

**LANDSLIDE RISK REDUCTION OF THE INFORMAL  
FOOTHILL SETTLEMENTS OF CHITTAGONG CITY  
THROUGH STRATEGIC DESIGN MEASURE**



A Dissertation for the Degree of Master in Disaster Management

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**Abstract:**

Globally Bangladesh is recognized as one of the most vulnerable countries to natural calamities. Along with cyclones and floods; two most discussed and disastrous hazards of the country, landslides have caused the death of nearly 235 people in various informal settlements of Chittagong city and its adjacent urban centers since 1997. In Chittagong city, about 30 percent of the total population lives in the informal settlements where living environments are quite unsatisfactory and they are deprived of access to basic facilities. The rapid growth of urban population of Chittagong city is fuelled by migration of the rural poor to the city, drawn by perceived chances of finding cash employment in the industrial sector and pushed by the limited opportunities in rural areas. On arrival, many are unable to afford proper housing, so turn to live in informal settlements. Ineffective hill management policy at the national level and weak enforcement by the local authorities has created space for growing many informal settlements along landslide prone hill slopes and foothills in Chittagong city. However, there is no institutional arrangement for vulnerability assessment of those informal settlements to landslides. Few researches on landslide focus on hill cutting issues but are unable to explain the role of formal institutional arrangements for reducing vulnerability of the informal settlers. Neither national level landslide risk reduction organizations nor local level organizations and NGOs have planned and executed any proper structural and non-structural mitigation measure other than conventional stabilization (simple retaining walls) of hill toe and relocation respectively. Besides being more affected by landslides the informal settlers have less willingness to adapt risk reduction measures like relocation. Mostly land tenure conflict, trust, socio-economic status (education, income) and powerlessness inhibit these populations in accepting new institutional arrangements. The growing distrust and conflict has tightened pre-landslide institutional arrangements for reducing vulnerability.

However, there is usually no standard rule of thumb solution because formulation of mitigation measure is often unique for each site and requires proper technical evolution of causative factors. This study explores different strategic design measures on the basis of assessment of risk, uncertainty, possible consequences, constructability, environmental impacts and costs. It suggests that, while proposing a specific measure, it is best to keep simple to match the physical characteristics of the hill and the availability of materials. The study makes an effort to contribute in the development of a comprehensive design solution to reduce landslide vulnerability that can be adapted to ensure the settlers immediate safety.

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## **LIST OF ACRONYMS**

APBN	Armed police Battalion
BMD	Bangladesh Meteorological Department
BDT	Bangladeshi Taka
BBS	Bangladesh Bureau of Statistics
CUS	Centre for Urban Studies
CCC	Chittagong City Corporation
CDA	Chittagong Development Authority
CMA	Chittagong Metropolitan Area
CRED	Center for Research on the Epidemiology of Disasters
DAP	Detailed Area Plan
DC	Divisional Commissioner
DoE	Department of Environment
DMB	Disaster Management Bureau
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GOB	Government of the People's Republic of Bangladesh
GPS	Global Positioning System
IEB	Institute of Engineers Bangladesh
ISDR	International Strategy for Disaster Reduction
IFRC	International Federation of Red Cross & Red Crescent
MoEF	Ministry of Environment & Forest
MoFDM	Ministry of Food and Disaster Management
MSL	Mean Sea Level
NGO	Non-government Organization
SAARC	South Asian Association for Regional Cooperation
UNDP	United Nations Development Programme
UNCHS	United Nations Commission on Human Settlements
WHO	World Health Organization

## APPENDIX 1

### List of the participants in the focus group

<b>Interview Date</b>	<b>Name of the participants</b>	<b>Designation</b>
November 09, 2013	Abul Kashem	Small Business man
	Md. Arif	Factory Worker
	Lokman Miyan	CTG Port Worker
	Joynal	Small Business man
	Md. Motaleb	Owner of 5 houses & Community Leader
	Bulbuli Begum	Housewife
	Shirin Akter	Housewife & working as a housemaid
	Maleka	Housewife & working as a housemaid
	Shofi	Salesman at a clothing store & Volunteer rescuer in 2007 landslide
	Milon Talukder	CTG Port Worker & Volunteer rescuer in 2007 landslide
Badol	Rickshawpuller	

## **APPENDIX 2**

### **Questions for focus group interview**

#### **Part A**

- Q1. How long time you were living along hill slopes?
- Q2. How many people were living in the settlements?
- Q3. Where were you when the landslides occurred of 2007 occurred?
- Q4. Which organizations were responsible for emergency after landslides of 2007, 2010, 2011?

#### **Part B**

- Q5. Do you all live in your own houses or rent?
- Q6. Do you support that these hills are the property of government, but you are living here through encroachment?
- Q7. How do you claim that these hills are your own property?
- Q8. How do you get water and electricity and who determines the unit rate?
- Q9. Do you use sanitary latrines?

#### **Part C**

- Q10. Do you feel that these places are risky to landslides?
- Q11. What do you know about the precaution of the landslides?
- Q12. Do you observe any early warning system before landslides?
- Q13. Did you see any mitigation measures such as structural defense along hill slopes by the government?

#### **Part D**

- Q14. Do you want to be relocated?
- Q15. What do you know about government's selected 2 relocation sites?
- Q16. Despite you are aware of the landslide, why you do not want to leave these places?
- Q17. Do you have any suggestion regarding landslide risk reduction?

**CHAPTER 01:**  
**INTRODUCTION**

## 1.1 Background

Landslide, a natural phenomenon, occurs throughout the world, under all climatic conditions and terrains, costs billions in monetary losses, and is responsible for thousands of deaths and injuries each year. Often, landslides cause long-term economic disruption, population displacement, and negative effects on the natural environment. They cause the most human fatalities in the developing and least developed countries. According to the EM-DAT (2009), between 2000 and 2008, landslides killed approximately 3345 people mostly in developing and least-developed countries like the Philippines, Nepal, China, India and Indonesia.

It may seem that the frequency of landslide disaster is rising, but this perceived rise may be more a function of vulnerability than an actual increase in intensity and frequency. Because of this vulnerability, the thresholds for damage, property loss and fatalities can be reached with ever lower intensity of landslides. There is increase of susceptibility of surface soil to instability as a result of more extensive human interaction of different kinds, increased vulnerability of exposed population and infrastructure as a result of growing population and rapid urbanization.

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

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

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

As development occurs, more and more of it will be on hillside slopes that are susceptible to landslide activity. All predictions are that worldwide slope distress due to urbanization and development will accelerate during the twenty-first century. In fact, low-income people in the cities of poor countries often occupy government or privately owned lands both legally and illegally and build informal settlements along unstable hill slopes without following any existing building codes, standards or regulations (Boulle et al. 1997, Payne 2001, Nathan 2005). Case study showed that landslides are the major cause of deaths in the informal settlements of the cities in poor countries for example, 30,000 deaths in Caracas of Venezuela in 1999 (Cross 2001). Currently, many informal settlements in several cities such as Manila, La Paz, Caracas, Rio de Janeiro and Ponce are found along vulnerable hill slopes (Alexander 2004, Nathan 2008).

Petley (2008) reports that in terms of occurrence of landslide fatalities in the year 2007 by nation, the most seriously affected country was China with 695 landslide induced death followed by Indonesia 465, India 352, Nepal 168, Bangladesh 150 & Vietnam 130. In terms of trigger, 89.6% worldwide fatalities were a result of landslides caused by intense and prolonged precipitation. However, earthquakes also trigger landslides in many urban areas. One notable feature of landslide hazards is the remarkable degree to which human activity can further the occurrence of these processes by destabilizing slopes that otherwise might have endured much longer between slope failures if left undisturbed (Schwab et al. 2005).

Over the last decades major institutional responses have been found in developed countries like Japan and the USA, aimed at reducing landslide vulnerability (Wold and Jochim 1989, Dai et al. 2002). These include structural measures along hill slopes, better land use planning, establishing proper drainage network, improved early warning systems



and relocation of the affected people. These methods have been used individually or in combination to reduce losses from existing or potential landslides.

However, there is still a lack of institutional arrangement to provide these mitigation measures to the vulnerable informal settlers in poor countries (Boulle et al. 1997). There are different approaches to deal with landslides, depending on needs, risks and available funds. Stabilization measures to fully remediate landslides according to the standard of practice often take time to investigate, design and construct and above all become expensive, particularly for developing and least developed countries. Significant stabilization measures might be required to protect critical facilities such as dams, expensive structures and primary highway routes. However, there are situations where full stabilization is impractical due to size of landslide, excessive cost, and highly dense foothill settlement, environmental and ownership restrictions. Cost, ownership issues, over populated hill slope and foot hill settlements etc are common problems found in poor countries while mitigating landslide vulnerabilities. Few researches have analyzed vulnerability of informal settlers to landslides, focusing risk and social impacts of landslides (Alexander 2004, O' Hare and Rivas 2005, Ayala 2008, Nathan 2008). Moreover, an absence of linkage between social vulnerability of informal settlers and institutional settings in landslide hazard risk reduction process has also been identified in developing countries.

This study explores other alternative mitigation options for situations where some risk-taking may be acceptable to owners and affected jurisdictions. In either case, owners or jurisdictions and design professionals have the responsibility to safeguard users of the property and protect the public from death or injury. The challenge is to develop an optimal treatment that is cost-effective and achieves stability, based on a reasonable level of study, sound scientific understanding and qualified landslide experience.

## **1.2 Problem Statement**

Bangladesh has already been recognized globally as one of the most vulnerable countries to natural hazards (Khan and Rahman 2007). Since 1997, landslides have caused the death of nearly 235 people in various informal settlements within Chittagong city and its adjacent small urban centers (Technical Report 2008). Different studies show that approximately 500,000 impoverished people are currently living in informal settlements on the risky foothills of Chittagong city (Islam 2008, Khan 2008). Since the 1980s, major

urban growth has taken place through rural-urban migration in different cities of Bangladesh (Islam 1994).

Due to lack of land ownership and government housing schemes, low-income people often occupied unused government land illegally for housing in Bangladesh (Ahmed 2007). Since the 1990s, many informal settlements were developed on government hills illegally in Chittagong city (Khan 2008). However, there was no institutional arrangement for vulnerability assessment of those informal settlements to landslides. Few research on landslides focuses on hill cutting issues and lacks an explanation of the role of formal institutional arrangements for reducing vulnerability of informal settlers to landslides like found in Chittagong city (Alam et al. 2005, Khan 2008, Islam 2008, Mahmood and Khan 2008). Neither National level landslide risk reduction organizations nor local level organizations and NGOs have planned and executed any proper structural mitigation measures other than conventional stabilization of hill toe.

There are a variety of ways to deal with landslides, depending on the degree of the landslide hazard as well as legal, social, environmental, geotechnical and economic factors. Adjustment and relocation are current institutional steps for reducing vulnerability of informal settlers to landslides in Chittagong city, Bangladesh (Islam 2008). However, there is usually no standard rule-of-thumb solution because formulation of mitigation measures is often unique for each site and requires proper technical evaluation of causative factors.

The selection of appropriate mitigation measures should be based on an assessment of risk, uncertainty, possible consequences, constructability, environmental impacts and costs. A final mitigation approach usually consists of a creative combination of several methods. When selecting a specific mitigation or stabilization method, it is best keep it simple to match the capabilities of contractors and the availability of materials. Simple low-tech precautions and actions can be adopted to ensure an individual's immediate safety.

### **1.3 Research Objective**

The aim of this thesis is to contribute in the development of a design solution that can reduce vulnerability of informal settlers to landslides. Based on a case study in Chittagong city of Bangladesh, it will propose an appropriate mitigation measure by assessing risk, possible consequences, constructability, environmental impacts and costs.

## **1.4 Research Question**

To accomplish study aims, I sought the answers to the following questions:

1. What are the root causes of illegal development of foothill settlement?
2. What are the pre and post-landslide institutional policies at national and local level?
3. Why does the proposed probable measures incompetent to reduce vulnerability of informal settlers to landslides in Chittagong city?

## **1.5 Methodology**

The study was divided into different phases. The initial phase consists of analysis of secondary information such as review of the scientific literatures, publications by the government and non-government organizations and news articles on landslides in Bangladesh. The ultimate aim was to identify stakeholders, selection of the informal settlement area and prepare a framework for collecting information from primary sources.

### **1.5.1 Information Collection**

The study has been conducted by collecting and analyzing both secondary and primary informations. This paper draws on a review of existing literature as well as focus group discussion and interviews in the informal settlements that were affected by landslides from 2007 to 2012, namely Matijharna and areas around Batali Hill.

#### 1.5.1.1 Primary Sources of Information

In addition to field survey, interviews of organizational respondents, professionals working there, and many published unpublished data of NGOs and development agencies have been utilized in this study.

##### *1.5.1.1.1 Organizational respondents*

The individual informants were selected from the technical report (2008), which was produced after landslides in 2007, based on their affiliation in the disaster management committee. In the semi-structured individual interview, informants were asked to list what kinds of policy actions are currently available for landslide vulnerability reduction in Bangladesh. Individuals of local level government agencies described institutional settings before landslides in 2007. They also described post-landslide institutional changes for reducing vulnerability of informal settlers. Other than government agencies, informants from the NGOs, media personal also provided valuable information on institutional arrangements for vulnerability reduction to landslides from their context.

#### *1.5.1.1.2 Focus Group*

A focus group is a kind of group interview, which facilitates participant interaction and discussion on certain topics (Morgan 1996, Freeman 2006). The focus group as a qualitative method identifies diversity of perceptions on specific topics through interactions of members within a group (Merton et al. 1990). After collecting data from the respondents of different organizations, a focus group interview was arranged on November 09, 2013 at the Matijharna settlement in Chittagong city, Bangladesh. The aim was to identify the implementation of the post-landslides institutional changes at the local level. Care was taken to ensure that women were included. Moreover, the focus group interview allowed to explore diverse perspectives and experiences of landslides from the participants and to understand problems like land tenure conflict, trust issues between local organizations and inhabitants from their context.

The focus group consisted of 11 people from the study site (Appendix 1). The participants were selected based on their experiences with landslides from 2007 to 2012. Four individuals were selected from household level as families that were affected with landslides. One person was selected who has experienced with temporary relocation. The community leader was selected as he dealt with law matters on claiming land tenure on hills. One home owner was selected who owns some risky houses along the hill slopes for rent to low income people. Two small sellers from the area have been selected as landslide has damaged their business property. Two volunteers were selected from the community who rescued a number of people in landslide incidence of 2007. In the focus group, the participants were asked to gather data on what institutional arrangements were available before and after the landslides in 2007 for them (Appendix 2). The group answered certain questions and the participants were also allowed to discuss and determine the key gaps between them and formal organizations regarding vulnerability reduction to landslides.

#### 1.5.1.2 Secondary Sources of Information

Secondary sources of information are an integral part of this research. When a project involves original (case study) research, secondary data can play an important role in providing a context for the primary data (Clark, 2005). Therefore, the basic aim of collecting secondary essentials for the research was to have an in-depth background as well as an overview. Various governmental and non-governmental organizations such as Chittagong City Corporation (CCC), Chittagong Development Authority (CDA), Department of Environment (DoE) Chittagong Division, Bangladesh Bureau of Statistics

(BBS), and Centre for Urban Studies (CUS), Dhaka were the most significant sources of secondary information. To some extent, individual people proved a fruitful source of gathering secondary records too. On-line information on contemporary urban landslide issues was also used to enrich the literature review and analysis sections.

### **1.5.2 Rationalization of Collected Information**

Validity is important throughout different stages of research to produce valid scientific knowledge (Kvale 1996). Rationalization is necessary to check whether the collected information from different respondents are not misinterpreted for better discussion and intended research outputs. For instance, do the informal foothill settlers of Chittagong city want to be relocated? To this question one or two respondents answered that they do not want to be relocated. But on the same question, respondents from landslide mitigation committee answered those informal settlers are ready for relocation. To avoid biasness, all these information were cross checked and finally found out that land tenure conflict between local authorities and informal settlers and uncertainty of income opportunities impeded implementing the relocation policy.

At local level, participants in the focus group explained land tenure conflict, how they owned current settlements and what kinds of institutional arrangements were available before and after the landslides in 2007. The informal settlers once experienced that the government agencies tried to evict after the landslide in 2007. Some affected people were rehabilitated immediately, but most of them returned to their previous place. At the end, all the key findings of each section of the focus group interview were checked by explaining the data in front of the participants. It also helped to fill any gap in understanding with regards to their vulnerability to landslides.

Corroboration of the collected data helped to understand how land tenure conflict arose, whether informal settlers were legally owners of the area or not from law perspectives, weak policy regarding structural measures, relocation and rehabilitation in post disaster period.

### **1.5.3 Analysis of the Information**

Content analysis is a procedure of data analysis in qualitative research used for categorizing verbal data and finding out hidden messages from the mass of the interviews (Hancock 1998). The essentials in this study were mostly verbal and document based without any statistical tests. First, information were listed from the answer script based on relevance of answers from the interviewees in two segments: pre- and post-landslides

from 2007 to 2012. In the pre-landslide segment, rather than using pre-conceived categories, the texts were analyzed to find the categories (Taylor et al. 2003). For example, why informal settlements grew in vulnerable areas to landslides? The author developed with the following categories:

- Unplanned hill cutting
- Weak hill management policy
- Absence of structural mitigation
- Immense rural-urban migration

Second, in post-landslide segment analysis of the technical report (2008) and comparing it to the answers of the individual respondents resulted into what new policy is now in practice for reducing vulnerability of informal settlers. At the end, by considering present scenario, relation between national and local level organizations, economic factors proposed some design solutions for the community without relocating them at the same time making them safe from landslide risks.

