2.25: Present condition of Lebubagan hill, Cantonment
Source: *Field Survey (August, 2014)*

Figure 2.26 :Lebubagan hill in 2007, Cantonment
Source: *Department of Environment, Chittagong*

Figure 2.27: Bungalow of officer of Finley Company in Finley Hill, Chotesshori
Source: *Field Survey (August, 2014)*

Blossom garden hill, Finley hill, Dolphin hill, the king of Chittagong hill and the hill of Amin Textile are located in protected areas. Housing settlements are not found in these hills. Some bungalows of government officers are located in these hills (Figure 2.27).

A slum has been developed through cutting Medical hill in Goachi Bagan. Houses are made of brick, tin and bamboo. Houses are of small sized comprised of one room for one family. Hosing Characteristics of Goachi Bagan hill is similar to the general characteristics described earlier (Figure 2.28), (Figure 2.29).

Figure 2.28: Housig condition in Goachi Bagan Hill, pachlish
Source: *Field Survey (August, 2014)*

Figure 2.29: Houses are constructed through hill cutting in Goachi Bagan Hill, pachlish
Source: *Field Survey (August, 2014)*

2.4.3 Utility and Drainage of the Clusters

General overview of utility facilities of landslide vulnerable communities:

Utility services are comprised of water, electricity and gas facilities. To understand the condition of landslide vulnerable communities, condition of utility facilities has been observed. It has been found that, as the socio economic condition of the communities surrounding the hills is quiet similar to each other; there is a similarity in the condition of utility services.

Water facilities: A general characteristic of the condition of water facilities has been observed for the landslide vulnerable communities who live near to the hills of Cluster 1, Cluster 3, Cluster 5 and Cluster 6. All the houses of communities surrounding the hills of Chittagong are provided with the water supply facility. Most of the water sources used in study areas are water taps and tube wells located either inside or outside of the study areas . Some shallow tube wells are constructed and financed by the inhabitants or personally by tenants. Some water supply connections are from one or more residential buildings, which is illegal and people of some areas need to buy water from the owner of that building. Consequently, the dwellers spend much of their time and resources buying water from local water lords, offices, factories, and other sources. This is so because the very poor of the slums do not have enough money to pay the metropolitan authority's water bills make full use of the system. People use this water in domestic and drinking purpose without boiling

and filtering. People use water for domestic purpose only. As sanitation and waste management condition of these areas are very poor so water easily gets polluted. Water pipelines are open to sky and not protected (Figure 2.30 and 2.31). So water pollution and water leakage are common phenomenon in these areas. There is no water network system in these areas. There is improved water facility in localities around the hills of Cluster 7, Cluster 8, Cluster 9 and Cluster 10. Water network exist in localities around these hills (Field survey, August, 2014). As hills of Cluster 2 and Cluster 4 are located in Chittagong cantonment and Chittagong University area, no settlement for general people is found. Improved water facilities exist in the surrounding areas of these hills (Field survey, August, 2014).

Figure 2.30: Poor management of water pipelines, Tankir pahar, Motijhorna area
Source: *Field survey, August, 2014*

Figure 2.31: Co existence of drainage and water pipelines, Motijhorna hill, Motijhorna. Source: *Field survey, August, 2014*

Electricity facility:

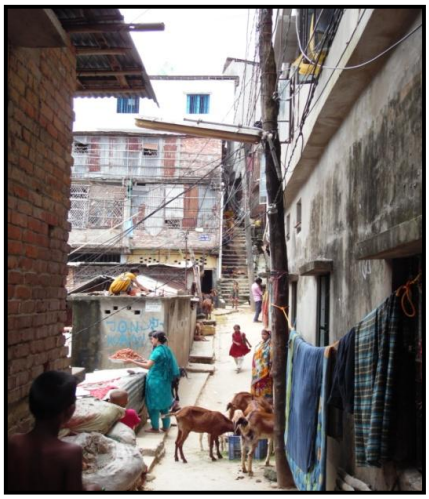
There is provision of electricity in the localities surrounding the landslide vulnerable hills. Improper arrangements of electric wires have been observed in the localities surrounding the hills of Cluster 1, Cluster 3, Cluster 5 and Cluster 6 (Figure 2.32 and 2.33) There are many houses in these localities which have illegal electric connection (Field survey, August, 2014).

Gas facility

Most of the landslide vulnerable communities have access to gas facilities. Some localities near Krishnochura housing properties, Golpahar, Medical hill of Goachi Bagan, Foy's lake zoo hill and observation tower hill do not have access to gas services (Field survey, August, 2014).

Figure 2.32: Electric meter is kept unprotected outside of the house, Chanmari bi lane, Motijhorna. Source: *Field survey, August, 2014*

Figure 2.33: Disorganized electric lines in landslide vulnerable communities
Source: *Field survey, August, 2014*



Drainage facility

Drainage system is an important factor for the hilly regions like Chittagong. As settlements are being developed through cutting hill, it is destroying the characteristics of natural drainage of hills. Drainage system has been found very poor in most of the study areas.
Drainage system for different study areas are analyzed in two sections

- Drainage condition in localities around the hills
- Drainage condition of hills

Drainage condition in localities around the hills: It has been observed from the field investigation that the drainage condition of the landslide vulnerable communities is very poor. Localities around the hills of cluster 1 have drainage facility but condition of drainage system is very poor. There is no management of the drainage network. Drainage network is broken in many places. People dump waste on drains which creates blockage and disturbs the function of drainage (Figure 2.34). Most of the drains are open to sky. Bad odor comes out from drains. Improper drainage system is a contributor to the unhygienic and unhealthy environment of these areas (Figure 2.35).

Figure 2.34: Open drain beside road Tankir hill, Motijhorna

Source: *Field survey, August, 2014*

Figure 2.35: Open draininsidecommunity Motijhornahill, Motijhorna

Source: *Field survey, August, 2014*

Figure 2.36: People dump waste on Naturally developed; Foy's lake zoo hill, Foy's lake area

Source: *Field survey, August, 2014*

Figure 2.37: Naturally developed drainage is disturbed by human activities; GolPahar, Akbar Shah area. Source: *Field survey, August, 2014*

There is no drainage system developed in the landslide vulnerable communities around the hills of cluster 3, cluster 5 and cluster 6. In these areas water is drained off through natural way (Figure 2.37). But due to human settlements, the natural drainage system always gets disturbed (Figure 2.36). Lack of drainage system has been deteriorating living condition of these communities.

Drainage condition of hills:

Rain water is naturally drained off through the slope of the hills. In Chittagong metropolitan area houses are constructed through cutting hill (Figure 2.38). In some areas hills are used for agricultural activities (Figure 2.3). These activities have destroyed the slope characteristics of hills, which results in deterioration of natural drainage condition of hills. Rain water cannot drains off properly and gets logged in different parts of hills. This causes landslide.

Figure 2.38: Houses are constructed through cutting hill; Medical hill of Goachi Bagan, Pachlish

Source: *Field survey, August, 2014*

Figure 2.39: People cut hill for agricultural purpose; Akbar Shah Mazar Hill; Akbar shah area

Source: *Field survey, August, 2014*

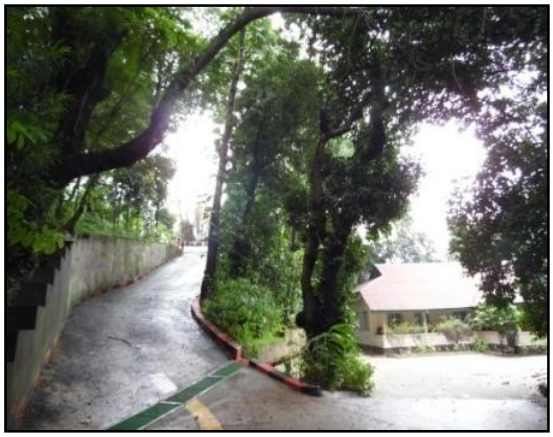
These are few hills have been found where houses are constructed maintaining proper drainage system for hills. Finley hill is a good example of it.

A Case Study on the Hill Drainage System of Finley Hill

Finley hill is under the authorization of Finley Tea Company. There are 8 bungalows for the officer's of this company. These bungalows and roads are constructed through hill cutting. But there exists a good drainage network (Figure a, b and d). This well developed drainage system helps to drain off water properly. Roads are constructed maintaining the slope of hills (Figure c). No landslide event has been occurred in Finley hill till now. Finley Hill shows a good example of manmade Hill drainage management.

(a)

(b)



(c)

(d)

2.4.4 Socio-economic condition

Socio-economic studies are usually required so that the local dynamics and development situation of communities are fully understood. These circumstances are important in determining the need and demand for a wide range of planning issues, services, infrastructure as well as the underlying rationale for feasibility indicators for projects.

Chittagong is the second largest city of Bangladesh. It is the port city and the industrial centre of Bangladesh. The Port of Chittagong, diversified industries, the headquarters of many of the oldest and largest Bangladeshi companies and the Chittagong Stock Exchange make it one of the fastest-growing cities in the world. The hilly areas in Chittagong are mainly the residence of the lower income people and most of them are migrated from different regions of Bangladesh.

In Tankir pahar, Motijharna pahar and Batatali hill areas of cluster 1, there are grocery shops, tailoring shops, tea stalls, saloons by the side of main road (Figure 2.40). Male persons mainly perform these activities. Female mostly work in the garments and houses of higher income people. They reside in unhygienic condition. Moreover, the schools and other facilities are not good at all. They have their health facility from nearby medicine store. In Chanmari bi lane area, people are engaged in business, government and private services and they are in middle-income group. They get better health, schooling and others facilities.

Figure 2.40: Shops by the side of main road in the areas of cluster (a) Tailoring shop, (b) Grocery shop**,** (c) Saloon

Source: *Field Survey, August, 2014*

(a) (b) (c)

There is no settlement in the hills in cluster 2 (Chittagong Cantonment Area) and cluster 4 (Chittagong University Area).

The people of Kushumbagh area (Cluster 3) are of lower income group and their main earning comes from working in grocery shops, garments, saloons, tea stalls, etc. (Figure 2.41).Female people work in garments and others' houses as maid. The socio-economic condition of these areas is as same as cluster 1. They are deprived of necessary facilities regarding health, education, recreation, etc.

Figure 2.41: Shops beside main road through Goribullah Shah Community.
Source: *Field Survey, August 2014*

The community people of cluster 5, work in the nearby shops, garments, etc. Mainly lower income people reside here. Their socio-economic condition is as like as the other lower income community of the study areas (Figure 2.42, 2.43).

In cluster 6 the people are of lower income group having no better facility of housing, health, education, etc.

Figure 2.42: Road side shops beside Akbar Shah Mazar Hill.
Source: *Field Survey, August, 2014*

Figure 2.43: Socio-economic condition at Red Hill area.
Source: *Field Survey, August, 2014*

The Holy Crescent and Krishnochura Housing in cluster 7 are restricted areas. Besides, Zakir Hossain Road in South Khulshi is the area with middle-income group. Their socio-economic condition is better than that of cluster 1, 3, 5 and 6 (Figure2.44)

Figure 2.44: Better socio-economic condition at Zakir Hossain Road in South Khulshi. Source: *Field Survey, August, 2014*

Figure 2.45: Middle income group people in Finley Hill.
Source: *Field Survey, August, 2014*

Figure 2.46: Lower Income Group people at the bottom of Dolphin Hill
Source: *Field Survey, August, 2014*

Figure 2.47: People at Goachi Bagan area.
Source: *Field Survey, August, 2014*

Figure 2.48: Housing at Goachi Bagan area.
Source: *Field Survey, August, 2014*

Cluster 8 contains the bungalows for the officers of Finley Tea Company. They are in High income group, so the socio-economic condition is much better than that of the other areas in our study (Figure 2.45). But in the bottom of Dolphin Hill there are some lower income people who survive mainly by doing household works in the bungalows on the top of the hill (Figure 2.46).

In cluster 9 Goachi Bagan Hill area's people are in lower income group (Figure 2.47 and Figure 2.48). They mainly work in shops, garments, construction sites, etc. They cannot afford the better housing, education, health facilities and so on. For that reason, they have to lead their life without them.

The areas in cluster 10 are different to each other. There is no settlement but a restaurant and party centre in Blossom Garden. A. K. Khan's House and the Amin Textile are restricted for out comers.

CHAPTER 3: DETAILED INVENTORY OF STUDY AREA

Inventory map has been prepared indicating of 57 landslide locations. There were some other landslide locations that could not be identified as local people have little knowledge on landslide. From the Landslide inventory map it is seen that landslide areas are located at the northern western part of Chittagong Metropolitan Area. (Figure 3.1).

Analyzing landslide location with respect to geology it is seen that most of the land slide locations are located in Dulphi tila formation and Tipam sandstone geological class (Figure 3.2).

By analyzing landslide inventory with respect to slope characteristics it is seen that, most of the lands of Chittagong Metropolitan Area are of flat slope. Slope of landslide location areas are found to be 30-40 degree (Figure 3.3). This is because; Inventory with respect to slope map has been prepared by using 30 m resolution Aster GDEM. As it covers a wide area the average slope value calculated is lower than the actual slope of landslide location. During the field survey it has been observed that there are many landslide locations whose slope is near vertical.