#### **1.5.4 Mapping of the Study Areas**

The identification of settlement and infrastructure is a critical step in achieving reduction in the risk posed by landslides. Settlements were identified and mapped, using aerial views (taken in April, 2013) from Google earth at a scale 1:750. Infrastructures such as roads were also mapped from aerial photographs. Fieldwork provided ground reference data. This involved cross-checking information from topographic maps, satellite images and aerial photographs. Photographs of settlements and infrastructure were taken, using a digital camera.

##### 1.5.4.1 Batali Hill & Motijharna Area

Motijharna informal settlement and Batali Hill area are closely spaced and very difficult to distinguish one from the other. The highly dense informal settlement areas were drawn together from analyzing data from satellite images, CC maps and field survey photographs. Tool used for mapping was Corel Draw.

#### **1.5.5 Landslide Inventory**

In all the areas, landslides were identified on aerial photographs from Google earth at a scale of 1:750. Images of last 13 years have been analyzed. This involved the identification of scars and channels and depositional areas. Ground reference data was acquired from secondary data sources. This data was also used to verify occurrences and

identify any scars not observed on the aerial photographs and satellite images. Unfortunately because of massive hill cutting in these areas finding footmarks of previous landslides was almost impossible. Local people, especially eye witnesses to the landslides, provided information on the location of the landslides, landslide histories, and the general weather conditions prior to the landslides.

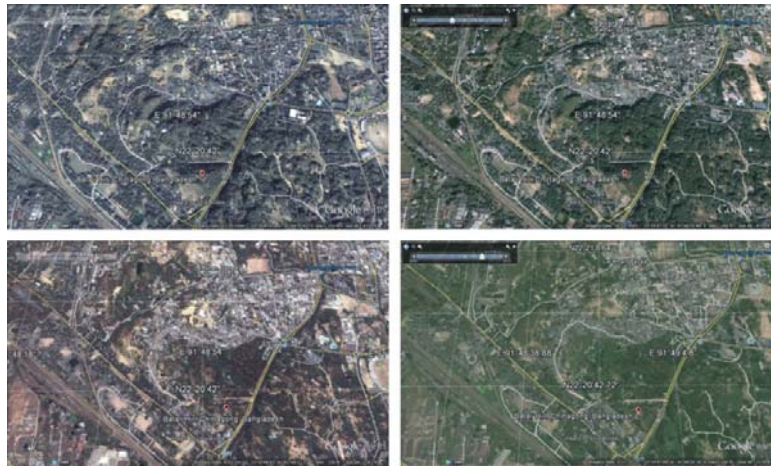


Fig: 1.1 Footmarks of previous landslide  
Source: Google Earth, 2013

## 1.6 Literature Review

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

Climate change, increased susceptibility of surface soil to instability, anthropogenic activities, growing urbanization, uncontrolled land-use and increased vulnerability of population and infrastructure as a result, all contribute to the growing landslide risk. In areas with high demographic density, protection works often cannot be built because of economic or environmental constraints, and is it not always possible to evacuate people because of societal reasons. Furthermore, according to the European Union Strategy for Soil Protection (COM232/2006), landslides are one of the main eight threats to European

soils. Many coastal regions have cliffs that are susceptible to failure from sea erosion (by undercutting at the toe) and their geometry (steep slope angle), resulting in loss of agricultural land and property. This can have a devastating effect on small communities. For instance, parts of the north-east coast cliffs of England are eroding at rates of 1m / yr. Developing countries of Himalayan region are at great risk of landslide.

Since 1950, increased development in hill side areas has underlined the importance of geologic factors promoting instability before beginning engineering analysis or repair. All too often, sites prone to land sliding have been the scene of repeated repair attempts within a few years of each other. Experience over the past more than half-century tends to suggest that many landslide repair attempts are made without benefit or full understanding of geometry and hydrologic regimen of the affected sites. In addition the blind implementation of a traditional, engineered repair scheme may not serve to mitigate adequately all manner and future slope of instability.

The growing hazard and risk, the need to protect people and property, the consequences of the expected climate change and the need for the society to adapt and learn to manage the risk, mitigation measures have been explored worldwide by policy makers; geoscientists and designers by learning from the past. According to Nadim & Lacasse (2008) the strategies for the mitigation of risks associated with landslides can broadly be classified in six categories:

- a. land use plans
- b. enforcement of building codes and good construction practice
- c. early warning systems
- d. community preparedness and public awareness campaigns
- e. Measures to pool and transfer the risks
- f. Construction of physical protection barriers.

The first five strategies are referred to as non-structural measures, which aim to reduce the consequences of landslides; while the last strategy comprises structural slope-stabilization measures, which aim to reduce the frequency and severity of the landslides.

Nadim & Lacasse (2008) recognized that identification of the optimal risk mitigation strategy involves:

- a. identification of possible landslide triggering scenarios, and the associated hazard level (frequency);
- b. analysis of possible consequences for the different scenarios;



- c. assessment of possible measures to reduce and/or eliminate the potential consequences;
- d. recommendation of specific remedial measure and if relevant reconstruction and rehabilitation plans;
- e. Transfer of knowledge and communication with authorities and society.

Many countries have experienced increased vulnerability to landslides and increased awareness of the need for mapping, due to industrial and recreational development over the entire country, infrastructure development, the consequences of interruption in the communication arteries and increase in population. A few major disasters in the past 30 years also helped "convince" the authorities to take preventive measures. To increase safety, reduce risk, and assist with emergency preparedness, a priority mapping is needed for landslides in clays, rock slides and snow avalanches. Susceptibility mapping has been done continuously in European countries since the late 1970s. The susceptibility, hazard and risk maps are especially useful for the planning of new dwellings, schools, recreation areas, etc. The entire network of communication corridors and military and humanitarian (Red Cross) exercises have need for such maps (Karlsrud et al. 1984; Gregersen 1989).

Risk management integrates the recognition and assessment of risk with the development of appropriate strategies for its mitigation. Landslide risk management typically (but not solely) involves decisions at the local level. Lack of information about landslide risk and how this risk is changing on account of changes in climate, land-use, demography and other factors, appears to be a major constraint to provide improved mitigation in many countries. The selection of appropriate mitigation strategies should be based on a future-oriented, quantitative risk assessment; coupled with useful knowledge on the technical feasibility and costs and benefits of risk-reduction measures. In many situations, technical experts acting alone cannot choose the most "appropriate" set of mitigation and prevention measures. The complexities and technical details of managing landslide risk can easily conceal that any strategy is embedded in a social/political system and entails value judgments about who bears the risks and benefits, and who decides. Policy makers and affected parties engaged in solving environmental risk problems are thus increasingly recognizing that traditional expert-based decision-making processes are insufficient, especially in controversial risk contexts. Risk communication and stakeholder involvement has been widely acknowledged for supporting decisions on uncertain and controversial environmental risks, with the added bonus that participation enables the addition of local and subjective knowledge of the people most familiar with the problem.

Precisely which citizens, authorities, NGOs, industry groups, etc., should be involved in which way, however, has been the subject of a tremendous amount of experimentation and theory development. The decision is ultimately made by political representatives, but stakeholder involvement, combined with good risk-communication strategies, can often bring new options to light and delineate the terrain for agreement.

A proactive approach to risk management is instrumental for reducing significantly loss of lives and material damage associated natural hazards. The major natural disasters that have taken place over the last 5-10 years and received wide media attention, have clearly changed people's mind in terms of acknowledging risk management as an alternative to emergency management.

One can observe a positive trend internationally where preventive measures are increasingly recognized, both on the government level and among international donors. There is, however, a great need for intensified efforts, because the risk associated with natural disasters clearly increases far more rapidly than the efforts made to reduce this risk (Machan 2006). A number of countries and international donors have already set some exceptional examples. It is advantageous to study some of them to understand the measures and how they vary from country to country.

- Hong Kong, China

Hong Kong is unique in the world in terms of its combination of high seasonal rainfall and close proximity of dense urban development to steep terrain. A large number of man-made slopes are formed on hillsides to build buildings, roads and other facilities. As a result, landslides are one of the common natural hazards in Hong Kong. The situation was exacerbated by the lack of proper engineering standards in the design and construction of man-made slopes prior to the setting up of the Geotechnical Engineering Office (GEO, formerly known as the Geotechnical Control Office) in 1977 as a central body to regulate various aspects of slope safety in Hong Kong. In the past 65 years since 1947, some 470 people have been killed by landslides in Hong Kong, mostly as a result of failures associated with man-made slopes.

In 1977, the Government of the Hong Kong SAR embarked on a systematic programme, known as the Landslip Preventive Measure (LPM) Programme, to retrofit substandard man-made slopes. From 1977 to 2010, about 4500 substandard government man-made slopes have been upgraded through

engineering works. With the introduction of geotechnical control and the implementation of the LPM Programme, the landslide risk has decreased progressively and reached the “As low as reasonably practicable” (ALARP) zone in 2010. However, there is no room for complacency. If investment in slope safety is not maintained, the landslide risk will increase with time due to slope deterioration and encroachment of urban development or redevelopment up on steep natural hillside. For this, in 2010, the Government implemented the Landslip Prevention and Mitigation (LPMit) Programme to dovetail with the LPM Programme, with the focus on retrofitting the remaining moderate-risk substandard man-made slopes and mitigating systematically the natural terrain landslide risk pursuant to the “react-to-known” hazard principle.

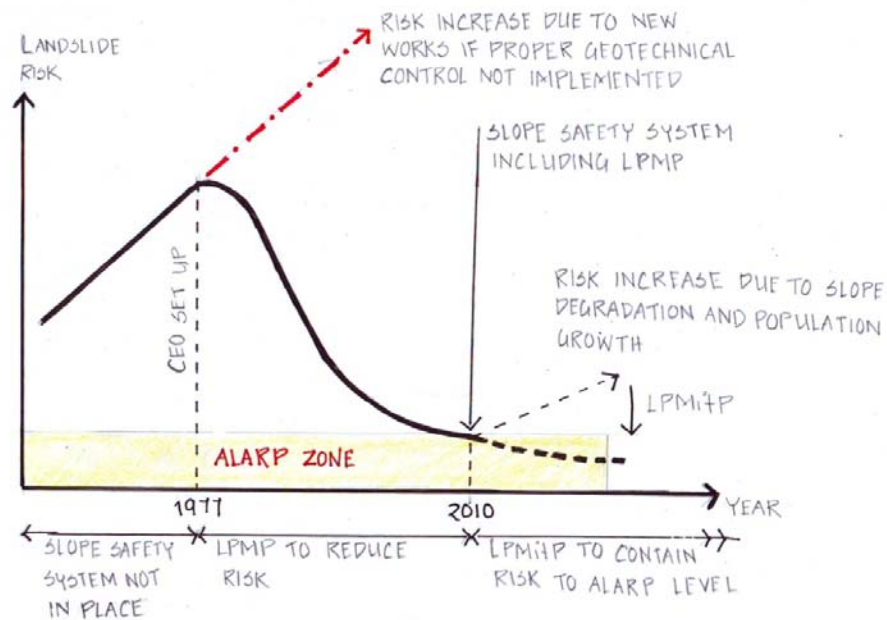


Fig: 1.2 Landslide risk profile of Hong Kong  
Source: Choi & Cheung, 2013; Author, 2013

LPMit Programme is also researching on natural terrain mitigation works. The objective of mitigation works is to divert or contain landslide debris instead of preventing failure, which involves evaluation of debris movement down the slope and its interaction with the mitigation measures. The technology is still evolving. Further development work is being carried out in order to enhance the reliability, cost-effectiveness and build ability of natural terrain mitigation measures. Flexible debris-resistant barriers are introduced as a part of the mitigation work, which are mainly formed of steel ring nets mounted between horizontal steel

ropes spanning between steel posts and anchored into the ground. The advantages of flexible barriers are that they are relatively easy to install on steep natural terrain, less visually obtrusive and have less environmental impact compared with reinforced concrete barriers.

Though flexible barriers have been in use for over twenty years as a protective measure against boulder falls and rock falls, the application of flexible barriers for resisting the impact of natural terrain landslide debris is a relatively new concept. The design methodology for flexible rock fall barriers is based on an energy approach whereby a falling rock or boulder is stopped in one go by the barrier designed to absorb the kinetic energy carried by the rock or boulder. The design usually entails the use of proprietary flexible barrier systems with specific energy absorbing capacities that are verified by full scale field testing in accordance with the relevant national or international standards.

The technology involved is relatively mature. In contrast to a rock fall, the impact of landslide debris hitting a flexible barrier is delivered as consecutive pulses due to the compressibility and mobility of the debris. Therefore, the design methodology for rock fall barriers is not applicable to the design of flexible barriers as a debris resisting structure. So far, there are no national or international standards for the design of flexible debris-resisting barriers. Suggestions on the design approaches for flexible debris-resisting barriers were prepared by Kwan and Cheung (2012) based on a review of the present state of knowledge, which would serve as a useful reference for the relevant practitioners.

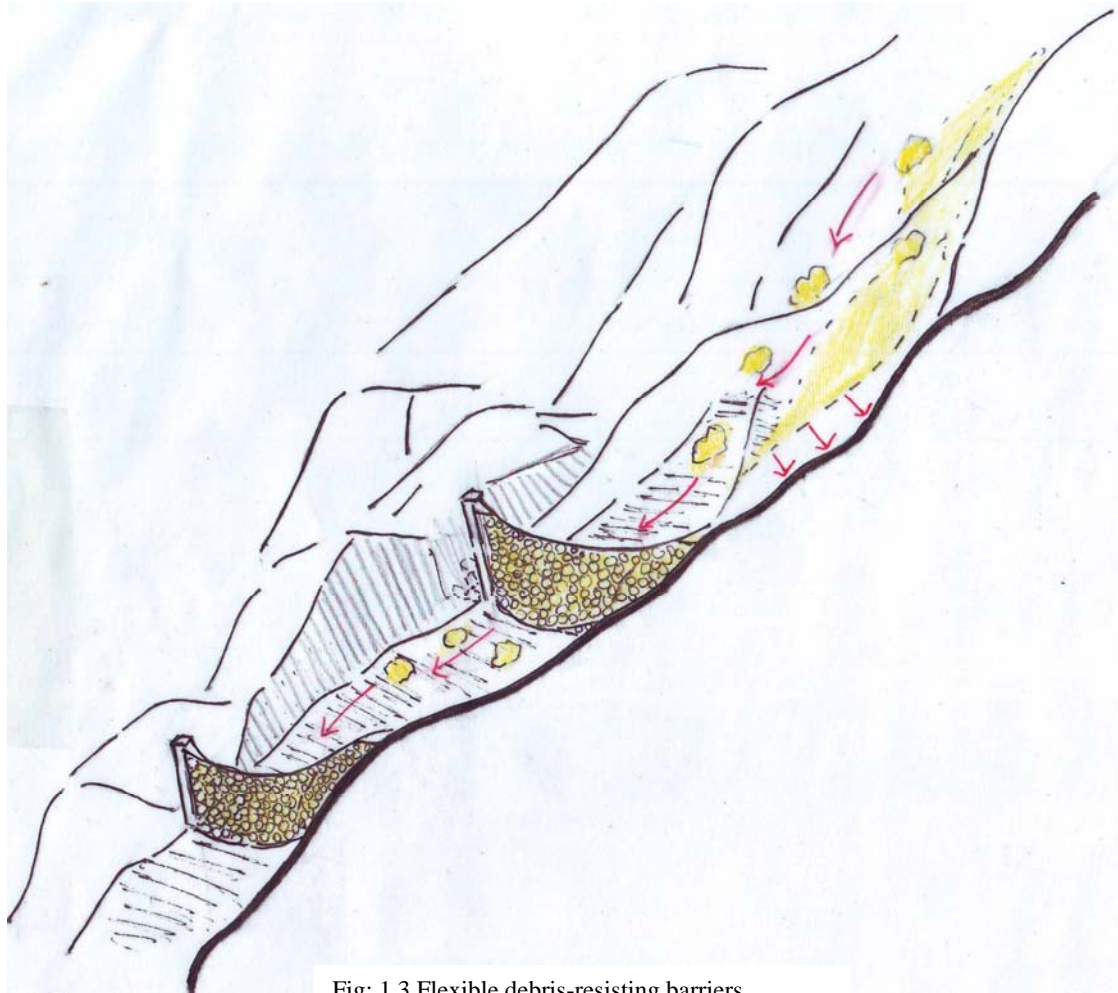


Fig: 1.3 Flexible debris-resisting barriers  
Source: Author, 2013

Apart from keeping the slopes safe, landscape design is treated as an essential part of the design of upgrading works for man-made slopes and natural terrain hazard mitigation works. Input by professional landscape architects is provided at the early stage of the design process to ensure that landscaping input is integrated with geotechnical input. Appropriate, native species are used in the landscaping works in order to create a visually acceptable and ecological sustainable slope environment. Sustained development in Hong Kong requires continued vigilance and perennial attention in respect of landslide risk management. Notwithstanding this, absolute slope safety is not practical or achievable due to many uncertainties inherent in the variables including geological settings, properties of soil and rock, rainfall pattern and groundwater conditions.

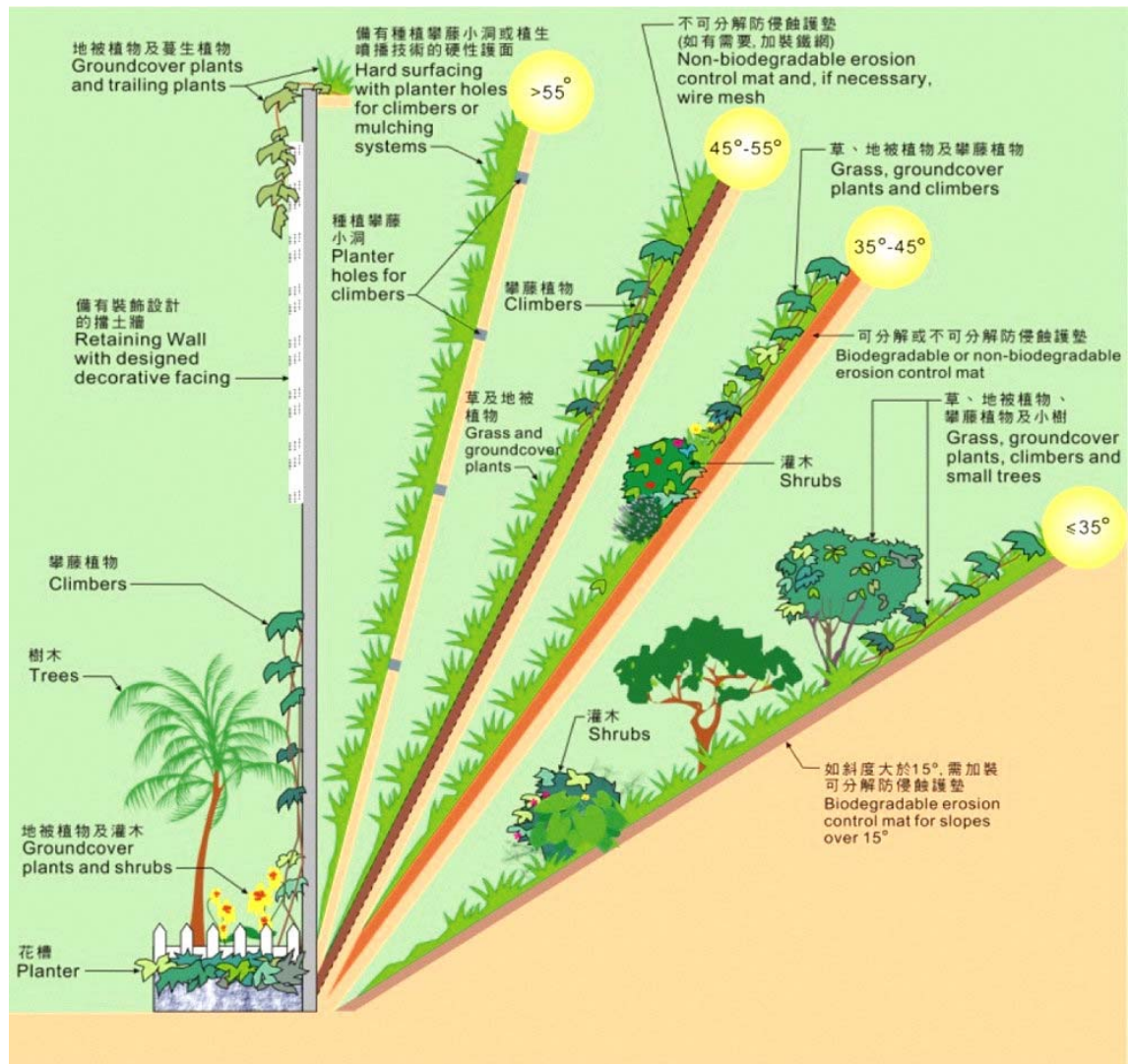


Fig: 1.4 Guide lines for planting on slopes  
Source: Choi & Cheung, 2013

- Rio de Janeiro, Brazil

Rio's dramatic topography and rapid urbanization process have made the city more prone to certain types of environmental hazards, including landslides, erosion, and deforestation. When the Portuguese arrived in the city's Guanabara Bay in 1501, the mountains were covered with thick Atlantic rainforest. In the ensuing years, as this protective covering has been stripped away to make room for settlements, the thin soils have become susceptible to landslides and the rock layer has been left exposed to weathering, making it more prone to erosion

Most of the consequences of the environmental hazards are inflicted with greater severity in the city's poorest areas, usually located on the mountain slopes.

According to the national census and other research, it is estimated that Rio has around 800,000 people living in slums located in the hills, of whom about 20 percent live in areas with a high risk of landslides.

The local government has been quite active in trying to reduce such environmental risks. Over the past 40 years, the Rio de Janeiro city government has undertaken a series of major steps to reduce the risk of landslides and repeated damage from storm-generated instability of the city's many steeply sloping hillsides. The Fundação Instituto de Geotécnica do Município do Rio de Janeiro (also known as GEO-Rio), created in the late 1960s, has been working diligently in environmental research and implementation of risk mitigation measures throughout the city ever since. Recently, GEO-Rio has strengthened its work by developing new containment techniques using alternative materials, such as tires and vegetal fibers, as well as by developing new mapping techniques to identify risk areas with greater precision. Today, GEO-Rio has an exceptionally detailed virtual map of all risk areas in the city, which is available on the web. The institution has also begun to train slum dwellers in methods for improving the condition of their neighborhoods, especially focused on small contingency efforts for landslide prevention.

GEO-Rio has also developed a pioneering alert system for heavy rains and landslides called Alerta Rio, which collects relevant data in every neighborhood of the city and publishes its results online. Since its introduction, this groundbreaking system has become a national and international reference standard for alert systems of this kind. A key aspect of Alerta Rio is community involvement at the neighborhood level, so that residents can develop small emergency plans and mitigation strategies using updated data.

Unlike other interventions designed and deployed as "permanent" fixtures, the audible early warning alarm system is designed to be temporary. The sirens are to be uninstalled from communities where high-risk areas have been eliminated through stabilization works, or by the removal of dwellings, when the civil works cost-benefit analyses show that the advantages to be gained from undertaking works are not outweighed by any perceived direct benefits (protection of homes) and indicate removal as the best option. In terms of equipment, the system comprises remote stations positioned in communities in accordance with the directions pinpointed on the risk maps prepared by the GEO-RIO Foundation. The

overriding technical aim has been to ensure the deployment of a robust, weather-resistant system that is accurate, trouble free, and endowed with backup facilities, so that temporary evacuation of homes can be achieved during severe weather events.

The temporary installation of an alarm system in the poorer settlements with high-risk areas has already saved lives,<sup>1</sup> and the rainfall warning bulletins issued by the Alerta Rio system have significantly reduced the damage caused by storms and heavy rains, given that the population and the public authorities in general have had more time to prepare for, and deal with, flooding or landslides in the vulnerable areas of the city. Note that since April 2010, a number of very substantial rainfall events (more than 50 mm per hour) were recorded along the different roads cutting through the mountainous terrain (the massifs) of the city without triggering any new landslides. In short, the city of Rio de Janeiro has demonstrated that it is well prepared, less vulnerable, and more resilient in its approach to adverse weather events. If one considers the short, medium, and long-term prospects, the recent risk-reduction interventions implemented by the city government have placed Rio de Janeiro in a leading position nationally

- MoSSaiC Approach

Caribbean Islands are highly vulnerable to landslides. Over population, unplanned urbanization and poor slope management triggers the risk. To reduce landslide vulnerability, a World Bank initiated community based mitigation measure was researched and developed in the Eastern Caribbean Islands. Management of Slope Stability in Communities (MoSSaiC) is an integrated method for engaging policy makers, project managers, practitioners and vulnerable communities in reducing urban landslide risk in developing countries. To achieve this goal, they established 3 foundations:

- a. Scientific Base
- b. Community Base
- c. Evidence Base



On these foundations, MoSSaiC developed some posters and leaflets for the community people. These helped the vulnerable population to understand the threats of unplanned growth and indiscriminate hill cutting. The posters also portrayed MoSSaiC developed “5 Steps to safer slopes”. These building techniques can be practiced at any area prone to landslide.



Fig: 1.5 Building techniques in landslide prone area  
Source: Anderson & Holcombe, 2013

Kjekstad (2007) suggested an approach based on three pillars for landslide risk management for developing countries:

- a. Pillar 1: Hazard and risk assessment
- b. Pillar 2: landslide mitigation measures
- c. Pillar 3: international cooperation and support

A milestone in international collaboration for natural disaster risk reduction was the approval of the "Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters" (ISDR 2005). This document, which was approved by 165 UN countries during the World Conference on Disaster Reduction in Kobe, January 2005, clarifies international working modes, responsibilities and priority actions for the coming 10 years.

The Hyogo Framework of Action has increased the awareness and importance of preventive and mitigation measures. It will also contribute to a much better practice for the implementation of risk reduction projects for two reasons:

- a. By the fact that governments will be in the driving seat, which means that coordination is likely to be improved,
- b. The fact that ISDR is given the responsibility for the follow-up of the plan will put pressure for action from countries that are most exposed.

Reducing the impact of landslide with passive and active counter measures is both an economical and social necessity. Loss statistics show that number of fatalities is much higher in developing countries than in developed countries. The frequency of landslide disasters is increasing due to more extreme weather than before, increased population and increased vulnerability. The situation calls for intensified focus on and action to provide effective and appropriate preventive measures.

### **1.7 Scopes & Limitations**

Since 1997, landslides have caused more casualties than any other natural hazard but cyclone in Bangladesh. Several mitigations measures have been taken by the government, numbers of disaster management committees are formed in national and local level but none of them are competent to reduce landslide vulnerability of the informal settlers. It is high time to explore different mitigation measures suitable for local condition. The study suggests that, scopes of inventing creative mitigation measures which will reduce landslide risk without threatening the low-income people of eviction and lessening their income sources are yet to explore.

One of the limitations of the study was insufficient data on landslide issues at different administrative level s in Bangladesh. The numbers of deaths, amount of damaged assets are not well documented. Government reports on institutional mitigation measures of landslide are still kept confidential. Little accessibility to existing reports compelled the author to rely on respondent's answers, research papers and news articles.

Another limitation was uncooperative attitude of the informal settlers. There was an ongoing conflict between informal settlers and government regarding land tenure and eviction for which local people were reluctant to answer questions individually. This limited the scope of forming a FGD incorporating informal settlers and administrative respondents. Present day political condition restricted the author to conduct several field studies.

**CHAPTER 02:**  
**RESEARCH CONTEXT**

## 2.1 Physiographic Features of Bangladesh Hills

Bangladesh has a varied physical geography and her area is characterized by two distinctive features: a broad deltaic plain and a small hilly region crossed by swiftly flowing rivers. Major portion of the total landmass is made up of fertile alluvial lowland which is part of the larger Plain of Bengal. Although altitudes up to 105 meters above sea level occur in the northern part of the plain, most elevations are less than 10 meters above sea level; elevations decrease in the coastal south, where the terrain is generally at sea level. The only exception to Bangladesh's low elevations is the small hilly region.

18% land of Bangladesh can be identified as terrace and hilly area. Pleistocene terrace has covered 10% and eastern and north-eastern tertiary hill are of only 8% of the country (Islam & Uddin, 2002). Physiographically, hilly Regions can be divided into the following three sub-regions;

1. Chittagong and Chittagong Hill Tract in the southeast
2. Hill Ranges of Northeastern Sylhet
3. Hill along the narrow northern strip of Sylhet and Mymensingh in the north & northwest

Chittagong Hills constitute the only significant hill system in the country and, in effect, are the western fringe of the north-south mountain ranges of Burma and eastern India. The Chittagong Hills rise steeply to narrow ridge lines, generally no wider than 36 meters, with Altitudes from 600 to 900 meters above sea level. At 1,052 meters altitude, the highest elevation in Bangladesh is found at Mowdok Mual, in the southeastern part of the hills. Fertile valleys lay between the hill lines, which generally run north-south. West of the Chittagong Hills is a broad plain, cut by rivers draining into the Bay of Bengal that rises to a final chain of low coastal hills, mostly below 200 meters, that attain a maximum elevation of 350 meters. West of these hills is a narrow, wet coastal plain located between the cities of Chittagong in the north and Cox's Bazar in the south.

Hills of Bangladesh have been uplifted and folded into a series of pitching anticlines and synclines. The higher hill ranges in the Chittagong Hill Tracts, Chittagong and Sylhet regions regarded as late Oligocene to mid-Miocene in age. Lower hills are mainly underlain by little-consolidated sands and shales of the Dupi Tila formation, which may be from late-Miocene age. (Brammer,1996). These hills are mainly composed by unconsolidated or little-consolidated beds of sandstones, siltstones and shales, together

with minor beds of limestone and conglomerates. Nature of parent materials strongly determines the texture of the soils. Shale results heavy silt loam or silty clay loam subsoil. Soils developed on sandstone have dominant textural class of sandy loams with occasional loamy sand or loam texture. Soils subject to erosion have topsoil with less clay content. The steepness of the landscape determines the depth of the soil. Soils are in general shallow in depth. Soils developed at steep or very steep slopes of the hilly regions are susceptible to erosion (including landslips on some soils). Washout materials are deposited at the foot of the hills (FAO, 1988).

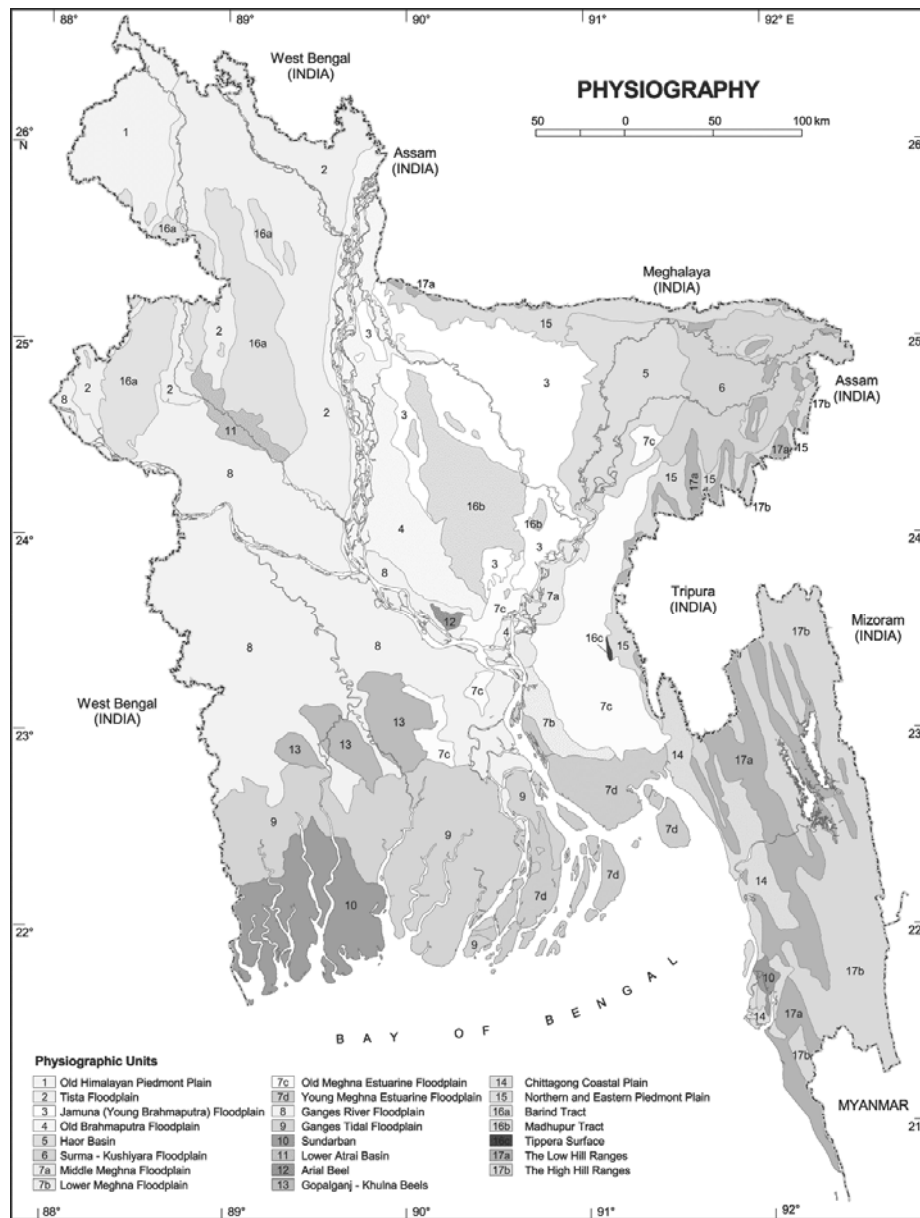


Fig: 2.1 Physiographic Features of Bangladesh  
Source: Sarker and Rashid 2013

## **2.2 Risks & Vulnerabilities of Hilly Region of Bangladesh**

Typically Hills are exposed to multiple hazards. Many of world's most sensitive resources including hilly regions of Bangladesh are particularly vulnerable due to high relief, steep slope, shallow soils, adverse climatic condition and geological variability. This region has been uplifted and folded into a series of anticline and syncline during the collision between the Indian and the Eurasian plates in Miocene period (Khan 1991; Mannan 2002). Soil composition of these regions is complex and the young rocks have higher contents of easily weatherable feldspars. Therefore, the soil of Bangladesh's hilly region is very much susceptible to the landslide risks during heavy rain carried by monsoon wind system.

Among the common natural and man-made hazards the hill ecosystem of the country are vulnerable to earthquake, water logging, flash flood and landslide etc. Climate change and induced variability further increases the frequency and intensity of the hydro-meteorological hazards including the convective storm, drought, and scarcity of the fresh water and destroying biodiversity. The annual rainfall ranges from 2,200mm along the western boundaries to 5,800mm in the north-east corner and even higher in different catchments (BBS 2009a, b). Strong moist air blows at the lower level from the Bay of Bengal during monsoon which creates feeder clouds over the hilly area. This process causes increased rainfall over the hilly region of north-east and southern part of the country. Excessive rainfall causes flash flood.