Figure 3.1: Land slide Inventory Mapping in Chittagong Metropolitan Area

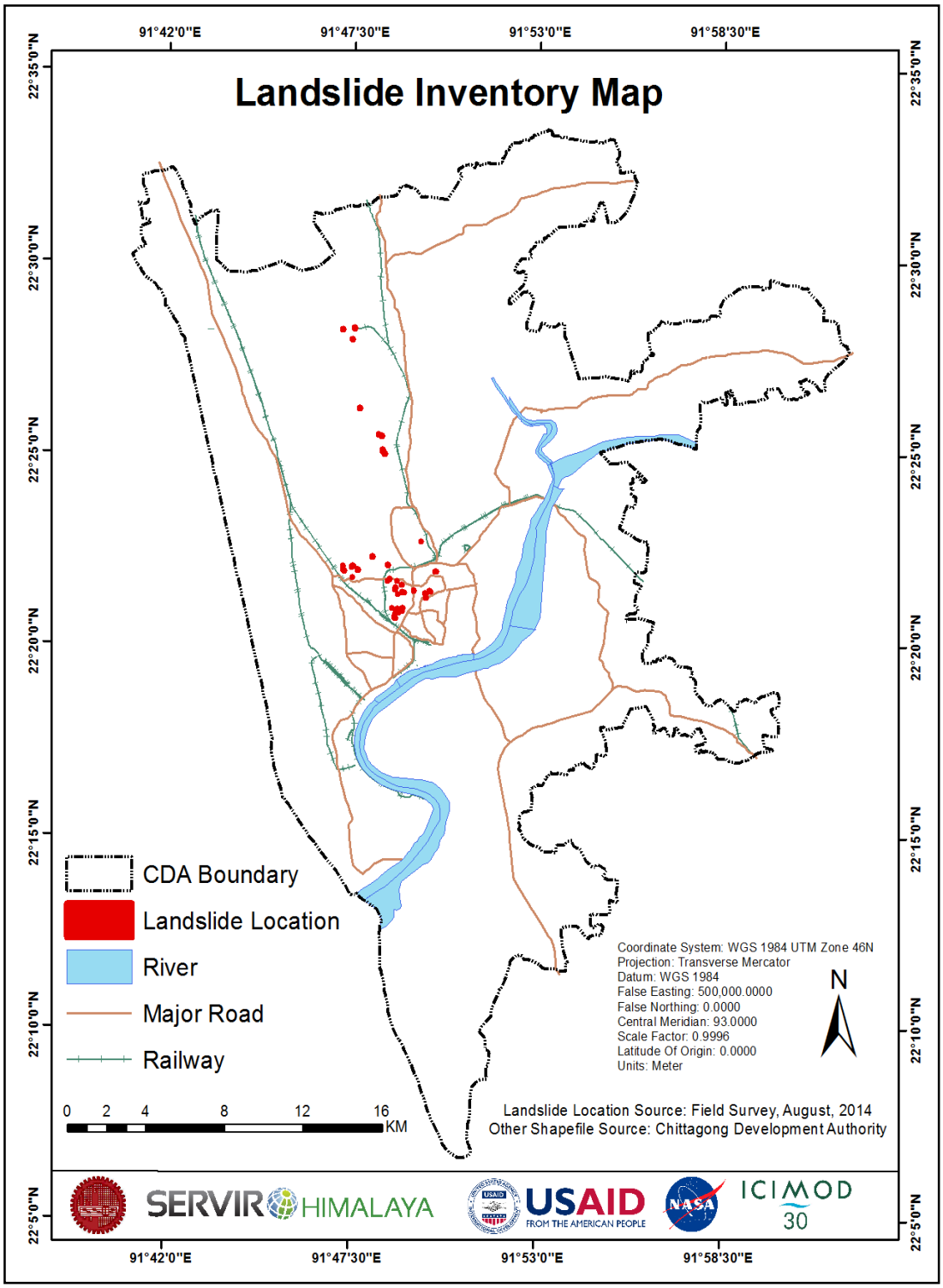


Figure 3.2: Land slide Inventory Mapping in respect of geology in Chittagong Metropolitan Area

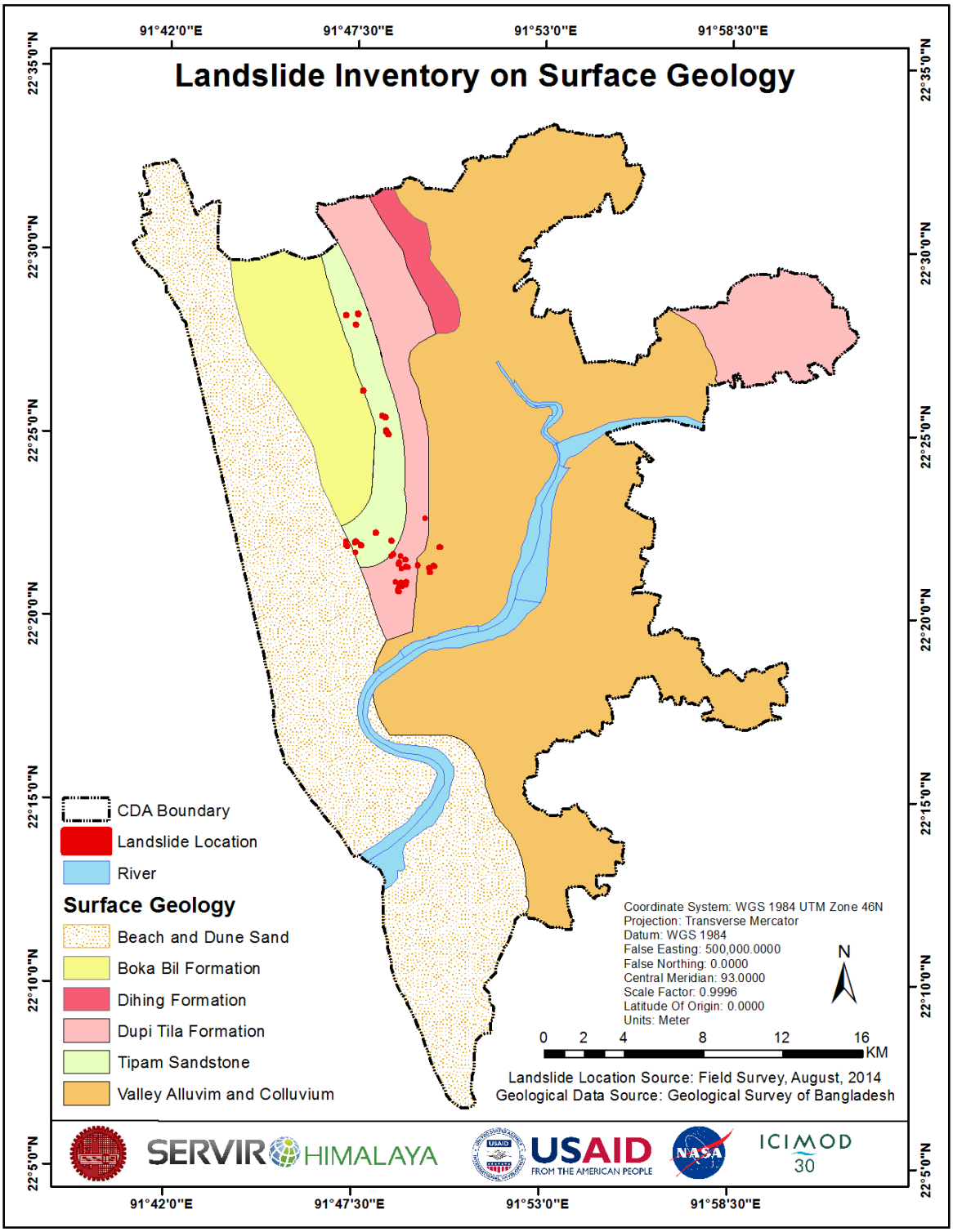
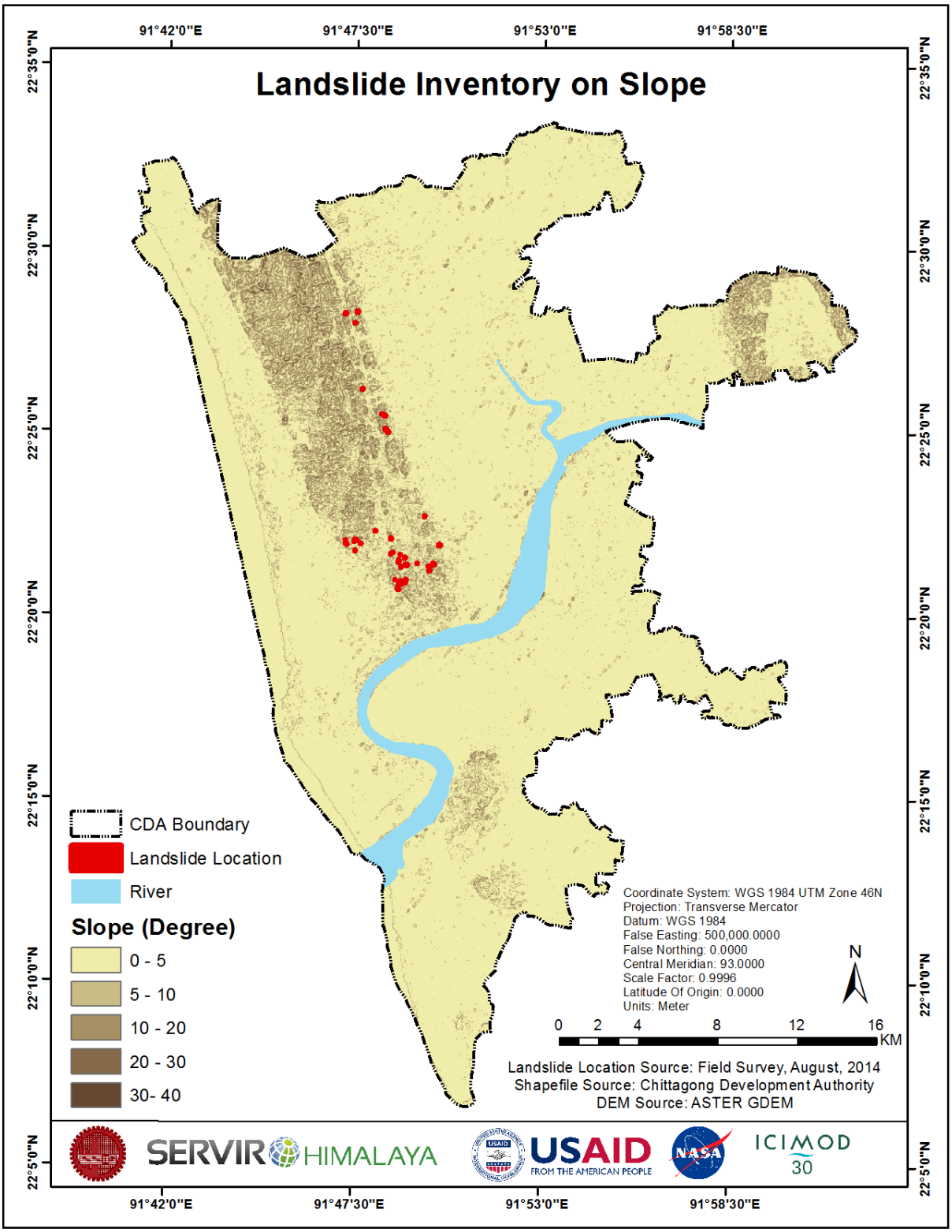
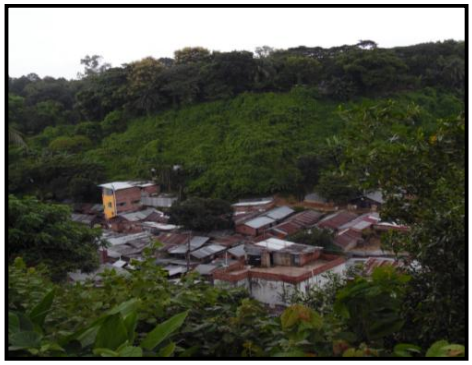
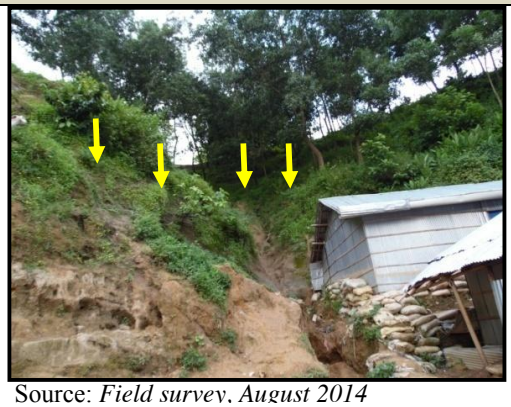


Figure 3.3: Land slide Inventory Mapping in respect of slope character Chittagong Metropolitan Area



Basic Information	
Landslide ID :01 **Landslide Location:** Motijhorna **Coordinates:** 22˚20 ’ 51.43’’ N, 91˚48 ’ 49.68’’ E	**Datum :**WGS 1984 **Elevation (m):** 55.95 **Area of Displaced Mass (sqm):** 89.91 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall **State:** Stabilized **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Bare soil and built over have been found as the land cover in this site.	
Causes of Movement: Improper construction work has been observed in this site. Along with this, Intense and prolonged rainfall contributed to the collapse of slope which finally turned into landslide.	
Land Slide History and Future Risk of Landslide	
Landslide in this site occurred on August, 2013. Intense and prolonged rainfall had been occurring for 8-10 days prior to landslide. A chunk of earth collapsed on a tin shed house. The house was completely destroyed. Two people died on spot. At present people has constructed a Boundary wall of about 10 feet to protect the place from further landslide. Utility facilities did not get damaged in this incident. Economic and Environmental loss was not quantifiable.	

Basic Information	
Landslide ID :02 **Landslide Location:** Motijhorna **Coordinates:** 22°20'50.45''**N**, 91°48'52.82''**E** **Datum :** WGS 1984 **Elevation (m):** 51.79 **Area of Displaced Mass (sqm):** 116.32 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall **State:** Stabilized **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type (%): Herbaceous vegetation is the Primary land cover of Motijhirna hill. Forest/ woodland type is also visible in this hill.	
Causes of Movement: Hill cutting is the major issue that caused landslide in this area and intense rainfall acted as a triggering factor for landslide.	
Land Slide History and Future Risk of Landslide	
Landslide in this site has occurred in 2013. Two people died on that incident. 1 semi built house partially collapsed. None was found to be injured. Utility facilities did not get damaged in this incident. Economic activities were hampered so does the social life of people. Environment has been found to be severely damaged. Excessive rainfall has been identified as the major triggering factor for landslide in this site. Hill cutting has worsened the landslide condition of this area. Moreover the soil of this site has been found to be sandy. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements located at the down slope of this hill are at a huge risk of massive landslide. In future landslide can occur in this hill as there is a possibility of destabilization of mass above the slope. The impact would be further destruction to the hill. Down slope movement of larger debris can create impact on houses and also people living there. The risk is moderate to high (Field survey, August 2014).	

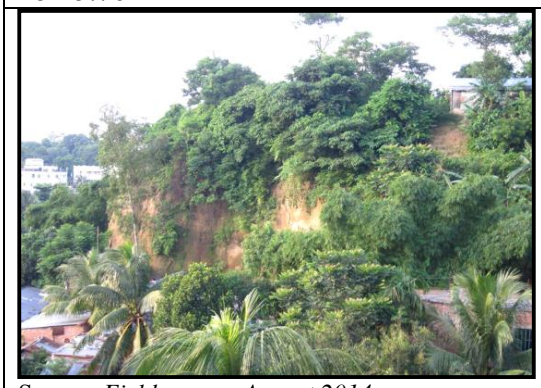
Basic Information	
Landslide ID :03 **Landslide Location:** Tankir Pahar **Coordinates:** 22°20'52.69''N, 91°48'59.38''E **Datum :** WGS 1984 **Elevation (m):** 44.46 **Area of Displaced Mass (sqm):** 11.02 **Rainfall: 88 mm**	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: topple **State:** Active **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation is the Primary land cover of Motijhirna hill. Forest/ woodland type is also visible in this hill.	
Causes of Movement: Hill cutting is the major issue that caused landslide in this area and intense rainfall acted as a triggering factor for landslide.	
Land Slide History and Future Risk of Landslide	
Landslide in this site has occurred in 11 June 2007 (Dept. Of Environment, Chittagong). One semi built house partially collapsed. None was found to be injured or dead. Utility facilities did not get damaged in this incident. Economic activities were hampered so does the social life of people. Environment has been found to be severely damaged (Field survey, August 2014). Excessive rainfall has been identified as the major triggering factor for landslide in this site. Houses have been built at the down slope through cutting Hill which has worsened the landslide condition of this area. Moreover the soil of this site has been found to be sandy. The escapement slope is found to be near vertical. The failed mass is a part of upper portion. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements located at the down slope of this hill are at a huge risk of massive landslide. The risk is moderate (Field survey, August 2014).	

Basic Information	
Landslide ID :04 **Landslide Location:** Chanmari Bi Lane, Lalkhan Bazar **Coordinates:** 22°20 ’57.40’’N , 91° 48’59.66’’E	**Datum:** WGS 1984 **Elevation (m):** 32.56 **Area of Displaced Mass (sqm):** 15.03 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Topple **State:** Stabilized **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Bare soil and built over have been found as the land cover in this site.	
Causes of Movement: Improper construction work has been observed in this site. Along with this, intense and prolonged rainfall contributed to the collapse of slope which finally turned into landslide.	
Land Slide History and Future Risk of Landslide	
Landslide in this site occurred on 22 June, 2014 (Field survey, August 2014). Intense and prolonged rainfall had been occurring for 5-7 days prior to landslide. Boundary wall of a five storied building was partially collapsed. None was found to be injured or dead. Utility facilities did not get damaged in this incident. Economic and Environmental loss was not quantifiable. Boundary wall was constructed through cutting hill which made escarpment vertical. Soil characteristic of this site is of sandy type. Boundary wall was not reinforced. During rainfall water got logged into the side of the wall which triggered landslide. Land use around the site is residential. There is high-rise buildings and roadway in this site. Houses at the down slope and road upon the hill are at risk of getting damaged by landslide (Field survey, August 2014).	

Basic Information	
Landslide ID :05 **Landslide Location:** Tanker Pahar , Motijhorna **Coordinates:** 22°20 ’54.27’’N, 91° 48’51.60’’E	**Datum:** WGS 1984 **Elevation (m):** 41.18 **Area of Displaced Mass (sqm):** 331.84 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Slide **State:** Active, Reactivated, Suspended **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type (%): Herbaceous vegetation is the Primary land cover of Tanker Pahar. Forest/ woodland type is also visible in this hill.	
Causes of Movement: Hill cutting is the major issue that caused landslide in this area and intense rainfall acted as a triggering factor for landslide.	
Land Slide History and Future Risk of Landslide	
Landslide in this site occurred in 1982, 1989,1991,1994,1996 and 2013. 10 houses got damaged and almost 22 people died due to landslide at different periods. Utility facilities were highly damaged in this incident. Economic activities were hampered so does the social life of people. Environment has been found to be severely damaged. Still there are many houses located at the down slope of the hill. Soil of this site has been found to be sandy. The escapement slope is found to be near vertical. The failed mass is a part of upper portion. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements located at the down slope of this hill are at a huge risk of massive landslide. The risk is high (Field survey, August 2014).	

Basic Information	
Landslide ID :06 **Landslide Location:** Tankir Pahar , Motijhorna **Coordinates:** 22°20 ’55.71’’N, 91° 48’50.11’’E	**Datum :** WGS 1984 **Elevation (m):** 47.04 **Area of Displaced Mass (sqm):** 211.06 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Slide **State:** Active, Reactivated, Suspended **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation is the Primary land cover of Tanker pahar.Forest/ woodland type is also visible in this hill.	
Causes of Movement: Hill cutting is the major issue that caused landslide in this area and intense rainfall acted as a triggering factor for landslide.	
Land Slide History and Future Risk of Landslide	
Landslide in this site occurred in 1998 and 2010. Five houses got destroyed and 11 people died during the landslide of 1998. Utility facilities were highly damaged in this incident. Economic activities were hampered so does the social life of people. Environment has been found to be severely damaged. One house was partially collapsed during the landslide of 2010. Damage intensity of this landslide was low. Still there are many houses located at the down slope of the hill. Soil of this site has been found to be sandy. The escapement slope is found to be near vertical. The failed mass is a part of upper portion. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements located at the down slope of this hill are at a huge risk of massive landslide. The risk is high (Field Survey, August 2014).	

Basic Information	
Landslide ID :07 **Landslide Location:** Batali hill, Motijhorna **Coordinates:** 22°20'52.57''N, 91°48'47.23''E **Datum:** WGS 1984 **Elevation (m):** 44.26 **Area of Displaced Mass (sqm):** 59.1 **Rainfall:** 5 mm	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation is the Primary land cover of Batali hill. Forest/ woodland type is also visible in this hill.	
Causes of Movement: Intense and prolonged rainfall**:** (268 mm in 7 days rainfall event) inducing collapse of slope are main the causes of movement.	
Land Slide History and Future Risk of Landslide	
In 23 August, 2008 a major landslide occurred in this area. Though no casualties were reported as the area had been evacuated ahead of time (Bangladesh News, 2008). Part of Batali hill collapsed on 23 August afternoon, damaging a number of temporary structures on the slopes and at the foot of the hill. Utility facilities did not get damaged in this incident. Economic activities were hampered so does the social life of people. Environmental damage is unquantifiable. Excessive rainfall has been identified as the major triggering factor for landslide in this site. Soil of this site has been found to be sandy. The escapement slope is found to be near vertical. The failed mass is a part of upper portion. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. There are a few houses on this spot. Settlements located at the down slope of this hill are at a huge risk of massive landslide. The risk is moderate.	

Basic Information	
Landslide ID :08 **Landslide Location:** Batali hill, Motijhorna **Coordinates:** 22°20 ’47.00’’N, 91° 48’45.76’’E	**Datum:** WGS 1984 **Elevation (m):** 55.03 **Area of Displaced Mass (sqm):** 126.7 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Forest/ woodland are the Primary land cover of Batali hill.	
Causes of Movement: Hill cutting is the major issue that caused landslide in this area and intense rainfall acted as a triggering factor for landslide.	
Land Slide History and Future Risk of Landslide	
Landslide Batali hill has become very common phenomenon of rainy season. Landslide in this hill has been occurring since 2011 on every rainy season. Landslide of 2011 caused damaged to two houses. Heavy and prolonged rainfall easily cause debris flow as soil of this hill is found to be of loose, sandy characteristic. No casualties of landslide have been identified. Utility facilities got damaged during the landslide of 2011. During rainy season, people leave their houses and shift to other places. This incurs a loss to their economic activities. Environment has been found to be severely damaged due to landslides. Still there are many houses located at the down slope of the hill. The escapement slope is found to be near vertical. The failed mass is a part of upper portion. Settlements located at the down slope of this hill are at a huge risk of massive landslide. The risk is high (Field Survey, August 2014)	

Basic Information	
Landslide ID :09 **Landslide Location:** Tiger pass, Motijhorna **Coordinates:** 22°20'42.41''N, 91°48'45.92''E	**Datum :** WGS 1984 **Elevation (m):** 31.66 **Area of Displaced Mass (sqm):** 427.04 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	 Source: *Department of Environment*
Landslide Mechanism	
Type of Movement: Topple, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Bare soil and built over have been found as the land cover in this site.	
Causes of Movement: Weak foundation of wall as well as loose soil contributed to the movement.	
Land Slide History and Future Risk of Landslide	
Retaining wall of Tiger pass collapsed on July 1 in 2011. Seventeen people died in this incident (Demo News Portal, July 28 2014). Houses located down the slope got damaged severely. Utility facilities got damaged in this incident. Economic activities were hampered so does the social life of people. Environmental damage is unquantifiable.Incessant rains in the port city have caused a retaining wall to collapse at Batali Hill, triggering a hill slide (bdnews24, 2011). The escapement slope is found to be near vertical. Vertical Slope characteristics and loose sandy soil can be considered as a contributing factor to future landslide for this hill. Settlements located at the down slope of this hill are at a risk of landslide. The risk is moderate.	

Basic Information	
Landslide ID :10 **Landslide Location:** Lebu Bagan, Chittagong Cantonment **Coordinates:**22˚25'2.46''N , 91˚48'22.86''E	**Datum :** WGS 1984 **Elevation (m):** 30.82 **Area of Displaced Mass (sqm):** 757.61 **Rainfall:** 88mm

Source: *Field survey, August 2014*

Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Dormant **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth

Land Cover/Use Type (%):

Forest/ woodland is the Primary land cover of Lebu bagan. Herbaceous vegetation is also visible in this hill.

Causes of Movement:

Excessive rainfall event (658 mm in 9 days rainfall event) is the main cause of movement.

Land Slide History and Future Risk of Landslide

A massive landslide occurred in Lebu bagan in 11 June, 2007. As many as thirty people were killed and 20-30 people were injured in landslide which hit houses at Lebu Bagan of Chittagong Cantonment (Dept of Environment, Chittagong).The heavy rainfall saturated the hillsides in and around the city giving residents no chance to escape when a tide of mud and water swept down on their homes in the early hours of yesterday morning, burying whole families under mud and debris while they slept. The powerful current simply washed others away. At present there exists no settlement. People were moved from this place. Now this place has become woodland area. Future risk of landslide is low.

Basic Information	
Landslide ID :11 **Landslide Location:** Lebu Bagan, Chittagong Cantonment **Coordinates:**22°25'4.37''N, 91°48'22.43''E	**Datum :** WGS 1984 **Elevation (m):** 41.22 **Area of Displaced Mass (sqm):** 84.56 **Rainfall:** 88mm


Source: *Field survey, August 2014*

Landslide Mechanism	
Type of Movement: Slide **State:** Dormant **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth

Land Cover/Use Type :

Forest/ woodland is the Primary land cover of Lebu bagan. Herbaceous vegetation is also visible in this hill.

Causes of Movement:

Excessive rainfall event (658 mm in 9 days rainfall event) is the main cause of movement.

Land Slide History and Future Risk of Landslide

A massive landslide occurred in Lebubagan in 11 June, 2007. As many as five persons were killed and 20-50 people were injured and in landslide which hit houses at Lebu Bagan of Chittagong Cantonment (Dept. Of Environment, Chittagong). The heavy rainfall saturated the hillsides in and around the city giving residents no chance to escape when a tide of mud and water swept down on their homes in the early hours of yesterday morning, burying whole families under mud and debris while they slept. The powerful current simply washed others away. At present there exists no settlement. People were moved from this place. Now this place has become woodland area. Future risk of landslide is low.