Apart from the associated factors of geology and climatology, impacts of hazards in the hilly regions are also influenced by human activities. Destruction of mountain forests, inappropriate farming practices accelerates erosion and exposure of land to the risk of landslides, environmental degradation and sudden floods. Unplanned and unsustainable development interventions such as construction of roads and infrastructures, housing etc. without considering local geographical characteristics and soil type influences secondary disasters. It increased the risk of damages and losses. Increasing population because of migration from main land to the mountains is a major factor that led to greater concentrations of population in valleys which triggered environmental degradation and vulnerability to large scale disasters.

Common attribution of vulnerability of mountain people in Bangladesh are poverty, landlessness, inaccessibility to natural resource base, illiteracy, isolation, backwardness and fragility stemming from rugged terrain and harsh climates; in turn, risks are linked

with greater proneness to geophysical extremes, unfriendly agricultural practice, increasing population and scarce resources.

High rate of inequality is very common scenario in the hilly region and prevalence of poor and vulnerable people increase with elevation (Hassan et al. 2005; Huddleston and Ataman 2003). There is a disproportionate suffering of mountain people of Bangladesh from poverty and low level of development than the plain land. Intensification of prevalent poverty are caused by some specific constrains including fragile ecosystem, remoteness, inadequate accessibility and marginalization of mountain communities from the mainstream, lack of equity in terms of access to basic facilities such as water, sanitation, health care, education and physical infrastructure; as well as to markets, political power and representation, lack of employment opportunities and proneness to natural disasters.

Economic backwardness is one of the major reasons of vulnerability of this region. The poverty map by World Bank-World Food program-BBs joint initiatives (2005) shows the highest incidence of extreme poverty in the south-east and north-east hilly region (Sarker & Rashid, 2013). In the Chittagong Hill Tracts region about three-fourth of the households (74%) are living below the lower poverty line and 86% below the upper poverty line. The households living below lower and upper poverty lines are 78% and 89% respectively among indigenous people and 69% and 83% respectively among Bengali (UNDP 2009).

Dependency on natural resources for livelihood and other necessities are one of the major factors that make mountain people prone to climate change and natural disaster. Majority of them are engaged in agricultural activity and thus are highly dependent on natural resources. By the impact of climate change alternative livelihood options are getting limited. It may further limit the capacity of the local community of the local people to cope with and adapt to relevantly new and extreme environmental events resulting force more people to below poverty line. Climate change and associated hazards may significantly influence in the slow economic development, high rate of poverty, marginalization, lack of health and nutrition and changed livelihood options of the people (UNEP-WCMC 2002). Furthermore, the ecosystem and people are subject to variety of drivers of change including development policies, political rivalry and increasing pressure on land and resources due to economic growth, increasing population and livelihood patterns. Despite high degree of uncertainty, the biophysical fragility of the ecosystem of

the hilly region has direct consequences for the socio-economic vulnerability of the mountain people.

### 2.3 Landslide Risk

Geologists, engineers, and other professionals often rely on unique and slightly differing definitions of landslides. This diversity in definitions reflects the complex nature of the many disciplines associated with this disaster. Landslide is a general term used to describe the down slope movement of soil, rock, and organic materials under the effects of gravity and also the landform that results from such movement. It is a natural phenomenon and accelerated by human interventions.

Landslide is one of the neglected disasters in Bangladesh as much as these took place in isolated and dispersed locations and do not create big headlines as earthquake, flood or cyclone does. The cumulative effects of landslides, however, in terms of lives, properties and infrastructure have been quiet substantial. There have been instances when many settlements in hilly slopes have gone into complete oblivion and many rural and urban settlements have been very severely affected due to landslides.

Bangladesh is affected by landslides due to variety of factors; both natural and manmade. Amongst the natural factors, geology as well as hydro-meteorology has played their parts. Earthquakes with even lesser magnitude have triggered massive movement in the hilly slopes. Incessant rainfall has been a more common factor for causing landslides. Even cyclonic storms and resulting precipitation resulted landslides in the hills, as cyclone AILA had demonstrated. The climate change and its impact on glacial melts and changing rainfall pattern have the potentiality of increasing both the frequency and intensity of landslides. Large scale deforestation has definitely increased the incidence of landslides just as unplanned settlements intensified the impact of such disaster.

Area	Moderate Susceptibility	High Susceptibility	Very High Susceptibility	Total
Chittagong Hill Tracts	350	1,814	10,765	12,929
Chittagong & Cox's Bazar	414	949	954	2,317
Greater Sylhet District	-	35	102	137
Others (Comilla, Netrokona, Jamalpur)	-	35	105	137
<b>Total</b>	925 (5%)	3,260 (20%)	12,785 (75%)	16,970(100%)

Table: 2.1 Landslide susceptibility to different soil erosion in the hilly areas of Bangladesh  
Source: Sarker & Rashid 2013; Khan 2011



## **2.4 Causes of Landslide in Bangladesh**

Landslide is occurred due to both internal and external forces. Slope failure and mass wasting occurs when acting gravitational force exceeds its resisting force on a slope. Slopes stability is maintained by slope material's strength and cohesion and the amount of internal friction between materials. It is also known as shear strength of slope. Landslide occurs when the stability of a slope changes from a stable to an unstable condition. A change in the stability can be caused by a number of factors, acting together or alone.

There are two primary causes associated with major landslides in Bangladesh; natural causes and human induced causes. Sometimes, landslides are caused, or made worse, by a combination of the two factors. Natural causes are the major mechanism for landslides. A single reason or a combination of different natural reasons may cause this disaster. Effects of these causes varied widely and depend on steepness of slope, morphology or shape of the terrain, soil properties, and underlying geology etc. Human induced causes such as unplanned settlement in the risky zone, modern agricultural practice without considering soil type, cutting hill for roads and other constructions without considering proper slope etc. increase the intensity of the impact of landslide.

### **2.4.1 Natural Causes:**

Slope saturation by water is the primary cause of the landslide. Saturation can be occurred due to intense rainfall, changes in ground-water levels and surface water level changes along coastlines, earth dams and in the banks of lakes, reservoirs, canals and rivers (Highland and Bodrowsky 2008). Precipitation and run-off are closely related to the sudden inundation of hill slope and landslide.

Flooding may cause landslides by undercutting banks of streams and rivers and by saturation of slopes by surface water (overland flow). Conversely, landslides also can cause flooding when sliding rock and debris block stream channels and other waterways, allowing large volumes of water to back up behind such dams. Previous geological events or modern irrigation practice may cause losing soil particles and ease the saturation process. Deforestation helps in removal of topsoil from the surface of the hill. Few major natural causes of landslide are given below:

#### 2.4.1.1 Rainfall

Rainfall causes landslide by loosening the soil compaction and also by increasing the weight of the soils of the hills. Bangladesh enjoys generally a sub-tropical monsoon climate. Monsoon starts in June and stays up to October. This period accounts for 80% of the total annual rainfall. The average annual rainfall varies from 1429 to 4338 millimeter. The maximum rainfall is recorded in the coastal areas of Chittagong and Chittagong Hill Tracts and northern part of Sylhet district. The average yearly rainfall of Chittagong is approximately 3000 mm. The highest rainfall happens in the month of June. Landslide frequency in Bangladesh is also highest in the month of June as well.

The hilly region of Bangladesh mainly comprise sandstones, shales and siltstones which have been partially consolidated to varying degrees, and which locally contain lime or pyrites. Seepage down of the rainwater dissolves these limestone and soils of the slopes are converted into clay that moves downward causing landslide. Sometimes, intensive and massive rainfall occurs due to depression or cyclone in the Bay of Bengal. More rainfall increases the probability of landslide. The last landslide occurred during this type of massive rainfall in Bangladesh.

#### 2.4.1.2 Earthquake

Earthquake may cause high intensity landslides in Bangladesh as it reduces shear strength of soil particles. Earthquakes in steep landslide-prone areas greatly increase the likelihood that landslides will occur due to ground shaking alone, liquefaction of susceptible sediments or shaking caused dilation of soil materials. It allows rapid infiltration of water. Shear strength is controlled by a number of variables such as friction, which itself is proportional to the normal force, as well as many other variables such as the roughness, cohesion and dryness of the material.

#### 2.4.1.3 Soil Composition

Formation of hill soil is an important factor to trigger landslide. According to geological time scale hilly area of Bangladesh developed in tertiary age and is basically composed of unconsolidated sedimentary rocks such as sandstone, siltstone, shale and conglomerate. The hilly region is underlain by tertiary and quaternary sediments that have been folded, faulted and uplifted, then deeply dissected by rivers and streams (Bammer 1996). These areas consist of sandstones, shale and siltstone which have less stability. Acid properties of hilly soil are easily saturated with water. The bedrock and soil structure of these hills are not stable, for which reason these areas are highly prone to landslide.

#### 2.4.1.4 Gravity

Mass wasting is caused by gravity. On a mass of material gravity exerts a force downward proportional to the amount of mass. Saturation of the pore spaces increased the weight of the mass increasing the shear force as well as intensity of hazard.

#### **2.4.2 Human Interventions**

Expanding population in the landslide prone area due to migration are the primary means by which humans are contributing to the landslide disasters. The new settlement creates disturbance to the natural drainage system and destabilize the slopes. Unsustainable and unplanned use of land for industrial purpose and irrigation practice by the migrated people is also reducing stability of the soil for containing moisture and losing bondage of top soil. Landslide related human induced factors are given below:

##### 2.4.2.1 Hill cutting

Presently indiscriminate hill cutting is one of the major causes of landslide in Bangladesh. Hills are being cut for building construction; develop residential/housing area, clay and sand mining and developing road network. Bangladesh is a densely populated country and for accommodation people build house on the top of the hills or on slope or on the foot of hills without following the existing rules and regulations. Greedy influential people and muscle-men invade the Government hills and build temporary houses on them to earn money by renting them to the poor people.

Poor people who live in those houses are highly vulnerable to landslide. Because of hill cutting, the slopes become instable. The hills are cut with slopes of 70-80 degrees. When it rains, water dissolves the minerals of the soil of the hills that loosen its compaction. Soils of the hills also become heavy by absorbing rainwater. If rain intensity is too high, minerals of soil dissolve very quickly and the soil turns into mud and becomes very heavy. The steep slope of the hill cannot bear the mass weight of the wet soil or mud that results the landslide.



Fig: 2.2 Hill cutting for brick field  
Source: The Daily star, 17 June 2011



Fig: 2.3 Hill cutting for road expansion  
Source: Dainik Notunbarta, 10 June 2013

#### 2.4.2.2 Informal Settlements

Besides of being an agrarian society Bangladesh experiences immense urbanization. The rapid growth of urban population in cities of Bangladesh is fuelled by migration of the rural poor to the city, drawn by perceived chances of finding cash employment in the industrial sector and pushed by the limited opportunities in rural areas. On arrival, many are unable to afford proper housing and so, turn to live in informal settlements. Urban informal settlements are generally excluded from public sector resources, severely limiting access of residents to formal education, healthcare services and water and sanitation.

Like most of cities of the world, informal settlements in Bangladesh tend to be built on vacant government land or private vacant land located in low-lying areas, river banks, foothills and valleys vulnerable to natural disasters. Specially, from 1990 rural people started to migrate from different parts of the country to the hilly region as abundant land and natural resources are available there and migrated people face less struggles for livelihood and living space. As these people from flat plain do not have any understanding about living in the hills and hill ecosystem, they unknowingly welcomed threats of landslide by unsustainable land use, vegetation, disrupting natural drainage of a hill etc.



Fig: 2.4 Informal settlements in Batali Hill area  
Source: Author, 2013



Fig: 2.5 Informal settlements in Lehubagan area  
Source: Author, 2013

#### 2.4.2.3 Deforestation & Afforestation

Deforestation in the hill areas is another major reason of landslide. Deforested areas are more prone to landslide than a forested area. Vegetation protects the soils and makes slope stable which reduce the risk of landslides. Large trees provide strong root structures into the earth that anchor the soil and protect it from any erosion. Some of the afforestation practices are also responsible for destabilization of soils. This happens when

trees are planted without considering local soil characteristics and type of vegetation suitable for that particular area.



Fig: 2.6 Unsustainable vegetation  
Source: Daily Star, 13 May 2013,



Fig: 2.7 Deforestation  
Source: Daily Star, 23 March 2013

#### 2.4.2.3 Modern Irrigation Practice

Modern irrigation practice without considering the traditional knowledge loosens the bondage of soil particles. Rice terraces are disappearing frequently. People are more inclined to the crop production practice of flat plains. This concludes in the rapid disappearance of rice terraces, hills and forests.

#### 2.4.2.5 Inappropriate drainage system

Natural drainage lines on slopes are blocked by terracing/ contour bounding adopted to prevent soil erosion and to enhance percolation during dry season for cultivation, without adequate provision for surface drainage of excess storm water during high intensity rains increase the landslide vulnerability.

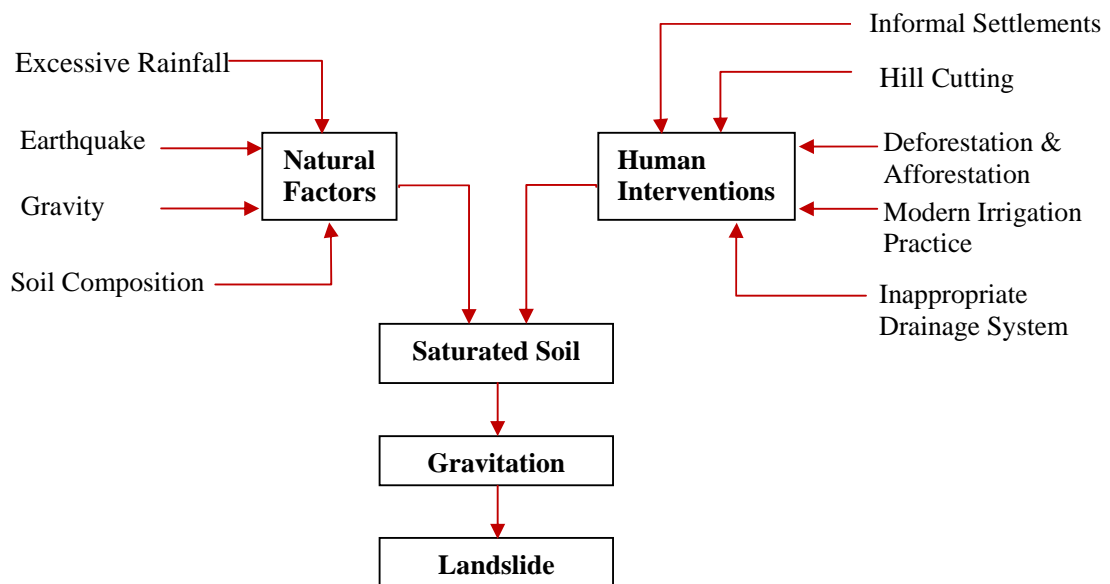


Fig: 2.8 Landslide Causes  
Source: Author, 2013

## **2.5 Landslide Incidences in Bangladesh**

The physiographic characteristics of Bangladesh make the country more susceptible to landslide. Physiographically, most of the area of Bangladesh is floodplain and only 18% is hilly and tract area (Islam & Uddin,2001). According to geological time scale hilly area of Bangladesh developed in tertiary age and is basically composed of unconsolidated sedimentary rocks such as sandstone, siltstone, shale and conglomerate. The hilly region is underlain by tertiary and quaternary sediments that have been folded, faulted and uplifted, then deeply dissected by rivers and streams (Bammer 1996). These areas consist of sandstones, shale and siltstone which have less stability. Acid properties of hilly soil are easily saturated with water. The bedrock and soil structure of these hills are not stable, for which reason these areas are highly prone to landslide.

Unsustainable lands use and alteration in the hills including indiscriminate deforestation and hill cutting are two major factors in Bangladesh that aggravated the landslide vulnerability in the hilly areas. Excessive rainfall within shorter time span often cause landslide specifically in the areas composed of unconsolidated rocks. This situation is further aggravated if the slopes are steep and exposed because of indiscriminate hill cutting. Because of climate change, the country is experiencing extremely high intensity rainfall in the recent years which is making the situation real grave. Bangladesh is a multi-hazard prone country and landslide is not new phenomenon in Bangladesh. However, it was never been hazardous like the recent incident of Chittagong.

The susceptibility of the soil erosion in the Chittagong Hill Tracts is very high among the vast hilly region of Bangladesh. Chittagong city is the second largest city of Bangladesh comprising hills formed during tertiary time. A north-south hill range crosses the city and many settlements and slums have been developed in the foothills and lower income people are living in these areas in a risky situation. However most of the casualties due to landslide disaster occurred near Chittagong, Bandarban and Cox's Bazar area due to large number of people live in these areas. During the devastated landslide of 1998, 1999, 2000, 2007, 2011 and 2012 all these areas were affected.