Basic Information	
Landslide ID :12 **Landslide Location:** Lebu Bagan, Chittagong Cantonment **Coordinates:**22°25'4.78''N , 91°48'22.46''E	**Datum :** WGS 1984 **Elevation (m):** 40.19 **Area of Displaced Mass (sqm):** 50.17 **Rainfall:** 88mm


Source: *Field survey, August 2014*

Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Dormant **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth

Land Cover/Use Type :

Forest/ woodland is the Primary land cover of Lebu bagan. Herbaceous vegetation is also visible in this hill.

Causes of Movement:

Excessive rainfall event (658 mm in 9 days rainfall event) is the main cause of movement.

Land Slide History and Future Risk of Landslide

A massive landslide occurred in Lebubagan in 11 June, 2007. As many as two persons were killed and 10-15 people were injured in landslide which hit houses at Lebu Bagan of Chittagong Cantonment. The heavy rainfall saturated the hillsides in and around the city giving residents no chance to escape when a tide of mud and water swept down on their homes in the early hours of yesterday morning, burying whole families under mud and debris while they slept. The powerful current simply washed others away. At present there exists no settlement. People were moved from this place. Now this place has become woodland area. Future risk of landslide is low.

Basic Information	
Landslide ID :13 **Landslide Location:** Kaicchaghona , Chittagong Cantonment **Coordinates:**22°25'28.57''N 91°48'14.87''E **Datum :** WGS 1984 **Elevation (m):** 37.64 **Area of Displaced Mass (sqm):** 145.5 **Rainfall:** 88mm	
Landslide Mechanism	
Type of Movement: Slide **State:** Stabilized **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Forest/ woodland is the Primary land cover of Kaicchaghona. Herbaceous vegetation is also visible in this hill.	
Causes of Movement: Excessive rainfall event (658 mm in 9 days rainfall event) is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
A massive landslide occurred in Kaicchaghona in 11 June, 2007. As many as two persons were killed and 12-15 people were injured and in landslide which hit houses at Kaicchaghona of Chittagong Cantonment (Dept. Of Environment). Many houses got destroyed in this disaster. The heavy rainfall saturated the hillsides in and around the city giving residents no chance to escape when a tide of mud and water swept down on their homes in the early hours of yesterday morning, burying whole families under mud and debris while they slept. The powerful current simply washed others away. At present there exists no settlement. People were moved from this place. Now this place has become woodland area. Future risk of landslide is low.	

Basic Information	
Landslide ID :14 **Landslide Location:** Kaicchaghona , Chittagong Cantonment **Coordinates:** 22°25'26.00''N ,91°48'20.91''E **Datum :** WGS 1984 **Elevation (m):** 24.71 **Area of Displaced Mass (sqm):** 582.27 **Rainfall:** 88mm	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, slide **State:** Stabilized **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation is the Primary land cover of Kaicchaghona. Forest/ woodland type is also visible in this hill.	
Causes of Movement: Excessive rainfall event (658 mm in 9 days rainfall event) is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
A massive landslide occurred in Kaicchaghona in 11 June, 2007. As many as seven persons were killed and 20-30 people were injured and in landslide which hit houses at Kaicchaghona of Chittagong Cantonment (Dept of Environment, Chittagong). Many houses got destroyed in this disaster. The heavy rainfall saturated the hillsides in and around the city giving residents no chance to escape when a tide of mud and water swept down on their homes in the early hours of yesterday morning, burying whole families under mud and debris while they slept. The powerful current simply washed others away. At present there exists no settlement. People were moved from this place. Now this place has become woodland area. Future risk of landslide is low.	

Basic Information	
Landslide ID :15 **Landslide Location:** Lebu Bagan , Chittagong Cantonment **Coordinates:** 22°25'58.80''N , 91°48'26.31''E **Datum :** WGS 1984 **Elevation (m):** 46.07 **Area of Displaced Mass (Sqm):** 1359.5 **Rainfall:** 88mm	 Source: *Dept. Of Environment, 2007*
Landslide Mechanism	
Type of Movement: Fall, slide **State:** Dormant **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation is the Primary land cover of Lebu Bagan. Forest/ woodland type is also visible in this hill.	
Causes of Movement: Excessive rainfall event (658 mm in 9 days rainfall event) is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
A massive landslide occurred in Lebu Bagan in 11 June, 2007. As many as forty persons (Dept. of Environment, Chittagong) were killed and almost 50 people were injured (Field survey, August 2014) and in landslide which hit houses at Lebu Bagan of Chittagong Cantonment. Many houses got destroyed in this disaster. The heavy rainfall saturated the hillsides in and around the city giving residents no chance to escape when a tide of mud and water swept down on their homes in the early hours of yesterday morning, burying whole families under mud and debris while they slept. The powerful current simply washed others away. At present there exists no settlement. People were moved from this place. Now this place has become woodland area. Future risk of landslide is low.	

Basic Information	
Landslide ID :16 **Landslide Location:** Sekandar Para, Chittagong Cantonment **Coordinates:** 22°26'09.57''N , 91°47'41.53''E **Datum :** WGS 1984 **Elevation (m):** 40.68 **Area of Displaced Mass (sqm):** 181.7 **Rainfall:** 88mm	 Source: *Dept. Of Environment, 2007*
Landslide Mechanism	
Type of Movement: Slide **State:** Stabilized **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Forest/ woodland and Herbaceous vegetation are the Primary land cover of Sekandar Para	
Causes of Movement: Excessive rainfall event (268 mm in 7 days rainfall event) is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
A massive landslide occurred in at Sekandar Para in 11 June, 2007. As many as three persons (Dept. of Environment, Chittagong) were killed and almost nine people were injured (Field survey, August 2014) and in landslide which hit houses at Sekandar Para of Chittagong Cantonment. Many houses got destroyed in this disaster. The heavy rainfall saturated the hillsides in and around the city giving residents no chance to escape when a tide of mud and water swept down on their homes in the early hours of yesterday morning, burying whole families under mud and debris while they slept. The powerful current simply washed others away. At present there exists no settlement. People were moved from this place. Now this place has become woodland area. Future risk of landslide is low.	

Basic Information	
Landslide ID :17 **Landslide Location:** Sekandar Para, Chittagong Cantonment **Coordinates:** 22°26'09.05''N , 91°47'40.51''E **Datum and Elevation (m):** WGS 1984 **Area of Displaced Mass (sqm):** 198.89 **Rainfall:** 88mm	 Source: *Dept. Of Environment, 2007*
Landslide Mechanism	
Type of Movement: Slide **State:** Stabilized **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Forest/ woodland and Herbaceous vegetation are the Primary land cover of Sekandar Para	
Causes of Movement: Excessive rainfall event (268 mm in 7 days rainfall event) is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
A massive landslide occurred in at Sekandar Para in 11 June, 2007. As many as two persons (Dept. of Environment, Chittagong) were killed and almost seven people were injured (Field survey, August 2014) and in landslide which hit houses at Sekandar Para of Chittagong Cantonment. Many houses got destroyed in this disaster. The heavy rainfall saturated the hillsides in and around the city giving residents no chance to escape when a tide of mud and water swept down on their homes in the early hours of yesterday morning, burying whole families under mud and debris while they slept. The powerful current simply washed others away. At present there exists no settlement. People were moved from this place. Now this place has become woodland area. Future risk of landslide is low.	

Basic Information	
Landslide ID :18 **Landslide Location:** Sekandar Para, Chittagong Cantonment **Coordinates:** 22°26'10.17''N , 91°47'41.10''E **Datum :** WGS 1984 **Elevation (m):** 48.51 **Area of Displaced Mass (sqm):** 211.61 **Rainfall:** 88 mm	 Source: *Dept. Of Environment, 2007*
Landslide Mechanism	
Type of Movement: Slide **State:** Stabilized **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Forest/ woodland and Herbaceous vegetation are the Primary land cover of Sekandar Para	
Causes of Movement: Excessive rainfall event (658 mm in 9 days rainfall event) is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
A massive landslide occurred in at Sekandar Para in 11 June, 2007. As many as four persons (Dept. of Environment, Chittagong) were killed and almost twelve people were injured (Field survey, August 2014) and in landslide which hit houses at Sekandar Para of Chittagong Cantonment. Many houses got destroyed in this disaster. The heavy rainfall saturated the hillsides in and around the city giving residents no chance to escape when a tide of mud and water swept down on their homes in the early hours of yesterday morning, burying whole families under mud and debris while they slept. The powerful current simply washed others away. At present there exists no settlement. People were moved from this place. Now this place has become woodland area. Future risk of landslide is low.	

Basic Information	
Landslide ID :19 **Landslide Location:** Ispahani Hill, Kushumbagh **Coordinates:** 22°21' 18.33'' N, 91°48'50.66''E	**Datum and** **Elevation (m):** WGS 1984 **Area of Displaced Mass (sqm):** 233.06 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	 Figure: Man cutting hill to construct house *Source: Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, slide **State:** Active **Distribution:** Advancing	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Forest/ woodland and Herbaceous vegetation are the Primary land cover of Ispahani Hill.	
Causes of Movement: Excessive rainfall event and hill cutting is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in Ispahani hill occurs in every rainy season. People cut hill to construct houses at the slopes of hill. There are some tin shed houses are seen located at slopes of Ispahani hill. Till now no big landslide has occurred in this place. Landslides that have been occurring in every rainy season have low damage intensity. Soil characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements located at the down slope of this hill are at a huge risk of massive landslide. The risk is high (Field Survey, August 2014)	

Basic Information	
Landslide ID :20 **Landslide Location:** Kushumbagh Housing, Kushumbagh **Coordinates:** 22˚21'21.11''N , 91˚49'1.83''E	**Datum :** WGS 1984 **Elevation (m):** 26.98 **Area of Displaced Mass (sqm):** 152.79 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, slide **State:** Active **Distribution:** Advancing	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation are the Primary land cover of Kushumbagh Housing hill	
Causes of Movement: Excessive rainfall and hill cutting is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in Kushumbagh Housing, hill occurs in every rainy season. People cut hill to construct houses at the slopes of hill. There are some tin shed houses are seen located at slopes of Kushumbagh Housing hill. Till now no big landslide has occurred in this place. Landslides that have been occurring in every rainy season have low damage intensity. Soil characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements located at the down slope of this hill are at a huge risk of massive landslide. The risk is high.	

Basic Information	
Landslide ID :21 **Landslide Location:** Goribullah shah, Kushumbagh **Coordinates:** 22°21'21.97''N , 91°48'58.98''E	**Datum :** WGS 1984 **Elevation (m):** 36.68 **Area of Displaced Mass (sqm):** 241.79 **Rainfall:** Unknown

Source: *Field survey, August 2014*

Landslide Mechanism	
Type of Movement: Topple, slide **State:** Active **Distribution:** Advancing	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth

Land Cover/Use Type :

Herbaceous vegetation is the Primary land cover of Goribullah shah hill

Causes of Movement:

Excessive rainfall and hill cutting is the main cause of movement.

Land Slide History and Future Risk of Landslide

Land slide in Goribullah shah hill occurs in every rainy season. People cut hill to construct houses at the slopes of hill. There are some tin shed houses are seen located at slopes of Goribullah shah hill. Till now no big landslide has occurred in this place. Landslides that have been occurring in every rainy season have low damage intensity. Soil characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements located at the down slope of this hill are at a huge risk of massive landslide. The risk is high (Field Survey, August 2014)

Basic Information	
Landslide ID :22 **Landslide Location:** Chittagong University **Coordinates:** 22°28' 15.81'' N , 91°47' 31.18'' E	**Datum :** WGS 1984 **Elevation (m):** 39.81 **Area of Displaced Mass (sqm):** 390.34 **Rainfall:** 88mm

Source: *Field survey, August 2014*

Landslide Mechanism	
Type of Movement: Topple, slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth

Land Cover/Use Type :

Herbaceous vegetation and forest/woodland are the Primary land cover of Chittagong University hill.

Causes of Movement:

Excessive rainfall event (658 mm in 9 days rainfall event) is the main cause of movement.

Land Slide History and Future Risk of Landslide

Land slide in Chittagong University hill occurred in 11 June, 2007. . None was found to be injured or dead. Intense and prolonged rainfall had been occurring for 5-7 days prior to landslide. Utility facilities did not get damaged in this incident. Economic and Environmental loss was not quantifiable. Soil characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. No Settlements are located at the down slope of this hill.

Basic Information	
Landslide ID :23 **Landslide Location:** Chittagong University **Coordinates:** 22°28' 12.77'' N, 91°47'10.06'' E **Datum and Elevation (m):** WGS 1984 **Area of Displaced Mass (sqm):** 1134.77 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation and forest/woodland are the Primary land cover of Chittagong University hill.	
Causes of Movement: Excessive rainfall is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in Chittagong University hill occurred in June, 2011. A huge chunk of earth fell from the top of the hill. None was found to be injured or dead. Intense and prolonged rainfall had been occurring for 5-7 days prior to landslide (Dept. Of Environment, Chittagong). Utility facilities did not get damaged in this incident. Economic and Environmental loss was not quantifiable. Soil characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. No Settlements are located at the down slope of this hill.	

Basic Information	
Landslide ID :24 **Landslide Location:** Chittagong University **Coordinates:** 22°28' 14.33'' N, 91°47'31.71'' E **Datum:** WGS 1984 **Elevation (m):** 35.18 **Area of Displaced Mass (sqm):** 313.42 **Rainfall:** 88 mm	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Topple, slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation and forest/woodland are the Primary land cover of Chittagong University hill.	
Causes of Movement: Excessive rainfall event (658 mm in 9 days rainfall event) is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in Chittagong University hill occurred in 11 June, 2007. None was found to be injured or dead. Intense and prolonged rainfall had been occurring for 5-7 days prior to landslide. Utility facilities did not get damaged in this incident. Economic and Environmental loss was not quantifiable. Soil characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. No Settlements are located at the down slope of this hill.	

Basic Information	
Landslide ID :25 **Landslide Location:** Chittagong University, Golachipa **Coordinates:** 22°27' 57.43'' N, 91°47'27.58'' E **Datum :** WGS 1984 **Elevation (m):** 37.92 **Area of Displaced Mass (sqm):** 212.7 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Topple, slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation and forest/woodland are the Primary land cover of Chittagong University hill.	
Causes of Movement: Excessive rainfall event (667 mm in 3 days rainfall event) is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
A significant land slide in Chittagong University hill, Golachipa occurred in 22 June, 2014. None was found to be injured or dead. Intense and prolonged rainfall had been occurring for 5-7 days prior to landslide. Utility facilities did not get damaged in this incident. Economic and Environmental loss was not quantifiable. Landslide in this hill occurs at every rainy season. Soil characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. No Settlements are located at the down slope of this hill.	

Basic Information	
Landslide ID :26 **Landslide Location:** Gol Pahar, Foy'z lake **Coordinates:** 22°22'2.0'' N, 91°47'12.8''E	**Datum :** WGS 1984 **Elevation (m):** 58.72 **Area of Displaced Mass (sqm):** 105.38 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation and forest/woodland are the Primary land cover of Gol Pahar hill.	
Causes of Movement: Excessive rainfall and hill cutting are the main cause of movement.	
Land Slide History and Future Risk of Landslide	
A significant land slide in Gol Pahar, Foy'z lake hill occurred in 1990. None was found to be injured or dead. Landslide in this hill occurs at every rainy season. Soil characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements are located at the down slope of this hill. People have constructed their house through cutting hill. Sac filled with sand have been used to protect hill from land slide. Still land slide has been occurring in this site. People located near Goal Pahar hill are in great risk of massive landslide.	

Basic Information	
Landslide ID :27 **Landslide Location:** Gol Pahar, Foy'z lake **Coordinates:** 22°21'55.13'' N, 91°47'15.41''E	**Datum:** WGS 1984 **Elevation (m):** 45.69 **Area of Displaced Mass (sqm):** 197.07 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation and forest/woodland are the Primary land cover of Gol Pahar hill.	
Causes of Movement: Excessive rainfall and hill cutting are the main cause of movement.	
Land Slide History and Future Risk of Landslide	
A significant land slide in Gol Pahar, Foy'z lake hill occurred in 1990. None was found to be injured or dead. Landslide in this hill occurs at every rainy season. Soil characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements are located at the down slope of this hill. People have constructed their house through cutting hill. Sac filled with sand have been used to protect hill from land slide. Still land slide has been occurring in this site. People located near Goal Pahar hill are in great risk of massive landslide (Field Survey, August 2014).	

Basic Information	
Landslide ID :28 **Landslide Location:** Gol Pahar, Foy'z lake **Coordinates:** 22°21'56.66'' N, 91°47'13.76''E **Datum :** WGS 1984 **Elevation (m):** 45.12 **Area of Displaced Mass (sqm):** 77.81 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation and forest/woodland are the Primary land cover of Gol Pahar hill.	
Causes of Movement: Excessive rainfall and hill cutting are the main cause of movement.	
Land Slide History and Future Risk of Landslide	
A significant land slide in Gol Pahar, Foy'z lake hill occurred in 1990. None was found to be injured or dead. Landslide in this hill occurs at every rainy season. Soil characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements are located at the down slope of this hill. People have constructed their house through cutting hill. Sac filled with sand have been used to protect hill from land slide. Still land slide has been occurring in this site. People located near Goal Pahar hill are in great risk of massive landslide (Field Survey, August 2014)	

Basic Information	
Landslide ID :29 **Landslide Location** Akbar Shah Mazar hill **Coordinates:** 22°21'44.69''N, 91°47'30.05''E	**Datum :** WGS 1984 **Elevation (m):** 28.41 **Area of Displaced Mass (sqm):** 231.26 **Rainfall:** 88 mm

Source: *Field survey, August 2014*

Landslide Mechanism	
Type of Movement: Fall, Flow **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth

Land Cover/Use Type :

Herbaceous vegetation and is the Primary land cover of Akbar shsh mazar hill.

Causes of Movement:

Excessive rainfall event (658 mm in 9 days rainfall event) and hill cutting are the main cause of movement.

Land Slide History and Future Risk of Landslide

A significant land slide in Akbar Shah Mazar hill hill occurred in 11 June 2007. Seven people were killed and 20-30 people were injured in that land slide occurrence (Feild Survey, August 2014). Twelve tin shed houses were completely destroyed. At present 200-250 families live in 30 houses located just down the slope of the hill. Characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical Slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements People have constructed their house through cutting hill. Sac filled with sand have been used to protect hill from land slide. People located near Goal Pahar hill are in great risk of massive landslide.

Basic Information	
Landslide ID :30 **Landslide Location**: Lal Pahar, Foy'z Lake **Coordinates:** 22°21'56.77''N , 91°47'39.52''E	**Datum :** WGS 1984 **Elevation (m):** 38.51 **Area of Displaced Mass (sqm):** 153.55 **Rainfall:** Unknown

Source: *Field survey, August 2014*

Landslide Mechanism	
Type of Movement: Topple, Slide **State:** Active **Distribution:** Advancing	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth

Land Cover/Use Type:

Herbaceous vegetation and is the Primary land cover of Lal Pahar.

Causes of Movement:

Excessive rainfall and hill cutting are the main cause of movement.

Land Slide History and Future Risk of Landslide

Land slide in Lal Pahar occurs at every rainy season. No information about any significant land slide in this site is found. At present 150-200 families live surrounding this hill area. Soil characteristic of this site is of sandy type. The escapement slope is found to be near vertical. Vertical slope characteristics can be considered as a contributing factor to future landslide for this hill. Settlements People have constructed their house through cutting hill. People located near Lal pahar are in great risk of massive landslide.

Basic Information	
Landslide ID :31 **Landslide Location**: Foy'z Lake Observation Tower hill **Coordinates:** 22°22'1.94''N , 91°47'32.67''E **Datum :** WGS 1984 **Elevation (m):** 45.42 **Area of Displaced Mass (sqm):** 456.7 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Slide **State:** Active **Distribution:** Advancing	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation and is the Primary land cover of Foy'z Lake Observation Tower hill	
Causes of Movement: Excessive rainfall is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in Foy'z Lake Observation Tower hill occurs at every rainy season. No information about any significant land slide in this site is found. At present 150-200 families live on the down slope area of the hill. Soil characteristic of this site is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical to incline. People have constructed their house through cutting hill at the down slope of hill. People located near Foy'z Lake Observation Tower hill are in moderate risk of massive landslide.	

Basic Information	
Landslide ID :32 **Landslide Location**: Foy'z Lake Zoo hill **Coordinates:** 22°22'2.34''N , 91°47'30.44''E **Datum :** WGS 1984 **Elevation (m):** 46.51 **Area of Displaced Mass (sqm):** 209.12 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Topple, Slide **State:** Active **Distribution:** Advancing	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation and is the Primary land cover Foy'z Lake Zoo hill	
Causes of Movement: Excessive rainfall is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in occurs in Foy'z Lake Zoo hill at every rainy season. No information about any significant land slide in this site is found. At present 150-200 families live on the down slope area of the hill. Soil characteristic of this site is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical to incline. People have constructed their house through cutting hill at the down slope of hill. People located near Foy'z Foy'z Lake Zoo hill are in moderate risk of massive landslide.	

Basic Information	
Landslide ID :33 **Landslide Location**: Foy's Lake Zoo hill **Coordinates:** 22˚22'0.04''N , 91˚47'28.93''E **Datum :** WGS 1984 **Elevation (m):** 34.63 **Area of Displaced Mass (sqm):** 45.86 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Slide **State:** Active **Distribution:** Advancing	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation and is the Primary land cover Foy'z Lake Zoo hill	
Causes of Movement: Excessive rainfall is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in occurs in Foy's Lake Zoo hill at every rainy season. No information about any significant land slide in this site is found. At present 150-200 families live on the down slope area of the hill. Soil characteristic of this site is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical to incline. People have constructed their house through cutting hill at the down slope of hill. People located near Foy's Foy's Lake Zoo hill are in moderate risk of massive landslide (Field Survey, August 2014)	

Basic Information	
Landslide ID :34 **Landslide Location**: Foy's Lake Zoo hill **Coordinates:** 22°22'1.93''N , 91°47'28.26''E **Datum a:** WGS 1984 **Elevation (m):** 48.67 **Area of Displaced Mass (sqm):** 75.88 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation and is the Primary land cover Foy'z Lake Zoo hill	
Causes of Movement: Excessive rainfall and hill cutting are the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in this site occurred in 2013. Damage intensity of that land slide was low. None was found to be dead or injured. At present 100-180 families live on the down slope area of the hill (Field survey, August 2014). Soil characteristic of this site is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical to incline. People have constructed their house through cutting hill at the down slope of hill. People located near Foy's Lake Zoo hill are in moderate risk of massive landslide (Field Survey, August 2014)	

Basic Information	
Landslide ID :35 **Landslide Location**: Foy'z Lake Zoo hill **Coordinates:** 22°22'2.95''N , 91°47'29.54''E **Datum :** WGS 1984 **Elevation (m):** 56.36 **Area of Displaced Mass (sqm):** 232.52 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation and is the Primary land cover Foy'z Lake Zoo hill	
Causes of Movement: Excessive rainfall and hill cutting are the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in this site occurred in 2013. Damage intensity of that land slide was low. None was found to be dead or injured. At present 100-180 families live on the down slope area of the hill (Field survey, August 2014). Soil characteristic of this site is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical to incline. People have constructed their house through cutting hill at the down slope of hill. People located near Foy's Lake Zoo hill are in moderate risk of massive landslide.	

Basic Information	
Landslide ID :36 **Landslide Location**: Nasirabad Housing Properties **Coordinates:** 22˚21'27.06''N , 91˚48'46.48'' E **Datum :** WGS 1984 **Elevation (m):** 44.13 **Area of Displaced Mass (sqm):** 208.57 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation is the Primary land cover Nasirabad Housing Properties	
Causes of Movement: Excessive rainfall and hill cutting are the main cause of movement.	
Land Slide History and Future Risk of Landslide	
No exact date of the occurrence of land slide in this site has been found. At present many multi storied buildings have been developed in this site through hill cutting. Soil characteristic of this site is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical to incline. People have constructed their house through cutting hill at the down slope of hill. People located near Nasirabad Housing Properties **are** in low risk of landslide.	

Basic Information	
Landslide ID :37 **Landslide Location**: Nasirabad Housing Properties **Coordinates:** 22˚21'33.04''N , 91˚48'57.77'' E **Datum :** WGS 1984 **Elevation (m):** 23.50 **Area of Displaced Mass (sqm):** 242.53 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation is the Primary land cover Nasirabad Housing Properties	
Causes of Movement: Excessive rainfall and hill cutting are the main cause of movement.	
Land Slide History and Future Risk of Landslide	
No exact date of land slide occurrence in this site has been found. At present many multi storied buildings have been developed in this site through hill cutting. Soil characteristic of this site is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical to incline. People have constructed their house through cutting hill at the down slope of hill. People located near Nasirabad Housing Properties are in low risk of landslide.	

Basic Information	
Landslide ID :38 **Landslide Location**: Jakir Hossain Road, South Khulshi **Coordinates:** 22˚21'39.27''N , 91˚48'49.37'' E	**Datum :** WGS 1984 **Elevation (m):** 35.00 **Area of Displaced Mass (sqm):** 56.05 **Rainfall:** Unknown
	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, Topple **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation is the Primary land cover of Jakir Hossain Road, South Khulshi .	
Causes of Movement: Excessive rainfall and hill cutting are the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in this site occurred in 2013. None was found to be dead or injured. Damage of the property for this event was insignificant. Zakr hossain road area is a well developed residential area. This area has been developed through hill cutting. A big retention wall has been constructed to protect the area from being damaged from land slide. Many multi storied buildings are located in this area. Soil characteristic of this hill is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical. There is a huge risk of land slide in this hill. But there is less chance of property damage as the area is protected by retention wall. Some semi built shops and houses are located near this hill which may suffer from being landslide (Field Survey, August 2014).	