<b>Year</b>	<b>Location</b>	<b>Soil Characteristics</b>	<b>Mechanism</b>	<b>Impact</b>
1968	Kaptai-Chandraghona Road	Deep, well drained loams derived mainly from tertiary sandstones & Shale which are permeable & exposed to massive erosion	Removal of protective vegetation make the bondage of soil loose which then exposed to the monsoon rain & erode rapidly.	Reservoirs silted up but no casualties occurred
1970	Ghagra-Rangamati Road	Well exposed sandstone on the anticline; yellow & grey medium grained occasionally pebbly sandstone & clayey sandstone with inter-beds of mottled clay	Deforestation make the bondage of soil loose which then exposed to the monsoon rain & erode rapidly and washed away houses and properties.	Roads & properties have been damaged, houses collapsed.
1990	Jhagar Beel, Rangamati	Well exposed sandstone on the anticline; shale, sandstones & siltstones in the underlying & overlying strata	Due to the deforestation & heavy prolonged rain during the monsoon period, this disaster occurred.	Roads & properties have been damaged
1997	Charaipada, Bandarban	Well exposed sandstone; lower portion is variegated coarse grained cross-bedded sandstones	Heavy rainfall creates excessive pressure of water which caused the soil washed away	90,000sqm area was affected but no casualties occurred
1999	Lama & Aziz Nagar Union, Bandarban; & Chittagong	Well exposed sandstone; sandstone & minor amounts of claystone & silt in the Chittagong area.	Heavy & incessant rainfall at that time was one of the causes of sliding	17 people killed, houses damaged & 893 ha of cultivated land & household garden and 50km road were damaged
2000	Chittagong University & Southern Chittagong	Well exposed sandstone; some small area are also sandy or rocky with steep hill slope are highly susceptible to erosion	Deluge of mud & water that swamped various part of the port city aimed torrential rain	13 people were killed & 20 injured; property damaged

<b>Year</b>	<b>Location</b>	<b>Soil Characteristics</b>	<b>Mechanism</b>	<b>Impact</b>
2007	Cantonment & Leubagan, Chittagong	Sandstone & Shale with very steep slope	Hill cutting made the soil bondage loose which is washed away due to heavy & prolonged monsoon rain	128 persons died of which 59 were children; 100 of people were injured & lots of property damaged.
2010	Cox's bazaar & Bandarban	Deep, well drained loams derived mainly from tertiary sandstones & shale; some of the area also consisted of well exposed sandstone & Boral formation	Settlement was developed at the foothill area by cutting the hill side & the prolonged torrential rains caused sever flood and mudslides.	53 persons died & a number of houses & properties damaged; roads have been blocked
2011	Batali Hill, Chittagong	Sandstone & shale with very steep slope	Settlement was developed at the foothill area without taking any precautionary measures & prolonged torrential rain caused severe food & mudslides	17 persons died including women & children; property damaged & houses washed away
2012	Lama & Naikhanchari, Bandarban; Chittagong Port Area; & Moheshkhali, Cox's Bazar	Deep, well drained loams derived mainly from tertiary sandstones & shale; some of the area also consisted of well exposed sandstone & Boral formation	Prolonged torrential rain due to the influence of monsoon depression over the Bay of Bengal washed away houses & settlements located on the foot hill area	108 people died; houses, roads & properties damaged & the communication with the affected area collapsed.

Table: 2.2 Historical landslides in Bangladesh & associated issues

Source: Sarker & Rashid, 2013



**CHAPTER 03:**  
**LANDSLIDE VULNERABILITY IN CHITTAGONG**

### **3.1 Vulnerable Hill Ecosystem and Threats to Landslide**

Hills are an important natural resource of Chittagong city that balances overall environmental quality and provide unique aesthetic values. According to Islam (2008) soil structure is an important factor contributing factor to landslides in Chittagong city. The soils of the city are sandy which makes them easily saturated during heavy rainfall and susceptible to massive soil erosion through formation of unstable and steep hill slopes (Khan 2008). Unplanned hill cuttings and removal of forest vegetation for construction of buildings on those steep slopes have increased landslide vulnerability to Chittagong city (CDA 2008). A field survey on hill ecology found that out of 86 existing hills, 57 hills have already been damaged by infrastructural development and permanent housing with urban expansion (Khan 2008). In fact, due to lack of sustainable urban planning, Chittagong city has expanded through transforming hills, which are presently fraught with landslide hazard.

### **3.2 Socio-Economic Context of Chittagong City**

Historically Chittagong has always been known as the most famous and wealthy city of Bengal kingdom because of its port that satisfied the easiest traffic demand. The city started as a small municipality in 1863 and significant urban growth began after the country's liberation in 1971, when it turned into a hub of major commercial and industrial activities (Hashemi 2006). In present day, the city has eight industrial zones, more than 720 industries and factories along the banks of the Karnafuli river. Its industrial opportunities and coastal environment create an economic diversity in the city that is greater than any other part of the country.

It has a major seaport and is considered the heart of all commercial and business activities. The national government declared Chittagong as the commercial capital of the country. The majority of people in Chittagong are involved in the import-export business, trade, and various related industrial and business activities. Forty per cent of heavy industrial activities of the country are located in Chittagong city and its adjacent areas.

In the last few years, Chittagong has experienced rapid urban growth because of the significant expansion of the port and other industrial developments. People from the surrounding areas migrated into the city in search of livelihood opportunities and better economic prosperity. The city has experienced a large population increase from 1 million in 1990 to presently around 4 million within Chittagong city corporation area according

to the census of 2011. Another estimate says the population would be as high as 5 million. However, with limited capacity to offer basic urban facilities, the city was not prepared to accommodate this inflow of migrants. Unplanned growth, shortage of housing, traffic congestion, interrupted power and water supply, rapid growth of slum areas, flooding and poor drainage, unemployment and environmental pollution are the resulting problems.

### **3.3 Physical Characteristics of Chittagong City**

Chittagong is the largest port and the second largest city of Bangladesh located in the south-eastern coast. It has a population estimated at about 5 million inhabitants. The Karnafuli River lies to the south, the coastal plain to the west and flood plain of Halda River to the east. Geographically, the city is located between 20 35' N to 22 59' N longitudes and 91 27' E to 92 22' E latitudes, which is the south-eastern part of Bangladesh. Both in terms of economy and ecology, this is a very important city. The main sea port gives it an economic significance. The core of the city is some 15 kilometers upstream of the river mouth where karnafuli meets the Bay of Bengal. A north-south central hill range extends into the urban zone from the north and gradually loses height as it comes closer to the river. The city comprises area of small hills and narrow valleys. The highest ground level within the city area is about 60m above Mean Sea Level (MSL).

The Chittagong Metropolitan Area (CMA) has very distinctive topographical features and it can be divided into at least eight geo-morphological classes; hills, piedmont, flood/alluvial plains, old tidal plain, tidal plain, supra tidal plain, natural levee and sandy beaches (Rahman *et al.* 2001). Due to its very distinctive types of topography (with the exception of Sylhet and northern Dinajpur) and coastal nature, the residential environment, growth pattern and development are quite different from other cities in Bangladesh.

The coastal areas of the city are highly prone to cyclone and tidal surge. Water-logging is a perennial problem but is more of a man made hazard. The hilly areas are highly exposed to landslide caused by heavy rainfall and unsustainable hill cut. The formation of informal settlements (generally termed “slums”) on hill slopes with unplanned hill-cutting is the main cause of vulnerability to landslides (Ahmed 2009). These have caused not only large numbers of deaths and physical injuries but have also swept away houses, caused damage to household goods and blocked road communication and utility lines in the affected settlements. Due to ineffective land use management in the hills and a lack of

alternative housing sites for the growing low-income population, many informal settlements have developed along hill slopes, which are home to nearly 500,000 low-income people. The more concentrated and extreme rainfall patterns that have been related to climate change are likely to exacerbate the risks of landslides for the residents of these settlements (Khan 2008).

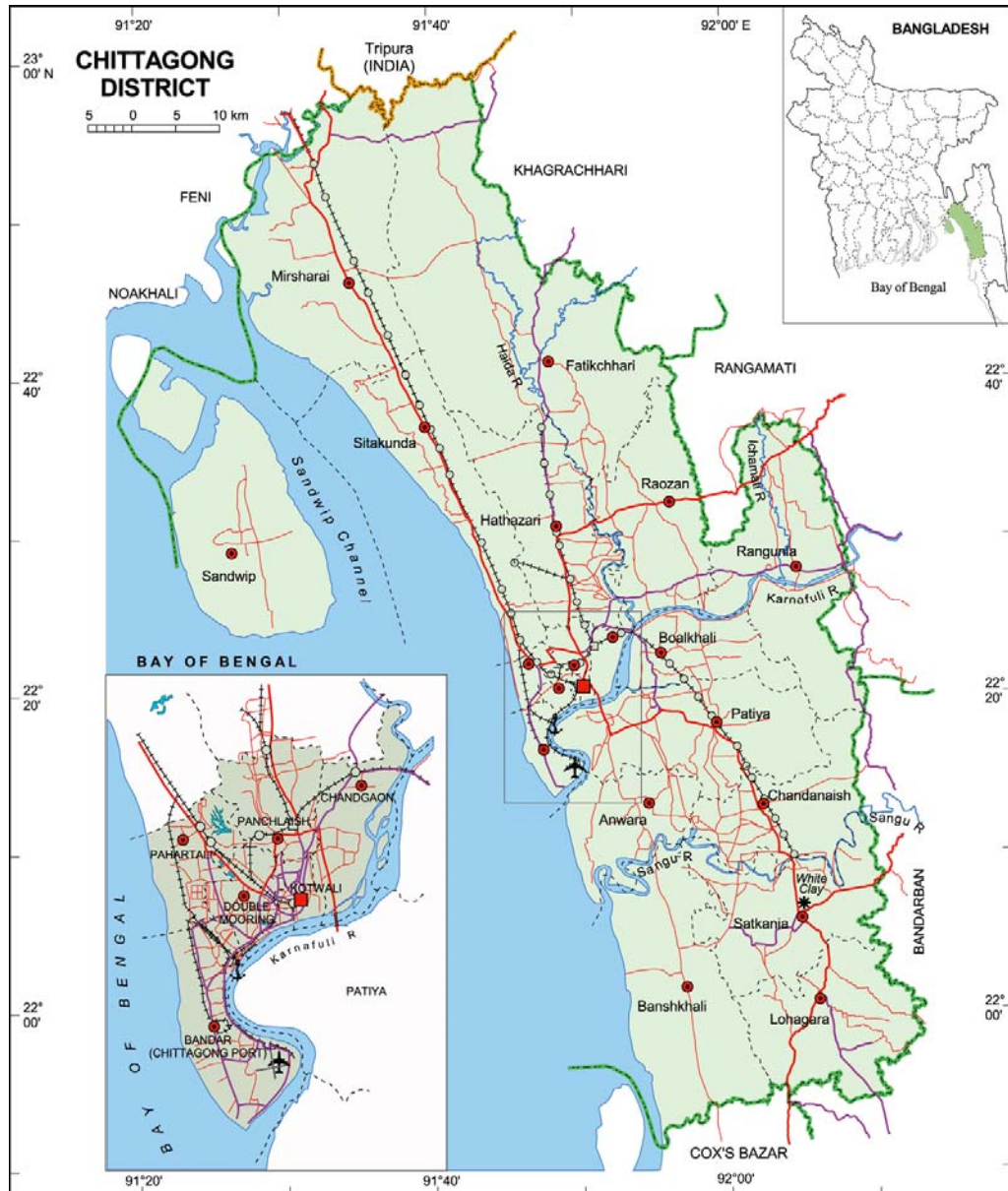


Fig: 3.1 Location map of Chittagong city  
Source: Banglapedia

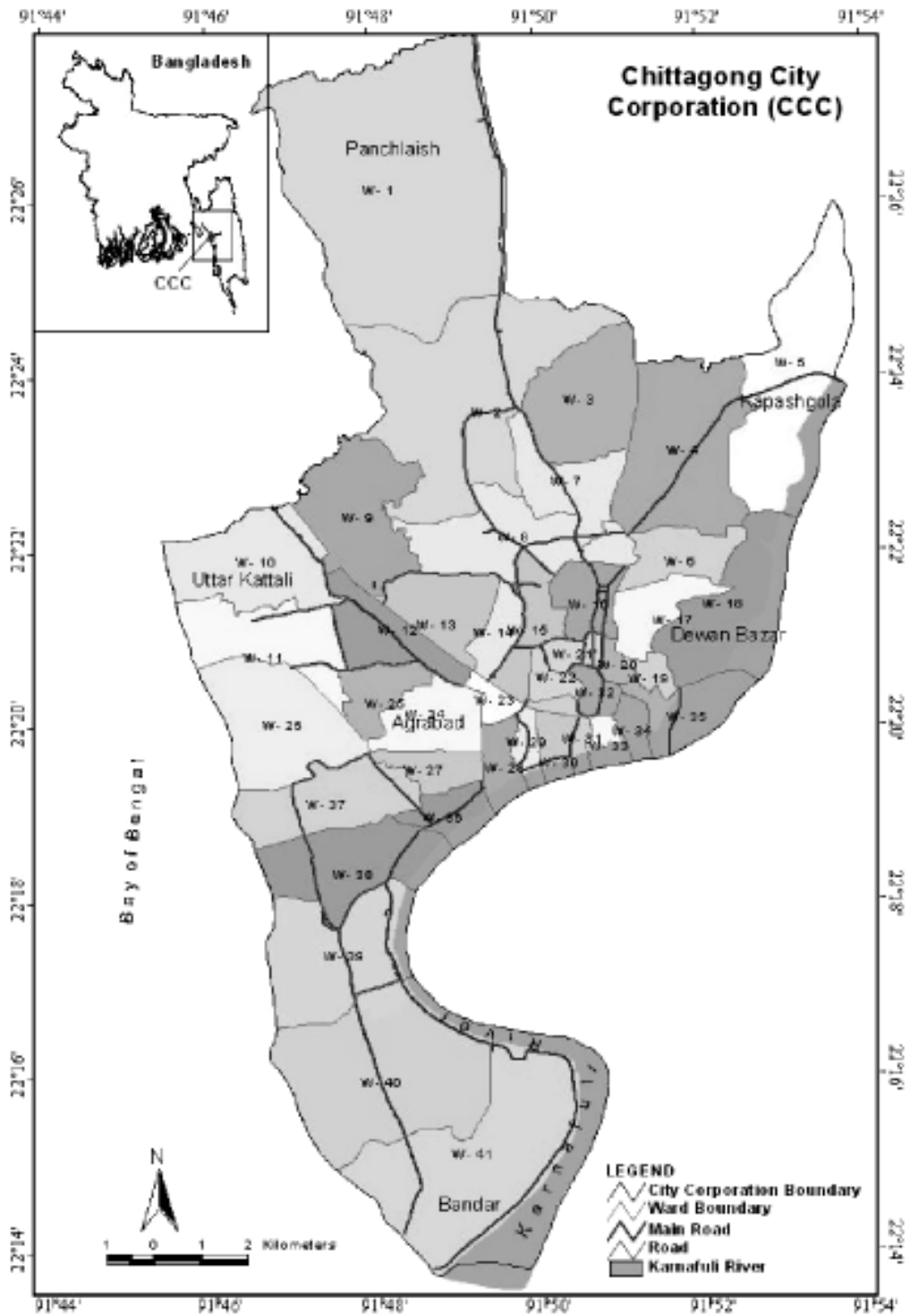


Fig: 3.2 Map of Chittagong city  
 Source: Mahmood & Khan 2010

### 3.4 Settlement History

Being a port city from early times, Chittagong has attracted people from various regions of the world. It has the country's main port as well as being a major trade centre. These characteristics have influenced the rapid increase in the urban population of the last few decades. Chittagong, which was considered a small ancient city until 1960, is now home to about 4.1 million people living in an area of about 177 sq. km. (CUS *et al.* 2006).

Chittagong Municipal Committee was established in 1863 with a population of 25,000 and within a very short period it was reconstituted as a Municipality on the 15th July 1864. Until 1898, the town was full of ditches, tidal canals and jungles and was extremely malarious and most of the roads were unpaved and muddy. There was only one primary school and one high school maintained by the Municipality (BBS, 2001). In 1947 the area of the town of Chittagong was only four and a half square miles and was centered around the low and small hillocks which were found scattered all over the city. It was again reconstituted under the Municipal Administrative Ordinance in 1960 with an area of 5.67 sq. miles and population of 190,414. Dampara, Nasirabad, Katalganj, Kapashgola and Solokbahar bound the town on the north, the Karnaphuli on the south, Chaktai *nullah* (canal) on the east and Madarbari, Pathantuli and Dewanhat on the west. Originally, the town was confined within this limit.

With rapid industrialisation and development the town soon grew into a city outstripping the old Municipality area. The city extended southwest up to Patenga where the Chittagong international airport is now located. Its expansion to the west incorporated the villages of Haliashahar, Askarabad and Agrabad. The government acquired the land of these villages to construct offices and commercial organizations; however, most of the areas are now under residential uses. To the north, the city extended up to Faujdarhat and the Chittagong Cantonment area and in the northeast up to Kalurghat.

The Government of Pakistan under Ordinance No 51 established the Chittagong Development Authority (CDA) in 1959 as an autonomous body to cope with the expansion of the city and to help it to develop in a planned way. The principal responsibilities of CDA under this Ordinance are as follows:

- To draw up a master plan for Chittagong and its adjoining area. This master plan is to be reviewed every five years;
- To design and execute short-term and long-term plans for the development and expansion of Chittagong City and

- To implement the East Bengal House Building Act of 1952. This includes the examination and approval of plans for construction of buildings in Chittagong.

The CDA drew up a master plan dividing the entire city into several blocks in 1961. The area that was earmarked for port development projects with provisions for office blocks of mercantile firms, was Sadarghat, Madarbari, Double Moorings and Halishahar. Government offices as well as residential quarters of officers and staffs were located in Agrabad. The railway authorities developed the western fringe of the low hill ranges up to Pahartali. For the development of industries, the CDA earmarked different zones for different industries. These zones were mainly in Nasirabad, Panchlaish, Fauzdarhat, Kalurghat and on a site near the Dhaka Trunk Road.

At that time, CDA drew up a "Regional Plan" covering an area of 212 square miles and a "Master Plan" covering an area of 100 square miles. The first Master Plan drafted in 1961, was abandoned due to the national political disorder in 1969. It is important to note that Bangladesh was a former province of Pakistan, known as 'East Pakistan', which existed between 1955 and 1971. East Pakistan was partitioned from Bengal based on a referendum in what was then British India in 1947 and became a province of Pakistan by the name of East Bengal. East Bengal was renamed East Pakistan in 1956 and later became the independent country of Bangladesh after the nine-month long Bangladesh Liberation War in 1971. Unfortunately, following independence there was no initiative to provide a master plan for the planned development of Chittagong for 20 years (between 1971 and 1991).