Basic Information	
Landslide ID :39 **Landslide Location**: Holy Crescent, Khulshi **Coordinates:** 22°21'42.26''N , 91°48'36.54''E	**Datum :** WGS 1984 **Elevation (m):** 26.57 **Area of Displaced Mass (sqm):** 62.3 **Rainfall:** Unknown
	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Topple, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type (%): Herbaceous vegetation and Forest/ Woodland are the Primary land cover of Holy Crescent, Khulshi.	
Causes of Movement: Excessive rainfall and hill cutting are the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in this site occurred in 2013. None was found to be dead or injured. Damage of the property for this event was insignificant. Many multi storied buildings are being constructed in this site. Soil characteristic of this hill is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical. There is a huge risk of land slide in this hill.	

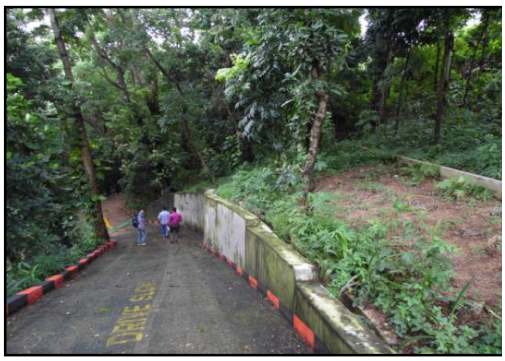
Basic Information	
Landslide ID : 40 **Landslide Location**: AKS Brick field **Coordinates:** 22°22'4.46''N , 91°48'33.14''E	**Datum :** WGS 1984 **Elevation (m):** 13.93 **Area of Displaced Mass (sqm):** 301.06 **Rainfall:** Unknown
Landslide Mechanism	
Type of Movement: Topple, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation and Forest/ Woodland are the Primary land cover of Holy Crescent, Khulshi.	
Causes of Movement: Excessive rainfall and hill cutting are the main cause of movement.	
Land Slide History and Future Risk of Landslide	
No exact date on the occurrence of landslide in this site has been found. At present many multi storied buildings have been developed in this site through hill cutting. Soil characteristic of this site is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical to incline. People have constructed their house through cutting hill at the down slope of hill. People located near AKS Brick field are in low risk of landslide.	

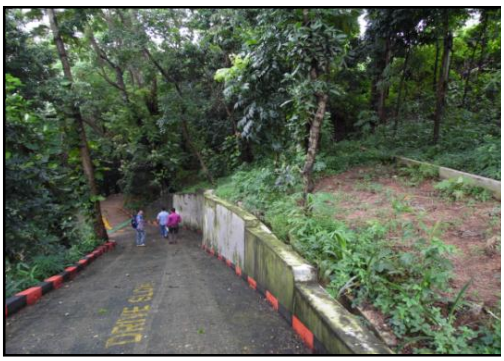
Basic Information	
Landslide ID : 41 **Landslide Location**: Krishnochura Housing **Coordinates:** 22°22'17.32''N , 91°48'5.60''E **Datum :** WGS 1984 **Elevation (m):** 15.93 **Area of Displaced Mass (sqm):** 145.06 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Topple, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation is the Primary land cover of Krishnochura Housing	
Causes of Movement: Excessive rainfall is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
No exact date of the occurrence of land slide has been found. A few houses made of tin have been seen in the site. These houses are constructed through hill cutting. People have prepared land for agricultural purpose through hill cutting. Soil characteristic of this site is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical to incline. There is risk of landslide in this hill.	

Basic Information	
Landslide ID : 42 **Landslide Location**: Krishnochura Housing **Coordinates:** 22°22'17.62''N , 91°48'4.71''E **Datum :** WGS 1984 **Elevation (m):** 15.11 **Area of Displaced Mass (sqm):** 76.43 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Topple, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation is the Primary land cover of Krishnochura Housing .	
Causes of Movement: Excessive rainfall is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
No exact date of the occurrence land slide has been found. A few houses made of tin have been seen in the site. These houses are constructed through hill cutting. People have prepared land for agricultural purpose through hill cutting. Soil characteristic of this site is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical to incline. There is risk of landslide in this hill.	

Basic Information	
Landslide ID : 43 **Landslide Location**: Nasirabad Housing **Coordinates:** 22°21'29.34''N , 91°48'47.09''E	**Datum :** WGS 1984 **Elevation (m):** 32.44 **Area of Displaced Mass (sqm):** 175.81 **Rainfall:** Unknown
Landslide Mechanism	
Type of Movement: Topple, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation is the Primary land cover of Krishnochura Housing	
Causes of Movement: Excessive rainfall is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
No exact date of the occurrence land slide has been found. At present many multi storied buildings have been developing in this site through hill cutting. Soil characteristic of this site is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical to incline. People have constructed their house through cutting hill at the down slope of hill. People located near Nasirabad Housing Properties **are** in low risk of landslide.	

Basic Information	
Landslide ID : 44 **Landslide Location**: Holy Crescent, Khulshi **Coordinates:** 22°21'39.70''N , 91°48'32.39''E **Datum :** WGS 1984 **Elevation (m):** 19.33 **Area of Displaced Mass (sqm):** 50.26 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Topple, Slide **State:** Stabilized **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Herbaceous vegetation is the Primary land cover of Krishnochura Housing	
Causes of Movement: Excessive rainfall is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in this site occurred in 2013. None was found to be dead or injured. Damage of the property for this event was insignificant. Many multi storied buildings are being constructed in this site. Soil characteristic of this hill is of sandy type. No natural or artificial drainage path has been seen in this site. The escapement slope is found to be near vertical. There is a huge risk of land slide in this hill.	

Basic Information	
Landslide ID : 45 **Landslide Location**: Finley hill **Coordinates:** 22°21'18.24''N , 91°49'40.12''E	**Datum:** WGS 1984 **Elevation (m):** 46.40 **Area of Displaced Mass (sqm):** 130.32 **Rainfall:** Unknown
 **Source:** ***Field survey, August 2014***	
Landslide Mechanism	
Type of Movement: Slide **State:** Stabilized **Distribution:** Confined	**Style:** Successive **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation and forest/ woodland are the Primary land cover of Finley hill.	
Causes of Movement: Excessive rainfall is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
No exact date of occurrence of the Land slide in this site has been found. Damage of the property for this event was insignificant. None was found to be dead or injured. Banglows of the officials of Finley company have been constructed on the slope of hill through hill cutting. This hill has been managed in a good way. There exists artificial drainage system so that rain water can easily be drained off. Soil characteristic of this hill is of sandy type. The escapement slope is found to be near vertical to incline. There is low risk of land slide in this hill.	

Basic Information	
Landslide ID : 46 **Landslide Location**: Finley hill **Coordinates:** 22°21'20.30''N, 91°49'39.66''E	**Datum :** WGS 1984 **Elevation (m):** 50.12 **Area of Displaced Mass (sqm):** 118.34 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	
Landslide Mechanism	
Type of Movement: Slide **State:** Stabilized **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation and forest/ woodland are the Primary land cover of Finley hill.	
Causes of Movement: Excessive rainfall is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
No exact date of occurrence of the Land slide in this site has been found. Damage of the property for this event was insignificant. None was found to be dead or injured. Banglows of the officials of Finley company have been constructed on the slope of hill through hill cutting. This hill has been managed in a good way. There exists artificial drainage system so that rain water can easily be drained off. Soil characteristic of this hill is of sandy type. The escapement slope is found to be near vertical to incline. There is low risk of land slide in this hill.	

Basic Information	
Landslide ID : 47 **Landslide Location**: Dolphin hill **Coordinates:** 22°21'13.09''N, 91°49'41.14''E **Datum:** WGS 1984 **Elevation (m):** 29.28 **Area of Displaced Mass (sqm):** 47.80 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation and forest/ woodland are the Primary land cover of Finley hill.	
Causes of Movement: Excessive rainfall is the main cause of movement.	
Land Slide History and Future Risk of Landslide	
No exact date of occurrence of the Land slide in this site has been found. Damage of the property for this event was insignificant. None was found to be dead or injured. Banglows of the officials have been constructed on the slope of hill through hill cutting. There exists artificial drainage system so that rain water can easily be drained off. Soil characteristic of this hill is of sandy type. The escapement slope is found to be near vertical to incline. There is low risk of land slide in this hill.	

Basic Information	
Landslide ID : 48 **Landslide Location**: Medical hill Goachi bagan, Pachlish **Coordinates:** 22°21'23.11''N, 91°49'49.15''E	**Datum :** WGS 1984 **Elevation (m):** 27.00 **Area of Displaced Mass (sqm):** 16.5 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	
Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Bare soil and Herbaceous vegetation are the Primary land cover of Medical hill.	
Causes of Movement: Excessive rainfall and hill cutting are the main causes of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in this site occurred on May 2014. No houses got damaged due to this event. None was found to be dead or injured. There are many settlements located surrounding this hill. People have constructed their houses through hill cutting. Natural drainage system is seriously hampered by the human activities. There exists no artificial drainage system to drain off rain water. Soil characteristic of this hill is of sandy type. The escapement slope is found to be near vertical to incline. There is a high risk of land slide in this hill and people living in this site may get severely affected by the future landslide.	

Basic Information	
Landslide ID : 49 **Landslide Location**: Medical hill Goachi bagan, Pachlish **Coordinates:** 22°21'22.93''N , 91°49'48.73''E	**Datum:** WGS 1984 **Elevation (m):** 23.12 **Area of Displaced Mass (sqm):** 31.67 **Rainfall:** Unknown
 Source: *Field survey, August 2014*	
Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Bare soil and Herbaceous vegetation are the Primary land cover of Medical hill.	
Causes of Movement: Excessive rainfall and hill cutting are the main causes of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in this site occurred on May 2014. No houses got damaged due to this event. None was found to be dead or injured. There are many settlements located on slope of this hill. People have constructed their houses through hill cutting. Natural drainage system is seriously hampered by the human activities. There exists no artificial drainage system to drain off rain water. Soil characteristic of this hill is of sandy type. The escapement slope is found to be near vertical to incline. There is a high risk of land slide in this hill and people living in this site may get severely affected by the future landslide.	

Basic Information	
Landslide ID : 51 **Landslide Location**: The King of Chittagong, Pachlish **Coordinates:** 22˚21'54.11''N , 91˚49'59.93''E **Datum:** WGS 1984 **Elevation (m):** 18.10 **Area of Displaced Mass (sqm):** 184.13 **Rainfall:** Unknown	
Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type (%): Bare soil and Herbaceous vegetation are the Primary land cover of King of Chittagong hill.	
Causes of Movement: Excessive rainfall and hill cutting are the main causes of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in this site occurred on July 2013. No houses got damaged due to this event. None was found to be dead or injured. A community centre named the king of Chittagong has been constructed at the top the hill through hill cutting. There exists artificial drainage system to drain off rain water. Soil characteristic of this hill is of sandy type. The escapement slope is found to be near vertical to incline. There is low risk of land slide in this hill. No significant numbers of settlements are located near this site.	

Basic Information	
Landslide ID : 51 **Landslide Location**: The King of Chittagong, Pachlish **Coordinates:** 22°21'54.11''N , 91°49'59.93''E	**Datum:** WGS 1984 **Elevation (m):** 18.10 **Area of Displaced Mass (sqm):** 184.13 **Rainfall:** Unknown
Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type (%): Bare soil and Herbaceous vegetation are the Primary land cover of King of Chittagong hill.	
Causes of Movement: Excessive rainfall and hill cutting are the main causes of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in this site occurred on July 2013. No houses got damaged due to this event. None was found to be dead or injured. A community centre named the king of Chittagong has been constructed at the top the hill through hill cutting. There exists artificial drainage system to drain off rain water. Soil characteristic of this hill is of sandy type. The escapement slope is found to be near vertical to incline. There is low risk of land slide in this hill. No significant numbers of settlements are located near this site.	

Basic Information	
Landslide ID : 52 **Landslide Location**: Medical Hill, Goachi Bagan **Coordinates:** 22°21'23.81''N , 91°49'47.70''E **Datum:** WGS 1984 **Elevation (m):** 21.59 **Area of Displaced Mass (sqm):** 226.23 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Bare soil and Herbaceous vegetation are the Primary land cover of King of Chittagong hill.	
Causes of Movement: Excessive rainfall and hill cutting are the main causes of movement.	
Land Slide History and Future Risk of Landslide	
Land slide in this site occurred on July 2011. One three storied building got damaged. None was found to be dead or injured. People shifted from that house and the building got demolished by the authority. At present many semi built houses have been constructed on this spot. Soil characteristic of this hill is of sandy type. The escapement slope is found to be near vertical. No natural or artificial drainage system has been found in the site. Human activities have destroyed the natural drainage system. There is a huge risk of future land slide in this hill.	

Basic Information	
Landslide ID : 53 **Landslide Location**: Medical Hill, Goachi Bagan **Coordinates:** 22°21'23.78''N , 91°49'48.51''E	**Datum :** WGS 1984 **Elevation (m):** 22.64 **Area of Displaced Mass (sqm):** 136 **Rainfall:** Unknown

Source: *Field survey, August 2014*

Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth

Land Cover/Use Type :

Bare soil and Herbaceous vegetation are the Primary land cover of King of Chittagong hill.

Causes of Movement:

Excessive rainfall and hill cutting are the main causes of movement.

Land Slide History and Future Risk of Landslide

Land slide in this site occurred on July 2011. One three storied building got damaged. None was found to be dead or injured. People shifted from that house and the building got demolished by the authority. At present many semi built houses have been constructed on this spot. Soil characteristic of this hill is of sandy type. The escapement slope is found to be near vertical. No natural or artificial drainage system has been found in the site. Human activities have destroyed the natural drainage system. There is a huge risk of future land slide in this hill.

Basic Information	
Landslide ID : 54 **Landslide Location**: AK Khan hill **Coordinates:** 22°20' 57.58'' N, 91°48'40.51'' E **Datum :** WGS 1984 **Elevation (m):** 48.36 **Area of Displaced Mass (sqm):** 33 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Fall, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Bare soil and Herbaceous vegetation and built cover are the Primary land cover of AK Khan hill.	
Causes of Movement: Excessive rainfall event (658 mm in 9 days rainfall event) and hill cutting are the main causes of movement.	
Land Slide History and Future Risk of Landslide	
A massive landslide occurred in this site on 2013. House of AK Khan is located at the top of the hill. This house was constructed through hill cutting. Loose soil and heavy rainfall acted as the major triggering factor of landslide. House was collapsed and severely damaged. None was found to be injured. Still people live in this house. Protection measure has been taken. Future risk of landslide is low.	

Basic Information	
Landslide ID : 55 **Landslide Location**: Amin Textile **Coordinates:** 22°22'41.45''N , 91°49'31.72''E **Datum :** WGS 1984 **Elevation (m):** 37.54 **Area of Displaced Mass (sqm):** 71.93 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Topple, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation are the Primary land cover of King of Chittagong hill.	
Causes of Movement: Excessive rainfall is the main causes of movement.	
Land Slide History and Future Risk of Landslide	
No exact date of occurrence of the Land slide in this site has been found. Damage of the property for this event was insignificant. None was found to be dead or injured. At present many semi built houses have been constructed on the surrounding areas of this hill. Soil characteristic of this hill is of sandy type. The escapement slope is found to be near vertical. No natural or artificial drainage system has been found in the site. Human activities have destroyed the natural drainage system. There is a huge risk of future land slide in this hill.	

Basic Information	
Landslide ID : 56 **Landslide Location**: Amin Textile **Coordinates:** 22°22'41.55''N , 91°49'32.14''E **Datum :** WGS 1984 **Elevation (m):** 34.21 **Area of Displaced Mass (sqm):** 71.93 **Rainfall:** Unknown	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Topple, Slide **State:** Active **Distribution:** Advancing	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type: Herbaceous vegetation are the Primary land cover of Amin Textile hill.	
Causes of Movement: Excessive rainfall is the main causes of movement.	
Land Slide History and Future Risk of Landslide	
No exact date of occurrence of the Land slide in this site has been found. From the field investigation it has been known from local people that damage of the property in that event was insignificant. None was found to be dead or injured. At present many semi built houses have been constructed on the surrounding areas of this hill. Soil characteristic of this hill is of sandy type. The escapement slope is found to be near vertical. No natural or artificial drainage system has been found in the site. Human activities have destroyed the natural drainage system. There is a huge risk of future land slide in this hill.	

Basic Information	
Landslide ID : 57 **Landslide Location**: Blossom Garden **Coordinates:** 22°21'24.43''N , 91°49'32.14''E	**Datum :** WGS 1984 **Elevation (m):** 21.31 **Area of Displaced Mass (sqm):** 188.59 **Rainfall:** Unknown
	 Source: *Field survey, August 2014*
Landslide Mechanism	
Type of Movement: Slide **State:** Stabilized **Distribution:** Confined	**Style:** Single **Water Content:** Moist **Material:** Soil/Earth
Land Cover/Use Type : Forest/ Woodland is the Primary land cover of Amin Textile	
Causes of Movement: Excessive rainfall and hill cutting are the main causes of movement.	
Land Slide History and Future Risk of Landslide	
No exact date of occurrence of the Land slide in this site has been found. Damage of the property for this event was insignificant. None was found to be dead or injured. At present construction work of housing is going on in this site. Natural slope characteristics of this hill have been destroyed through hill cutting. The escapement slope is found to be near vertical. Protection measure on this hiss has been taken. Sacks filled with sand are used for protection material. There is low risk of future landslide in this hill.	

CHAPTER 4: CONCLUSION

Landslides are one of the most significant natural damaging disasters in hilly environments. The rapid land cover change coupled with the increases intensity and frequency of adverse weather events is causing devastating effects in Bangladesh. Chittagong is the second largest and main seaport of Bangladesh. This city is highly vulnerable to landslide hazard with an increasing trend of frequency and damage. It has become a crying need to develop an early warning system of landslide for the hilly areas of CMA. The first step for this is to identify the land slide prone locations and analyze their characteristics. From this point of view this inventory report has been prepared.

This inventory reports shows all the landslide prone locations, previous history of land slide, landslide mechanism and future risk of landslides in those locations. People are the main victim of land slide occurrence. So an attempt has been made to find out who can become the primary victim landslide. For this the settlement pattern, road network, utility facilities and socio economic conditions have been analyzed. Underlying factors that contribute to the landslide are also tried to seek.

This inventory will provide detailed information on land slide conditions of different hills of Chittagong Metropolitan Area and help to achieve further objectives of the project.

REFERENCES

Alca´ntara-Ayala, I., Esteban-Cha´vez, O., Parrot, J.F. (2006). Landsliding related to land-cover change: A diachronic analysis of hillslope instability distribution in the Sierra Norte, Puebla, Mexico. Catena, 65, 152 – 165.

ADRC. (2014). Global Identifier Number (GLIDE). Retrieved 23/08/2014, from Asian Disaster Reduction Center, Kobe, Japan http://www.glidenumber.net

Ahammad, R. (2011). Constraints of pro-poor climate change adaptation in Chittagong city. *Environment and Urbanization, 23*(503). doi: 10.1177/0956247811414633

Ahasan, M. N., Chowdhury, M. A. M., & Quadir, D. A. (2011). Prediction of high impact rainfall events of summer monsoon over Bangladesh using high resolution MM5 model. *Sri Lankan Journal of Physics, 12*(2011), 43-58.

Alam, M. E., Taiyeb, M. A., & Akbar, M. T. (2005). Aspects of Socio-Environmental Problems Resulting from Hill Cutting in the city of Chittagong, Bangladesh: Local People's Perspective *Pakistan Journal of Social Science 3*(8), 1048-1052.

Bandara, R. M. S. (2005). Landslides in Sri Lanka. *VIDURAVA, 22*(02), 09-13. Retrieved from thakshana.nsf.ac.lk/pdf/VIDURAWA/VIDUE.../VIDUE-22(2)A-9.pdf

Baum, R. L., & Godt, J. W. (2009). Early warning of rainfall-induced shallow landslides and debris flows in the USA. *Landslides, 7*(2010), 259–272. doi: 10.1007/s10346-009-0177-0

BBC. (2012, 27/06). Heavy rains and landslides in Bangladesh kill 90. Retrieved from http://www.bbc.com/news/world-asia-18605765

Chau, K.T., and et al. (2004). Landslide hazard analysis for Hong Kong using landslide inventory and GIS. Computers & Geosciences, 30, 429 – 443.

Cities and climate change: global report on human settlements, 2011, United Nations Human Settlements Programme.

Chakraborty, P. and Uddin, M. (2014). Living in danger of landslide. Retrieved from 23rd August, 2014 from The Daily Star, http://www.thedailystar.net/living-in-danger-of-landslide-38276

CDMP-II. (2012). *Landslide Inventory and Landuse Mapping, DEM Preparation, Precepitation Threshold Value and Establishment of Early Warning Device* Dhaka 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 Ctg, *The Daily Star*. Retrieved from http://www.thedailystar.net/living-in-danger-of-landslide-38276

Chapagai, D. (2011). Landslide Problem of South Asia and vis-a-vis Global Scenario. In R. K. Dahal & D. Pathak (Eds.), *SAARC Training Program on Landslide Risk Management in South Asia*. Kathmandu, Nepal: SAARC Disaster Management Center.

Dahal, R. K., & Pathak, D. (Eds.). (2011). *SAARC Training Program on Landslide Risk Management in South Asia*. Kathmandu, Nepal SAARC Disaster Management Center

DMC. (2009). Sri Lanka National Report on Disaster Risk, Poverty and Human Development Relationship. Colombo: Disaster Management Center.

EM-DAT. (2014). The OFDA/CERD International Disaster Database. Retrieved 22/08/2014, from Université Catholique de Louvain, Brussels, Belgium http://www.emdat.be/database

GSP. (2014). Early Warning System For Landslide In Muzaffarabad (JICA) Retrieved 26/06/2014, from http://www.gsp.gov.pk/index.php?option=com_content&view=article&id=47%3Aearly-warning-system-for-landslide-in-muzaffarabad-jica&catid=1&Itemid=10

Guha-Sapir, D., Hoyois, P., & Below, R. (2013). Annual Disaster Statistical Review 2012: The numbers and trends. Brussels, Belgium: CRED.

Highland, L. M., & Bobrowsky, P. (2008). The Landslide Handbook- A Guide to Understanding Landslides (Vol. Circular 1325, pp. 129p.). Reston, Virginia: U.S. Geological Survey (USGS).

ISDR. (Ed.) (2009). Geneva, Switzerland: United Nations International Strategy for Disaster Reduction (UNISDR).

Lynch, K., & Hack, G. (1988). *Site Planning* (Third ed.). Cambridge, Massachusetts and London, England: The MIT Press.

POPULATION AND HOUSING CENSUS, SOCIO-ECONOMIC AND DEMOGRAPHIC REPORT, NATIONAL SERIES (2011), VOLUME – 4, Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID), Ministry of Planning

Reid, M. E., Baum, R. L., LaHusen, R. G., & Ellis, W. L. (2008). Capturing landslide dynamics and hydrologic triggers using near-real-time monitoring. *Landslides and Engineered Slopes*, 179-191.

Rubel, Y. A., & Ahmed, B. (2013). Understanding the issues involved in urban landslide vulnerability in Chittagong Metropolitan Area, Bangladesh. Nepal.

Sifatul Quader Chowdhury, Chittagong City, Banglapedia, National Encyclopedia of Bangladesh, Asiatic Society of Bangladesh, Dhaka, Bangladesh. Accessed on 12 September 2013. http://www.bpedia.org/C_0215.php

SAARC. (1992). Mass Wasting and Landslide *Regional Study on the Causes and Consequences of Natural Disasters and the Protection and Preservation of the Environment* (pp. 158-164). Kathmandu, Nepal: SAARC Secratariat.

Sarwar, G. M. (2008). *Landslide Tragedy of Bangladesh*. Paper presented at the The First World Landslide Forum, United Nations University (UNU), Tokyo, Japan.

SDMC. (2007). South Asia Disaster Report, 2007. New Delhi, India: SAARC Disaster Management Center.

SDMC. (2014). Initial Report: Landslide dam at Sunkoshi River in Sindhupal chowk Retrieved 22/08/14, 2014, from http://saarc-sdmc.nic.in

USGS. (2013). Landslide Monitoring Retrieved 26/08/2014, from http://landslides.usgs.gov/monitoring/

Westen, C. J. v., Alkema, D., Damen, M. C. J., Kerle, N., & Kingma, N. C. (2011). *Multi-hazard risk assessment: Distance education course Guide book*. Enschede, The Netherlands: United Nations University – ITC School on Disaster Geoinformation Management (UNU-ITC DGIM).

Yalcin, A. (2007). Environmental Impacts of Landslides: A Case Study from East Black Sea Region, Turkey. *Environmental Engineering Science*, *24*(6), 821-833. doi: 10.1089/ees.2006.0161

Yalcin, A. (2008). GIS-based landslide susceptibility mapping using analytical hierarchy process and bivariate statistics in Ardesen (Turkey): Comparisons of results and confirmations. Catena, 72, 1–12.

APPENDIX A

Landslide Investigation Report- 2014

[Modified from- Multinational Andean Project (2009), Landslide Classification System by Cruden and Varnes (1996); and Intensity Scales for Urban Landslide Damage developed by David E. Alexander (1989)]

Basic Information

1. Address/Location:
2. North/Latitude:
3. East/Longitude:
4. Datum:
5. Altitude (MASL):
6. Date(s) of Movement:
7. Rainfall on that day/ week (mm):
8. Area of displaced Mass (m):

Landslide Characteristics

9. Type of Movement
   - Fall
   - Topple
   - Slide
   - Spread
   - Flow
   - Creep

10. State
    - Active
    - Reactivated
    - Suspended
    - Inactive
    - Dormant
    - Abandoned
    - Stabilized
    - Relict

11. Distribution
    - Advancing
    - Retrogressive
    - Widening
    - Confined
    - Diminishing
    - Moving

12. Style
    - Complex
    - Composite
    - Multiple
    - Successive
    - Single

13. Water Content
- Dry
- Moist/ Wet
- Muddy
- Very wet

14. Material
- Rock
- Soil/Earth
- Debris
- Mixture

15. Land Cover Type (%)
- Herbaceous vegetation
- Forest/woodland
- Built over
- Water body
- Bare soil
- Others

16. Land Use Type (%)
- Protected area
- Residential
- Road way
- Vegetation
- Plantation/Forest
- Commercial
- Hills
- Agriculture/grazing
- Barren land
- Others

17. Causes of Movement
- Collapse of slope
- Improper construction work
- Weak/sensitive/weathered material
- Deposition of load on the slope
- Vegetation removal
- Intense rainfall
- Prolonged exceptional rainfall
- Earthquake or tectonic uplift
- Rapid drawdown of floods
- Excavation of slope
- Deforestation
- Irrigation
- Water leakage from utilities
- Artificial vibration
- Natural subterranean erosion
- Improper disposal of debris
- Poor maintenance of drainage
- Others

Damage Assessment

18. Number of Death:

19. Number of Injury:

20. Number of buildings damaged/ destroyed

21. Buildings/Infrastructure- Damage Intensity

- None
- Negligible
- Light
- Moderate
- Serious
- Very serious
- Partial collapse
- Total collapse

22. Electricity, Gas, Water and Sewer Mains-Damage Intensity

- None
- Light
- Moderate
- Serious
- Destruction I
- Destruction II

23. Roads- Damage Intensity

- None
- Negligible
- Light
- Moderate
- Serious
- Destruction I
- Destruction II

24. Economic Activity- Damage Intensity

- Light damage
- Moderate damage
- Severe damage
- Total destruction
- Not quantifiable

25. Additional Comments (Landslide History, Surrounding Settlement Pattern, People's Socio-Economic Condition, Geology, Slope Characteristics, Drainage System, Soil Characteristics, Land Use, and Future Risks etc.)