However, in the 1990s there were a number of initiatives to introduce planning processes in Chittagong. From the funds provided by the UNDP and UNCHS the subsequent Master Plan was drawn up for Chittagong City during the years 1992 to 1996:

- A structure plan for 1154 square kilometres of Chittagong city and the adjoining area,
- Urban area Master Plan for Chittagong City,
- Multi-Sectoral Investment Plan for the development of Chittagong City on a priority basis in a planned and balanced way,
- Master Plan for drainage and flood-protection of Chittagong City,
- Master Plan for easing the traffic congestion in Chittagong and for improvement of the traffic handling capacity of the city system,

- Proposals for updating the laws and rules relating to City Development and plans for restructuring the administrative system of CDA
- Manpower development for better functioning of CDA and transfer of technology for future city planning and development.

However, the CDA has not yet started implementing the Master Plan that was prepared more than a decade ago, reportedly due to government change ('*CDA Master Plan not Implemented even after a decade*', The Bangladesh Observer, July 25 2004). As consequences of not being properly planned and executed today's Chittagong suffers at every sector while providing urban facilities to its inhabitants. The major urban service concerns are acute shortage of water supply, power supply and sanitation facilities, mismanagement of the garbage disposal system, traffic jams and accidents, drainage problems, hill erosion hazards, flash flooding, lack of parks and playgrounds, poor local security and the condition of slums and squatter settlements (Rahman *et al.* 2001).

### **3.5 Settlement Pattern**

Some 140, 000 people in the developing world are abandoning their rural settlements daily and moving into the towns and cities in search of a new life (UNCHS 1990). Cities are being flooded with people looking for a job and a decent income. The City of Chittagong is not an exception to it.

Chittagong has been growing rapidly in its urban population but without the essential urban infrastructure facilities and services. Like many developing country cities it is experiencing a rapid growth of population mainly because of rural-urban migration (BBS, 1981, 1991 & 2001). As the new population is added the demand for different type of infrastructure facilities and services increase continuously. Urban areas are generally administered by the local government (City Corporation or Pourashava) whose main spheres of intervention are various municipal services, such as, water supply, sanitation, street lighting, roads and licensing (for businesses, vehicles, etc.). However, centrally managed and mostly dependent on government grants the urban administration and management system in Chittagong is performing inadequately in providing municipal services. Citizens are frequently unsatisfied with the quality of service facilities provided by different urban authorities. Like many urban centers, most of these services of Chittagong city are confined only to administrative hubs and residential enclaves of the rich and the middle class.



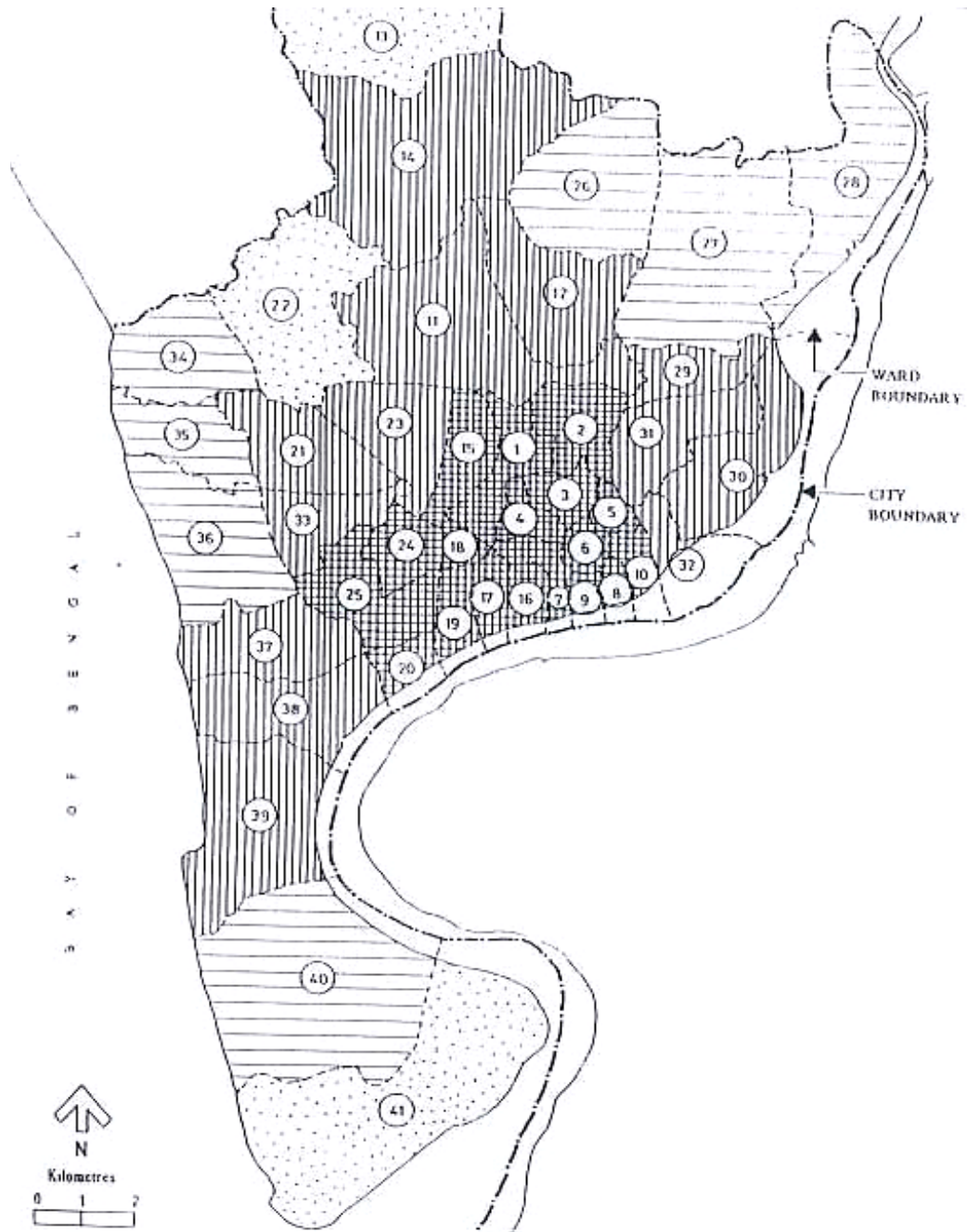


Fig: 3.3 Population Density in The City Area  
 Source: Chittagong Structure Plan, 1994

Chittagong has pacca, semi-pacca and katcha houses. In fact the private and informal sectors supply most of the housing in Chittagong. Due to lack of institutional control and monitoring, housing and residential processes contain an unplanned and irregular approach across the city. So far, there have been no planned development initiatives implemented in Chittagong even after the independence of Bangladesh in 1971. As a

result its residential, industrial and commercial growth did not follow any long term planning process, following a haphazard spatial expansion from the city's foundation as a municipality. Owing to population pressure, human settlements are spilling over everywhere.

The hilly nature of the city greatly influences the pattern of land uses. Hilly areas are used only for residential purposes especially for government staff quarters and at times, slums and squatter settlements have spread into the foothills. Based on land use, settlements of Chittagong city can be divided into two types: Formal Settlements & Informal settlements.

### **3.5.1 Formal Settlements**

Generally, the well-off people spread into those urban lands with better residential facilities which are flood free and connected with city's communication, transportation and healthcare facilities. Piedmont areas are highly valued for residential areas in this city due to the attraction of their suitable physical location. For this reason, various types of land uses such as residential, road and highways, commercial, administrative, institutional, parks and playgrounds are observed on the piedmont areas. The main uses of different tidal plains are agricultural but due to rapid urban growth the city is expanding across these areas and it is expected that within a short period of time these agricultural lands will turn into residential blocks. A lot of housing companies are now developing abandoned spaces and turning them into multi-functional city centers.



Fig: 3.4 Panoramic view of formal settlements of Chittagong city

Source: [www.ccc.org.bd](http://www.ccc.org.bd)

### 3.5.2 Informal Settlements

In Chittagong City, about 30 percent of the total population lives in the informal settlements where living environments are quite unsatisfactory and the people of these residential areas are worst affected in terms of quality and access to neighborhood facilities (Ashraf, 1995; Islam *et al.* 1997). The United Nations' definition of an informal settlement is:

*“An area characterized by overcrowding, deterioration, insanitary conditions or absence of facilities and amenities which, because of their conditions or any of them, endangered the health, safety and moral of its inhabitants and community.”*

The rapid growth of urban population in Chittagong city is fuelled by migration of the rural poor to the city, drawn by perceived chances of finding cash employment in the industrial sector and pushed by the limited opportunities in rural areas. On arrival, many are unable to afford proper housing and so, turn to live in informal settlements. Urban informal settlements are generally excluded from public sector resources, severely limiting access of residents to formal education, healthcare services and water and sanitation.

Like most of cities of Bangladesh, informal settlements in Chittagong tend to be built on vacant government land or private vacant land located in low-lying areas, foothills and valleys vulnerable to natural disasters. Many informal settlements are built on waste or polluted spaces, exposing residents to industrial noxious wastes. Houses in slum settlements are usually made of flimsy material which provides little protection from fire, or monsoon rain.



Fig: 3.5 Informal Settlement in Batali hill area  
Source: Author, 2013



Fig: 3.6 Informal Settlement in Motijharna area  
Source: Author, 2013

The poverty driven residents can not afford highly valued suitable land but must instead choose cheap accommodations in physically marginal areas which are generally less well served and managed by the urban authorities and at risk from floods, landslides, cyclones and tidal surges. Importantly these types of residences are expanding at an alarming rate.

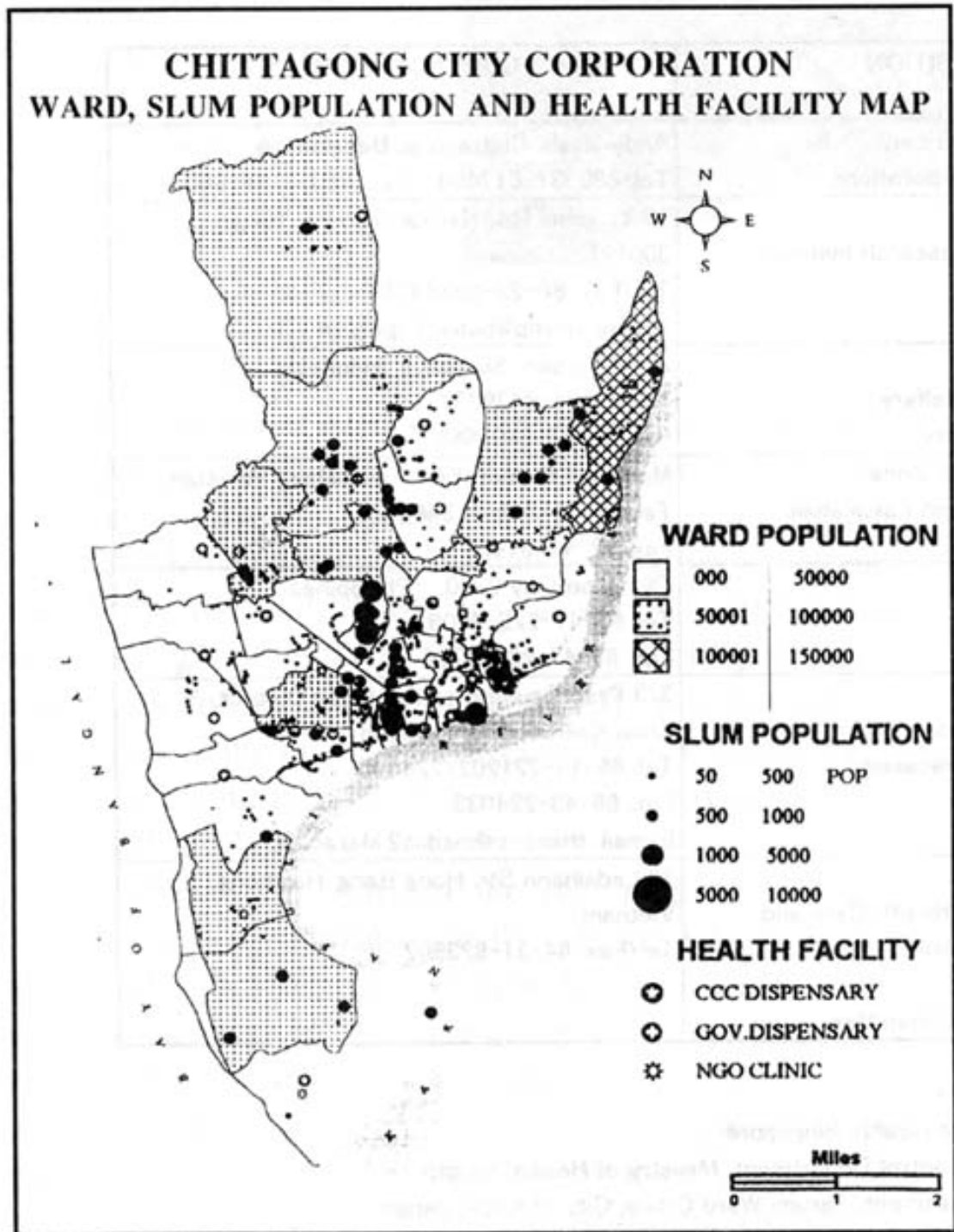


Fig: 3.7 Location of informal settlements in the city corporation area  
Source: Chittagong City Corporation (CCC)

### 3.6 Landslide Vulnerability in Chittagong City

In a landslide or rock falls, movements of the materials depend on the slope is caused by the slope instability, commonly observed in Chittagong and its adjacent areas of Bangladesh. Several geological, morphological, and human induced changes cause these slope instabilities. Chittagong hills are the part of tertiary hills. The geological structure and soils are weak of these hills and also have steep slopes which increase the risk of landslide. Risk is higher where settlement exists on the foothills and poor people live within the areas. Over the last few decades landslides have become an increasingly serious hazard, with much of the city's expansion a result of hill cutting for unplanned urban development. Since 1997, 15 landslides have killed nearly 400 people in the city and adjacent small urban centers. For example, the landslide disaster in June 2007 that was triggered by intense rainfall killed 128 people and affected 2,072 families in five informal settlements (Khan 2008). After the massive landslide of 2007, a technical committee has been created consisted of government agencies, Chittagong City Corporation (CCC), Chittagong Development Authority (CDA), researchers, engineers and NGO workers for identifying priorities for action, land use vulnerability assessment and zoning. That committee divided the city into 3 zones considering risking issues of landslide.



Fig: 3.8 Post-landslide conditions in Motijharna Area  
Source: The Daily Star

After the disastrous incidence of the year 2007, national and local level organizations came to know about the threat and severity of the apparently neglected natural hazard, landslide. Ministry of Food and Disaster Management included landslide as a national level natural disaster. Death toll went up in landslide incidences which took place later. In the year 2010, a workshop was held by SAARC at Bhutan titled “Landslide Risk Management in South Asia”. Mahmood & Khan (2010) presented a paper on that workshop considering the landslide of 2007 as a case study. In that, they conducted GPS (Global Positioning System) survey to prepare a landslide prone zoning map which was adopted by the disaster management committee later. Mahmood & Khan (2010) divided Chittagong city in to three different zones according to vulnerability of landslides:

### **3.6.1 High Risk Areas**

#### 3.6.1.1 Leubagan Area:

Leubagan area is located near Chittagong Cantonment in Hathazari Thana. Maximum inhabitants of Leubagan are poor labor/workers and live in foothill slum. They migrated from plain land and coastal area because of poverty and riverbank erosion. They do not have enough knowledge about the risk of landslide and how it can create a risky situation for them.

#### 3.6.1.2 Baizid Bostami Area:

The hills under Armed Police Battalion - 2 (APBN-2) in Baizid Bostami thana of Chittagong city. This is a lower income group residential area and most of the inhabitants live in foothill areas. Few people live on the hill top. These are Government owned land under APBN – 2. People of this area sell their labor in the industries built and located within the foothill areas. After the landslide, the APBN resettled only a few families to safer places. It has been observed that most people did not move from these risky locations. Some of the industries are still there under high vulnerability and people are still working in these industries.

#### 3.6.1.3 Kushumbag Residential Area:

Kushumbag residential area is located near the Chittagong Metropolitan Police line. This is a middle class residential area. Lots of houses and shops are built at the foothill though landslides are common in this area.

#### 3.6.1.4 Batali Hill Area:

This area is highly vulnerable as the hill is surrounded by foothill slums and settlements. Most of the inhabitants are poor factory workers. Any large scale landslide can cause massive destruction to slums and cause death of many people.

#### 3.6.1.5 Motijharna Area :

Motijharna is located at Lalkhanbazar area near Tigerpass. This area is also heavily populated and occupied by lower income groups.

### **3.6.2 Moderate Risk Area**

#### 3.6.2.1 Foy's Lake Area

A few housing areas are being developed behind the hills of Foy's lake. A massive hill cutting process is in progress. However, this area is not very populous and in some places, houses are yet to be built.

#### 3.6.2.2 Khulshi Area

This is a posh residential area located in the north and south of Khulshi hill. Indiscriminate hill cutting is common in this area. Most people who constructed houses in this area are rich and built protection wall (retaining wall) to protect their houses from landslide.

### **3.6.3 Low Vulnerable Areas**

#### 3.6.3.1 Nasirabad Area

Nasirabad Residential area is a posh residential area in Chittagong City. Most of the constructions are completed. There are few hills surrounding this area. Inhabitants of Nasirabad protected their houses by constructing concrete wall (retaining wall). For this reason, vulnerability of this area is less than other hilly areas of Chittagong city.

#### 3.6.3.2 Goalpara Slum

Goalpara slum is located near the Tigerpass and Chittagong Stadium. This area is populated by poor slum dwellers in the foothill. However, the hills are not too high and therefore the risk is low in this area.

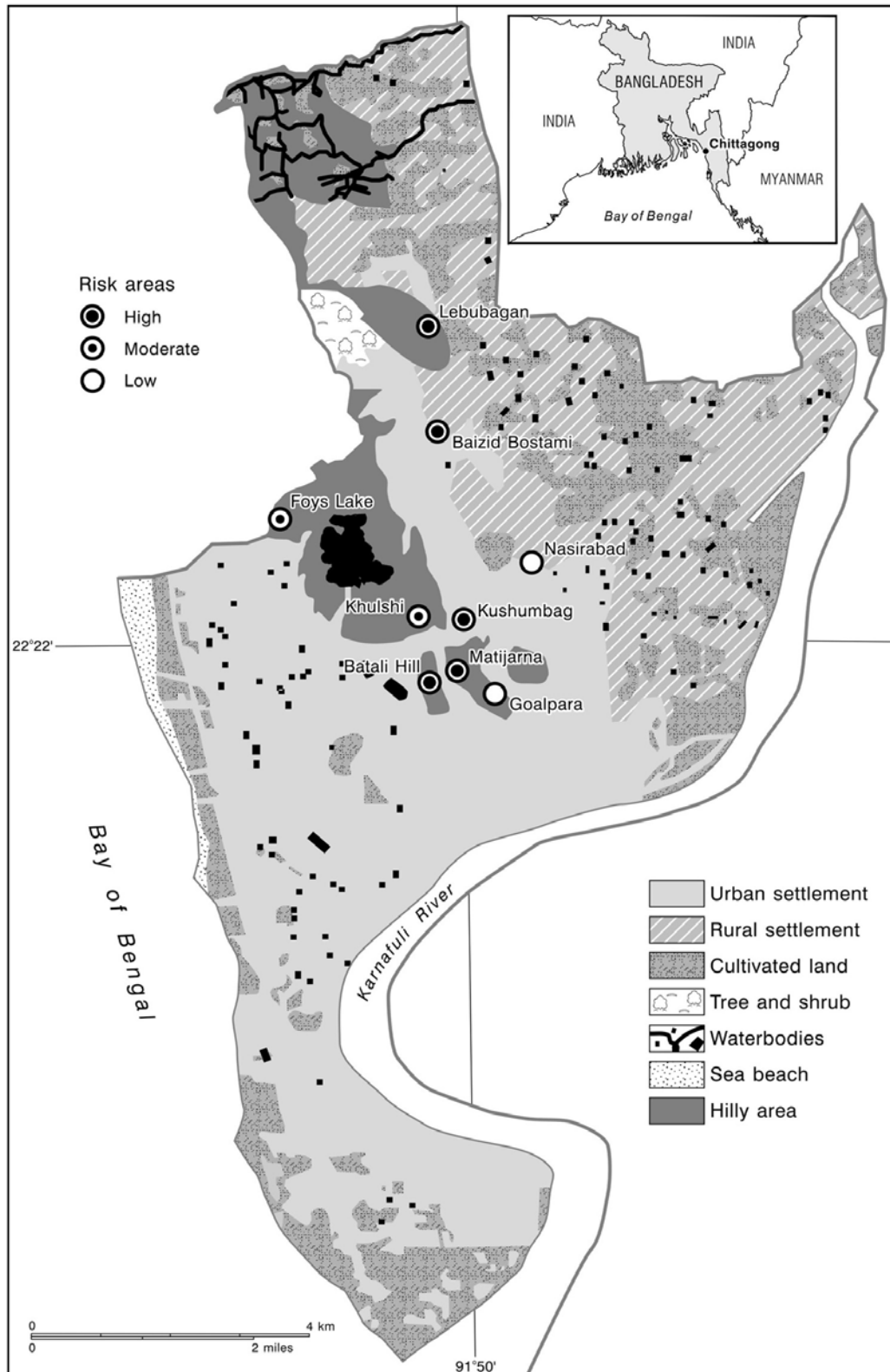


Fig: 3.9 Landslide vulnerability of Chittagong city  
 Source: Mahmood & Khan 2010



### **3.7 Institutional Factors Triggering Landslide Vulnerability**

Vulnerability, as a concept is dynamic and cuts across disciplines. A range of parameters are included for assessing the exposure of social- ecological systems to hazard and its capacity to adapt. Several researchers argued that vulnerability to any hazard is not only the outcome of natural forces; but also, depends on institutional settings that determine the social and economic possessions of affected communities and their ultimate coping capacity (Adger 2000, Wisner et al. 2003).

Landslides as a natural hazard not only occurs due to natural factors like heavy rainfall, earthquake and volcanic eruption, but are also triggered by human interventions like unplanned hill cutting for informal settlements, deforestation etc. then vulnerability to landslides depends on the strength of existing institutional arrangements in pre, during and post disaster situation.

#### **3.7.1 Feeble hill management policies**

Bangladesh has neither specific hill cutting nor hill management policies at the national level that can be executed at the local level. Only, according to the section 3(C), Bangladesh Building Construction Act, 1952 (amended in 1990), hill cutting has been allowed (not prohibited) with the permission of authorized government department under some terms and conditions. As per section, the authorized officer allows hill cutting when satisfied that the cutting or razing of hills is necessary for public housings and could be done without seriously damaging the original hill ecosystems, adjacent human lives, property and infrastructure or increasing siltation of water bodies (Ahammad 2009). If anybody violates those rules or has no permission for hill cutting, the offender will be imprisoned for up to 10 years or bound to compensate not more than BDT 1 million or both according to Article No. 15, Bangladesh Environment Conservation Act 1995 (Amended in 2000) that has been elucidated by Bangladesh Government Circular Letter No. Environment/General 497/91/604 dated 11th March 2002. However, with the rapid urbanization in Chittagong city, the laws could not ensure the effective guidelines for where and how housings should be established. So, most of the government administrative respondents understand that landslide vulnerability is an ultimate result of weak hill management policies.

Most of the informal settlements were built in a haphazard manner by private hill owners and illegal occupants of the hills, without following building rules and consequential

vulnerability to landslides. No one from either CDA or DoE was there to assess the vulnerability of those settlements to landslide. CDA controls major building construction rules and regulations in Chittagong city, but they don't go for any field monitoring whether the proposed structure will destroy the total hill ecosystems or increase harms to adjacent human lives and property. Though DoE has filed 20 police cases against illogical hill cuttings, but these could not stop hill cutting or inhabitation of the informal settlers along risky hill slopes. Basically weak hill management polices and lack of co-ordination between CDA & DoE triggered vulnerability risks.

### **3.7.2 Conflict of Hill Ownership**

Bangladesh railway is having a land tenure conflict on hill resources from over 20 years with the local people in the informal settlements. On one hand, respondent from the local office of the Bangladesh Railway, Chittagong claimed the informal settlement area as their own property, which they acquired from British emperor at the end of their regime in 1947. On the other hand, informal settlers claim that they are the legal occupants of those hills. They have legal documents as original owners of the hills.

*“We are the 4<sup>th</sup> generation living in this area. We are the legal owner of this land. Greedy railway officers want to make us landless and climb up more steps of luxury.”* – Shofi, Respondent from the focus group.

However, official of Railway, Chittagong complains that those houses were built with the support from some corrupt lawmakers, CCC, local politicians and fake land registration officials. Ahammad (2009) explains the situation by coating one of the respondents from Chittagong District Office, according to the law of The Limitation Act, 1908 (Bangladesh):

*“If someone uses any land in the absence of original owner without any objection for 20 years, the present occupants may claim the land as his own. However, there was objection from the Railway Department on the informal settlement before the stipulated time. So, those informal settlers are seemingly illegal occupants in those areas”* (A respondent from Chittagong District Administrative Office). (Ahammad 2009)

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

people. Because of land tenure conflict of the informal settlement with the Railway department, no civic facilities are available from CCC and CDA in the area, though are recognized as high risk zone to landslides.

### **3.7.3 Exclusion of Landslide Issues at National Level**

Landslide is one of the neglected disasters in Bangladesh as much as this took place in isolated and dispersed locations and does not create big headlines as earthquake, flood or cyclone does. To a large extent national disaster management policy of Bangladesh focuses on vulnerable communities, who generally live in coastal areas or riverine flood plains. Though, the cumulative effects of landslides, however, in terms of lives, properties and infrastructure have been quiet substantial. There have been instances when many settlements in hilly slopes have gone into complete oblivion and many rural and urban settlements have been very severely affected due to landslides. Landslides are generally perceived as a local hazard in Chittagong region due to its hilly topography. Therefore, many organizational respondents claimed that national authorities are less concerned with landslide hazard management. In 2002 a Public Circulation was published against hill cutting and landslide in Bangladesh. But, the government could not emphasize on landslide issues effectively. So, DoE and other local authorities often lacked the technical and geological knowledge and equipment to work on landslide hazard assessment.

The landslides in 2007 raised attention to the national level to incorporate the landslide issue in disaster management and a disaster management committee was formed in Chittagong. The mayor of Chittagong City Corporation chairs the committee that coordinates the local government departments such as the Chittagong Development Authority, the Bangladesh Water Development Board, and the Meteorological department, the Defense Authorities, the emergency authorities, ward representatives and NGOs. The committee is supposed to sit during the pre-monsoon period to define roles and responsibilities regarding pre and post disaster activities. However, in practice these agencies hardly coordinate amongst each other. One of the organizational respondents noted that:

*“Landslide risks during heavy rainfall were not well addressed by the city disaster management committee. There was a lack of systematic communication between the Meteorological department and the existing disaster management committees to work for emergency actions around the vulnerable slums along hill slopes.”*

### **3.7.4 Absence of Early Warning System**

The local Meteorological Department usually provides forecasts for heavy rainfall and issues a pre-hazard warning to the departments or agencies with responsibility for disaster preparedness. The highest rainfall (425.2 millimeters in 24 hours) was recorded on 11 June 2007 by the local Meteorological Department; however no specific responses, either before or during the rainfall, were undertaken by any of the agencies in the local disaster management committee because of their undefined roles. There was not any responsible agency to convey early warning to the informal settlers that they needed to move to a safe location.

Generally, Bangladesh Meteorological Department (BMD) forecasts weather report through electronic media (TV, Radio and Web), but it is not available in time to local people for taking early preparation. Almost all respondents of the focus group were aware that landslides might occur during heavy rainfall between June and September, but they had very limited knowledge of exactly why and when a landslide will come down on them or how they should take preparation. In fact, they were rarely informed of the meteorological data to predict the intensity of rain and no cooperation was found with CCC or any other organization to take emergency preparation before landslides. A respondent in one of the focus groups noted:

*“We presented the vulnerability issue to city corporation authorities, but they could not conduct any survey for landslide risk assessment along the informal settlement. If there were early warning and communication from government with other agencies and us, there would be fewer deaths from landslides.”*

### **3.7.5 Lack of Structural Measures**

Many residential buildings of Chittagong city were also established along hill slopes through safety measures, building codes and even guarded with concrete reinforcements and better drainage facilities. However, informal settlers as illegal occupants of hilly lands, CDA and CCC could not establish any structural measures along the settlement. Though experts on landslide issue kept giving warning to both national and local level authorities about the upcoming hazard and its massive impacts. An expert on landslide issue in Bangladesh stated that:

*“We already surveyed 60 risky informal settlements along hill slopes in Chittagong city and recommended the local authority to take right initiatives like awareness building*

*during rainfall or relocation of those people as early as possible. But, government authority did not take it seriously.”*

In fact, before the landslides in 2007, local authorities emphasized how to stop hill cutting and always blamed the informal settlers. Due to their negligence and inaccessibility of informal settlers to political decision-making process and as a low-income group, neither local authority nor the vulnerable population was able to establish any structural measures along those risky slopes.

### **3.7.6 Lack of Organizational Coordination**

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

Disaster risk reduction among the low-income groups living in informal settlements is hindered by poorly defined roles for urban government agencies and little coordination between them. This is hardly unique to Chittagong. A comparative study in 10 Asian cities highlighted how undefined roles and responsibilities of urban government agencies obstructed integrated urban development in general and pro-poor climate change adaptation in particular (Tanner, Polack & Guenther 2009)

The National Disaster Management Plan has recognized a number of urban hazards, including water logging, fire, earthquakes and landslides, but no risk reduction policy for these has been developed through national and urban government agencies. Only Chittagong City Corporation, as a locally elected government agency, addresses its responsibilities for infrastructure development, for instance through repairing roads and drainage systems inside the informal settlements in order to avoid water logging. However, it faces serious financial constraints and is not incorporating adaptation to intense rainfall into its responses. To a question regarding water logging risks in the city, one of the organizational respondents noted:

*“We propose that the drainage system must be regularly maintained to keep it clean, free of silt and in a state of good repair as a continuous process. But at present, the maintenance operation is limited by the inadequate budget and staff required for the expanded urban areas.”*

The roles of urban government agencies in Chittagong have not evolved in relation to climate change adaptation. After the 2007 landslides, vigilance teams were formed under the city corporation to monitor informal settlements that were at risk and to create awareness among their residents of the need to move to temporary safe shelters during rainfall. But these vigilance teams only included city corporation staff, who lack training for disaster management responses and typically undertake only routine works. The teams have not proved able to encourage and support the engagement of residents in community-based disaster preparedness.

**CHAPTER 04:**  
**CASE STUDY DESCRIPTION**

## 4.1 Study Area

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

### 4.1.1 Batali Hill

The Batali Hill is the highest hill within the Chittagong Metropolitan area. The hill is about 280 feet high. From the peak of the Batali Hill one can have a clear bird's eye view of the city. Aperture of the river Karnafuli, a comprehensive portion of the Bay of Bengal, Jetties of the Chittagong Sea port and a large portion of the city can be seen.

#### 4.1.1.1 Location

Batali Hill area is situated in the Tiger Pass area of the city. It is only 1 km. from the Zero point and is under Pahartoli Thana.

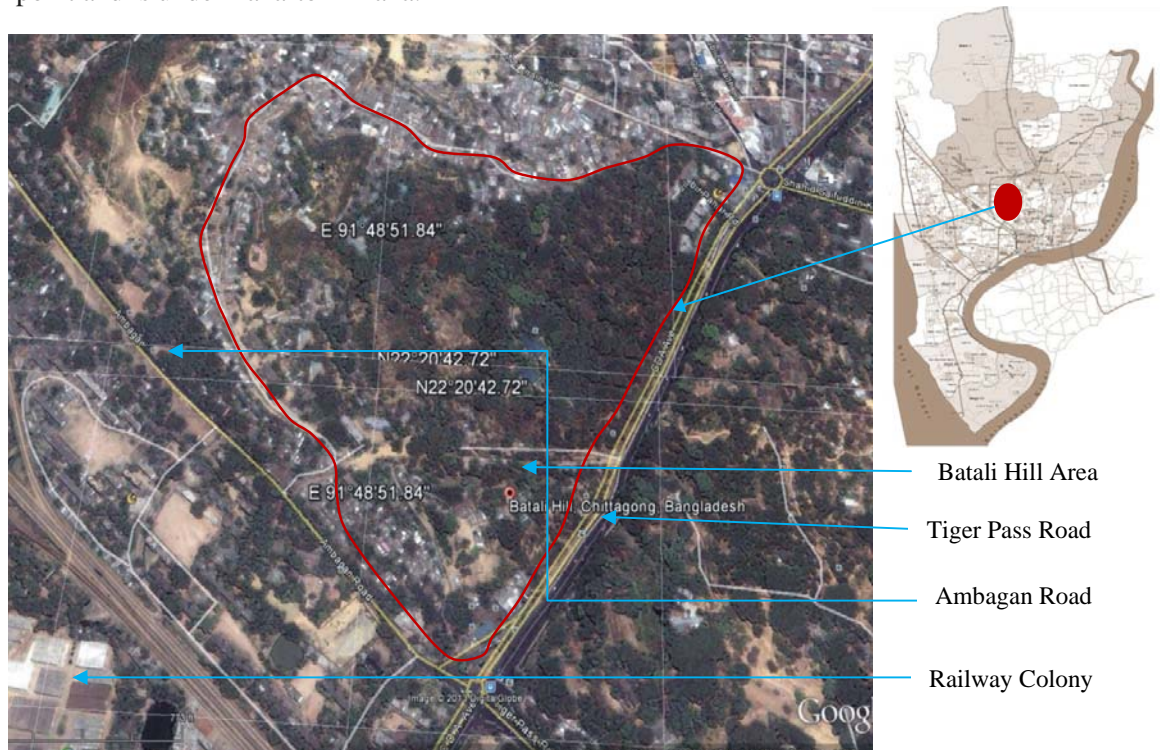


Fig: 4.1 Location of Batali Hill informal settlement

Source: Author, 2013



#### 4.1.1.2 Socio-economic Context

Batali hill area is highly populated. Most of the inhabitants of this area belong from lower income group. A major part of them are landless poor and migrated from different parts of the country. Easy access to work places and available government hills has triggered the growth rate of this informal settlement. People occupying this area are factory workers, railway porter, CCC employed cleaners, rickshaw pullers, Housemaids, vendors etc. by occupation.