APPENDIX B

FIELD PHOTOGRAPHS

Figure 1. : Measuring displacement of mass.

Figure 2. : Taking Photographs.

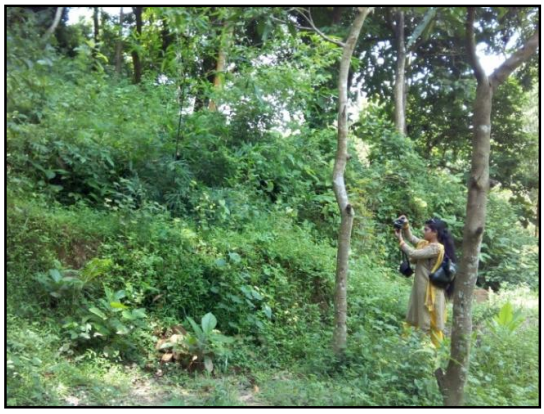


Figure 3 : Taking GPS value

Figure 4: Taking GPS value

Figure 5: Discussion on Project activities

Figure 6: A victim describing landslide event occurred in 2007 at Motijharna Area

Figure 7: A victim describing landslide event occurred in 2007 at Lebu Bagan Area

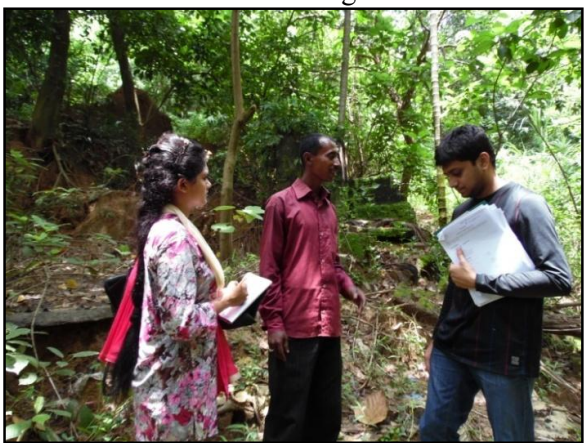
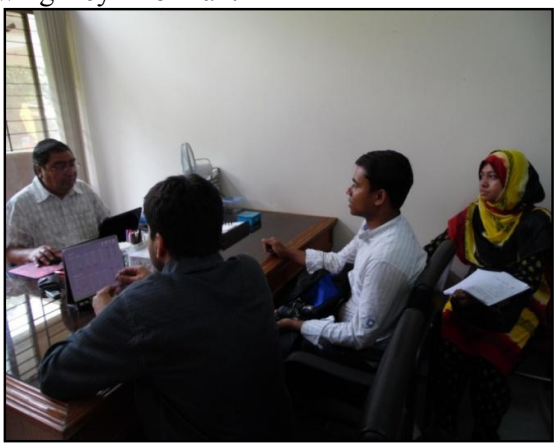


Figure 8: Discussion with local child

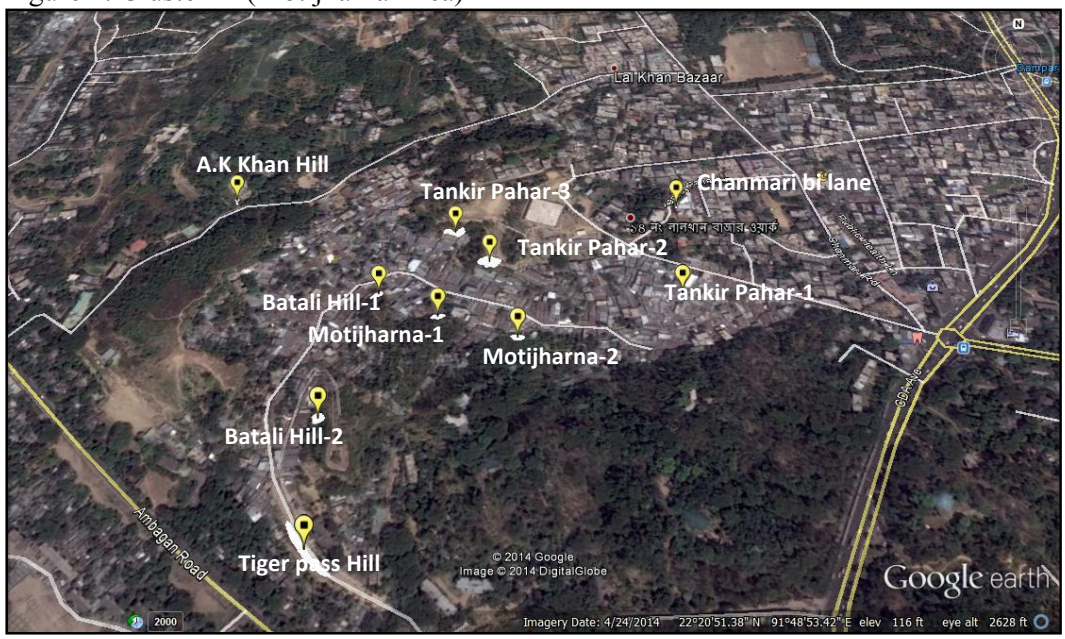
Figure 9 and10: Interviewing Key Informant



APPENDIX C

SATELLITE IMAGE OF THE LOCATIONS OF CLUSTER

Figure 1: Cluster- 1 (Motijharna Area)

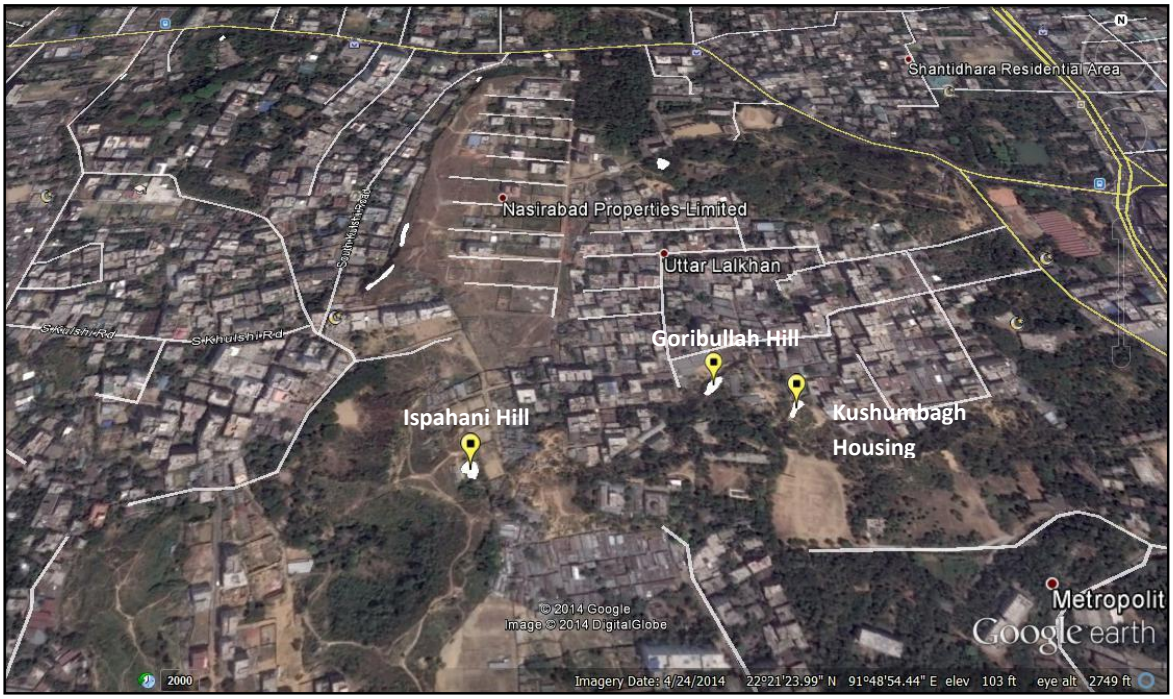


Source: *Google earth and field survey August, 2014*

Figure 2: Cluster- 2 (Chittagong Cantonment Area)

Source: *Google earth and field survey August, 2014*

Figure 3: Cluster- 3 (Kushumbagh Area)



Source: *Google earth and field survey August, 2014*

Figure 4: Cluster- 4 (Chittagong University Campus Area)

Source: *Google earth and field survey August, 2014*

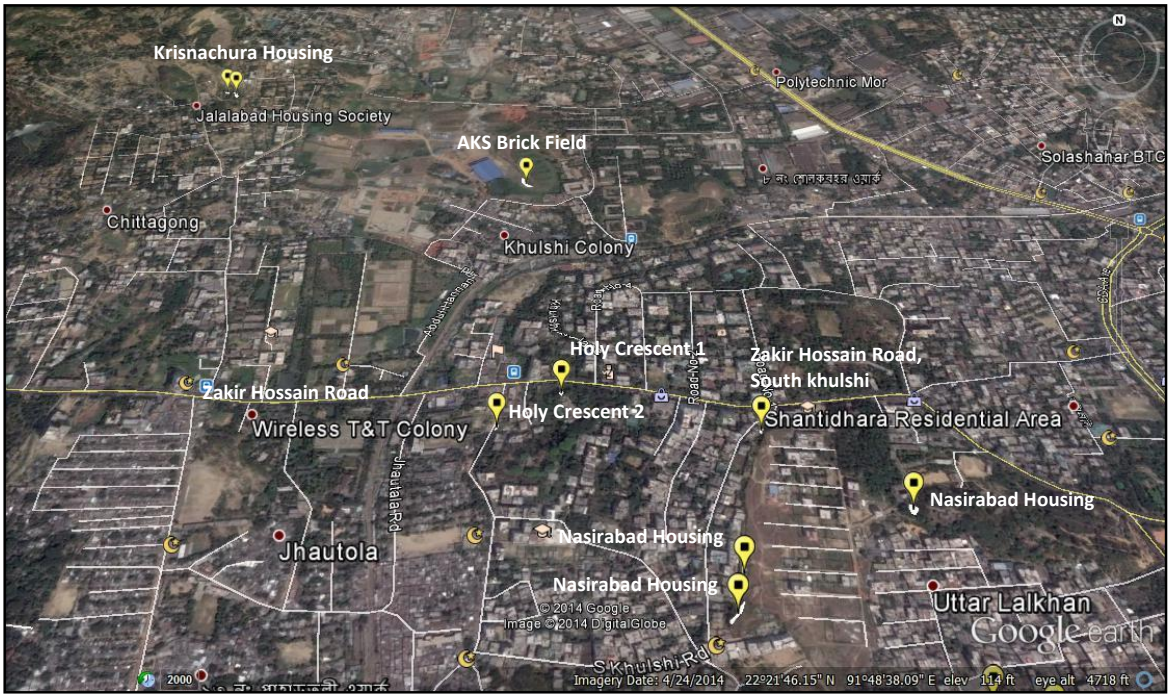
Figure 5: Cluster-5 (Akbar Shah Mazar Area)

Source: *Google earth and field survey August, 2014*

Figure 6: Cluster- 6 (Foy's Lake Area)

Source: *Google earth and field survey August, 2014*

Figure 7: Cluster- 7 (Khulshi Area)



Source: *Google earth and field survey August, 2014*

Figure 8: Cluster- 8 (Chatteswari Area)

Source: *Google earth and field survey August, 2014*

Figure 9: Cluster- 9 (Pachlaish Area)

Source: *Google earth and field survey August, 2014*

APPENDIX D

Project Team

The project team comprises of **8** personnel. They are as follows:

- **Advisor and Geotechnical Specialist:** Professor Dr. Tahmeed M. Al-Hussaini, PhD
- **Foreign Advisor and Landslide Specialist:** Professor IkuoTowhata, PhD (Japan)
- **Foreign Advisor and Social Vulnerability Specialist**: Professor David E. Alexander, PhD (United Kingdom)
- **Disaster Management Specialist:** Md. Shahinoor Rahman
- **GIS Specialist and Web-GIS Programmer:** Bayes Ahmed
- **RS Specialist:** Sharmin Ara
- **Research Assistant:** Sonia Rahman
- **Research Assistant:** Ferdous Farhana Huq