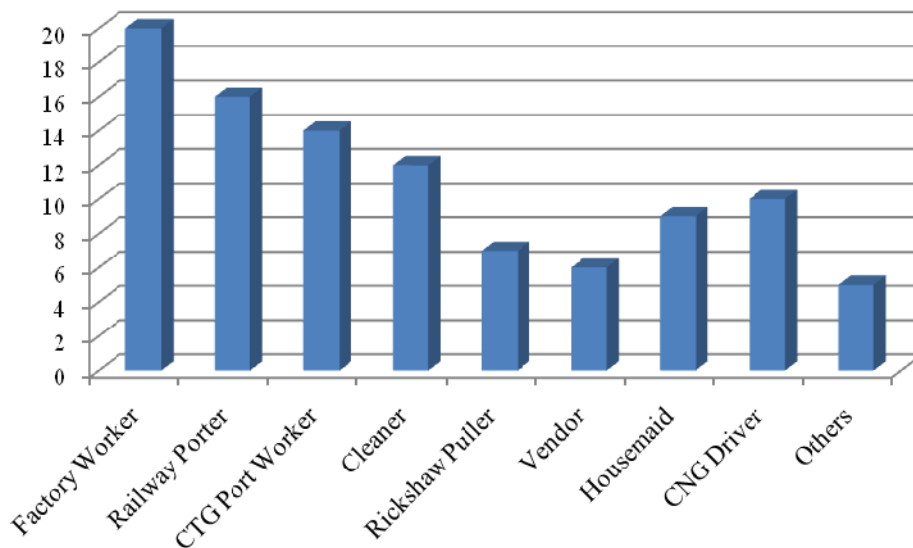


Fig: 4.2 Livelihood pattern of the informal settlers of Batali hill area

Source: Author, 2013

#### 4.1.1.3 Hill Ecosystem

Excessive hill cutting has sabotaged hill ecosystem. Unplanned growth of informal settlement along hill slopes and foot hill disrupted natural drainage system. As a result top soil easily gets saturated during heavy rainfall and triggers possibility of massive soil erosion and landslides. Unsustainable vegetation mostly in form of small vegetable gardens by the informal settlers who used to live in flat plains has made the scenario worse. People also collect wood and dried leafs from the hill. For which utmost part of the hill has become barren.

#### 4.1.2 Motijharna Area

Motijharna is the biggest informal settlement sitting at the core of the city. It has developed at the valley of Motijharna- Batali Hill. It was once been the main source of water supply for Chittagong city before water supply system was introduced. The entire settlement was severely damaged in the landslide occurrence of 2007 and still counted as one of vulnerable areas to landslide.

##### 4.1.2.1 Location

Motijharna area is situated at Lalkhan Bazar area near the Tiger Pass. It is almost impossible today to distinguish Motijharna informal settlement from Batali Hill informal settlement as they are so closely spaced. It is also under control of Pahartoli Thana.



Fig: 4.3 Location of Motijharna informal settlement

Source: Author, 2013

##### 4.1.2.2 Socio-economic Context

Population density of Motijharna informal settlement is very high. More than 50,000 people live in this area. Most of the inhabitants belong from lower income group. A major part of them are landless poor and migrated from coastal zone and greater Noakhali. Easy access to work places and available government hills has triggered the expansion. This informal settlement is badly reputed to be the shelter place of criminals. All sorts of anti-social activities are been being practiced here. People occupying this area are factory

workers, rickshaw pullers, CNG Drivers, Housemaids, Garments workers, vendors, Drug Dealers, hijackers etc. by occupation.

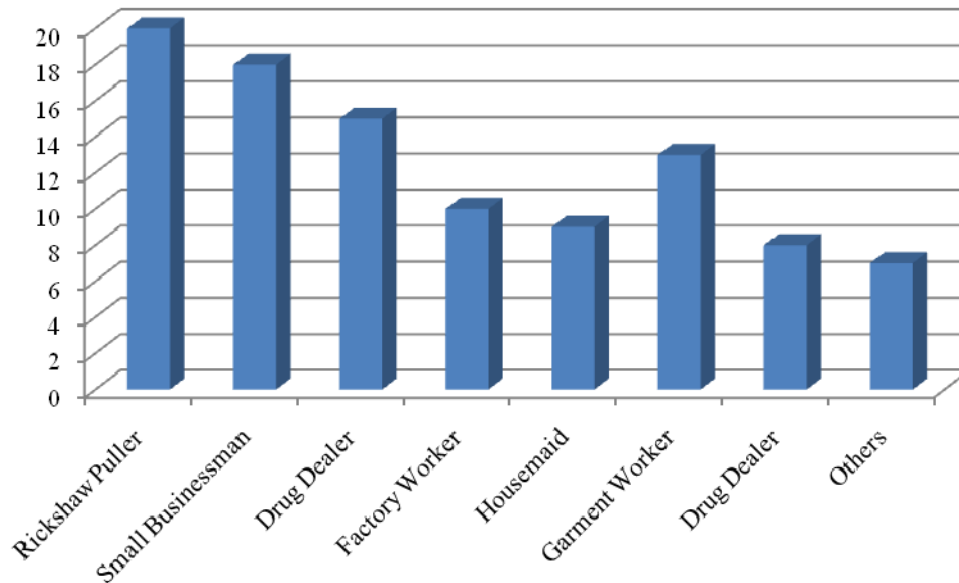


Fig: 4.4 Livelihood pattern of the informal settlers of Motijharna area  
Source: Author, 2013

#### 4.1.2.3 Hill Ecosystem

Unplanned growth of informal settlement along foot hill and in the valley disrupted natural drainage system. It causes flash flood and triggers landslide vulnerability. Motijharna informal settlement has blocked the sewerage system of Lalkhanbazar area. Very little or no vegetation is present there. Unsustainable garbage disposal and poor sanitation system made the scenario worse.

#### **4.2 Land Use Pattern**

In Batali Hill & Motijharna area informal settlements have grown on both hill slope and foot hill. Entire foot hill is densely covered by temporary structures. A few semi-permanent structures can be identified along the connecting narrow lanes. Small part of the hill at the end of Lalkhan Bazar circle has been commercially developed. Bangladesh railway has built 3 bungalows, though railway authority is not the legal owner. Part of the Batali hill has been almost diminished because of unplanned hill cutting.

Matijharna is expanding fast towards the adjacent railway hill. New structures along the hill slopes are permanent and of 3to 4 storied. Part of the settlement near the High Level Road is converting from temporary structures to permanent structures. Small traders are acquiring spaces along the connecting lanes and constructing semi-permanent structures.

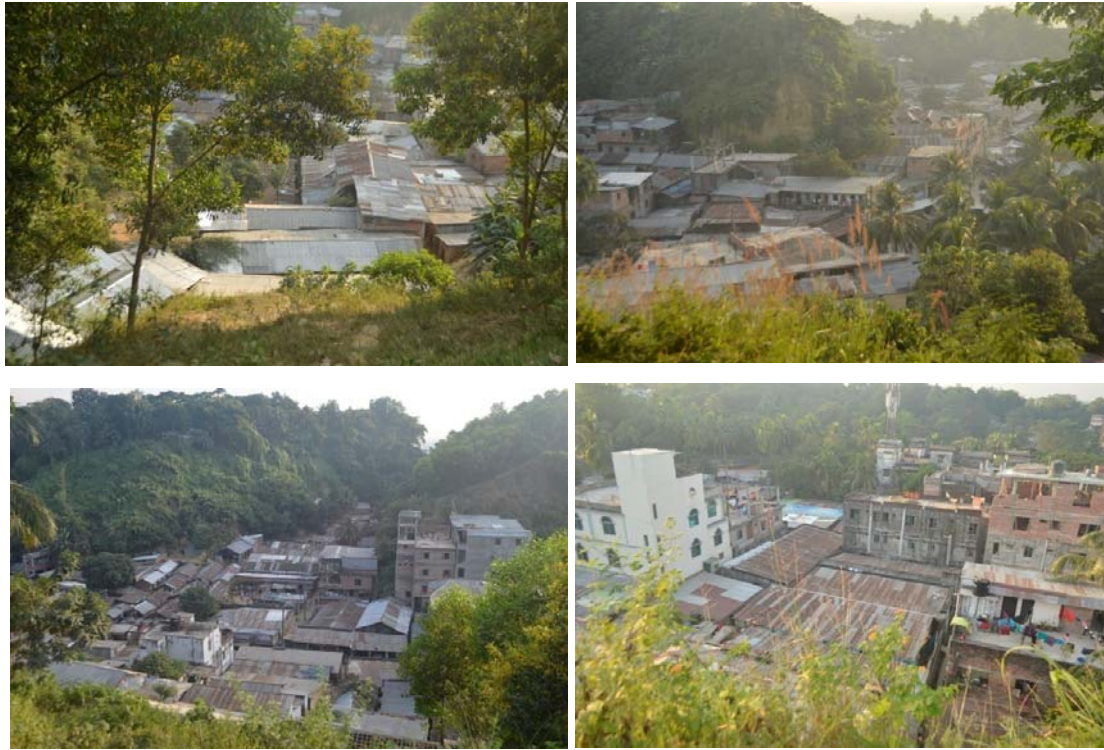


Fig: 4.5 Land Use Pattern of Matijharna-Batali Hill Area  
Source: Author, 2013

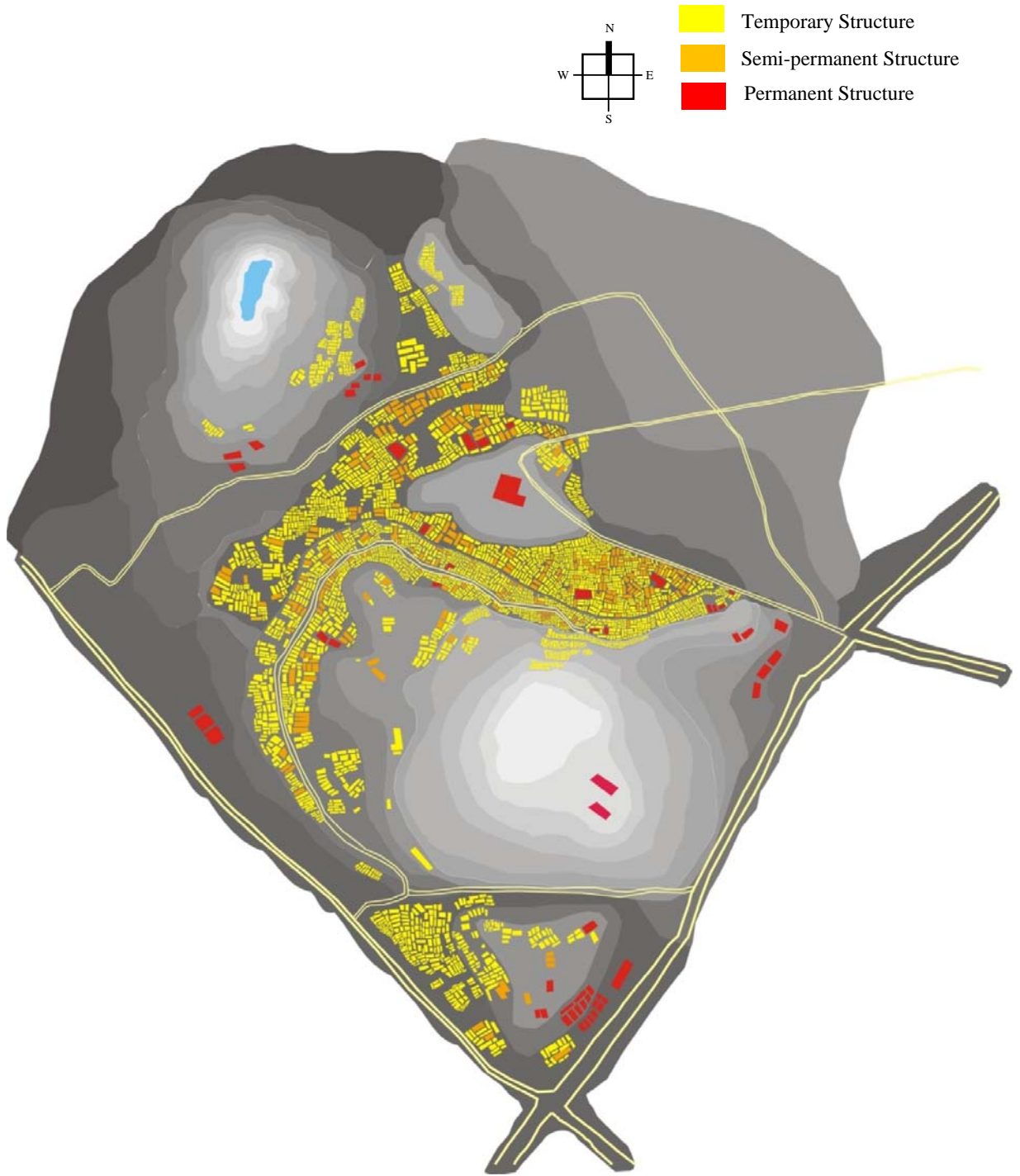


Fig: 4.6 Settlement pattern of Motijahrna- Batali hill area  
 Source: Author, 2013

### 4.3 Accessibility

Batali Hill informal settlement is located at the center of the city. Three internal narrow lanes provide an easy access to the settlement from two main roads of the city: Tiger Pass & Ambagan Road. The area can be accessed from Uttar Lalkhan Bazar by Motijharna road.

Motijharna informal settlement is accessible by four narrow lanes from the main road. These lanes connect the settlement with Tiger Pass road on Lalkhan Bazar circle and with CDA Avenue from High Level Road.

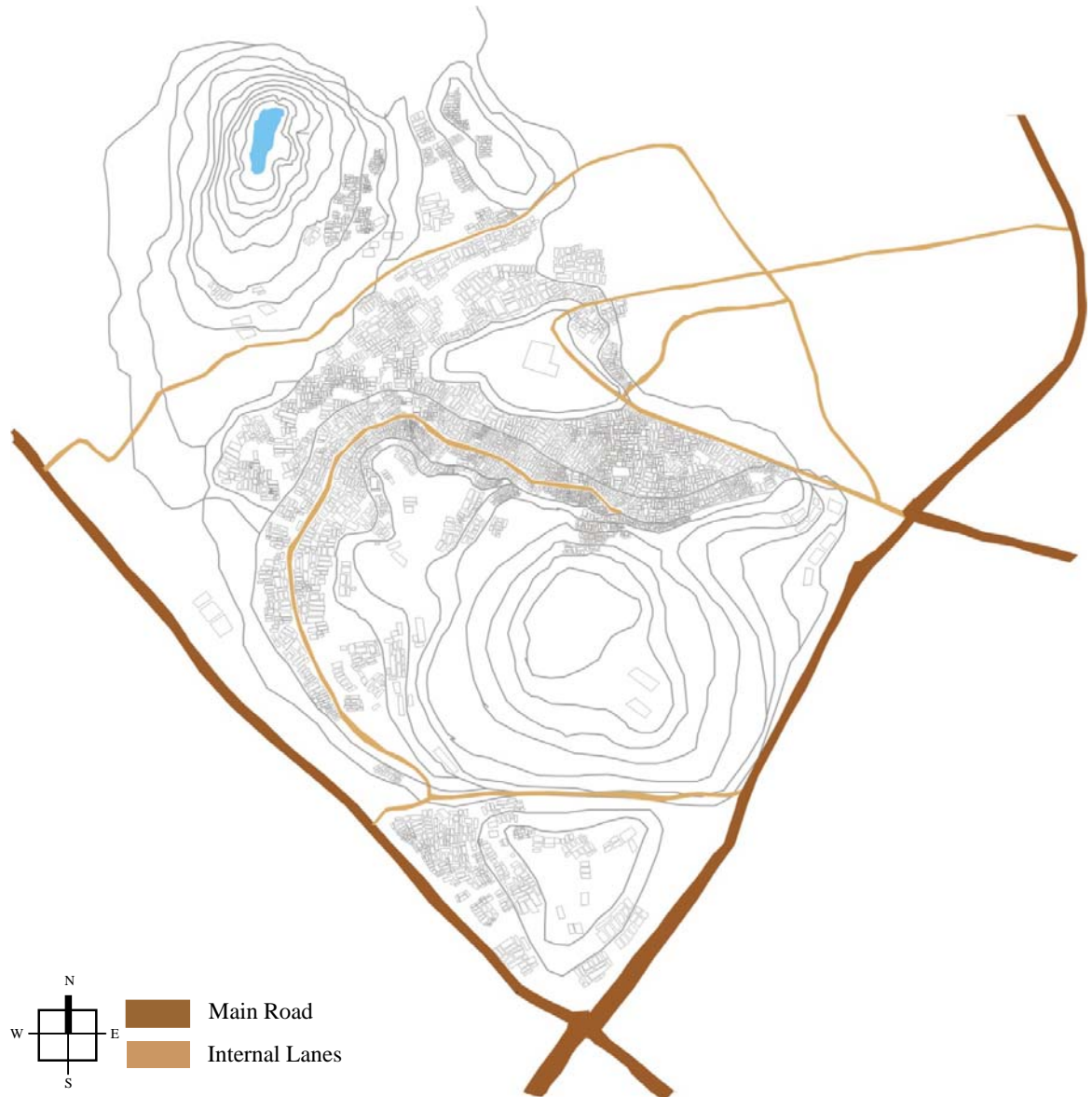


Fig: 4.7 Access to the informal settlements  
Source: Author, 2013

#### 4.4 Living at Risk

Informal settlers are almost 30% of total population of Chittagong City where the living environment is quite unsatisfactory. Like most other informal settlements in Chittagong, Batali Hill- Motijahrna informal settlement has been built on vacant government land (foothills and valleys) vulnerable to natural disasters. A lot of houses are built at the edge of the steep sloped hill not only for land scarcity but also to reduce building cost. The users build walls on three sides and use the hill side as the fourth wall. This practice makes them extremely vulnerable to landslides. Even in monsoon they suffer from water percolation through the top soil. Houses in these informal settlements are usually made of flimsy material which provides little protection from fire, or monsoon rain. In the study area, some of the houses were identified to be built on freshly cut hill side and were under high risk to land erosion.



Fig: 4.8 Over populated risky living condition

Source: Author, 2013

People living in slopes of Batali Hill & at the foot hill settlements of Motijharna are prone to landslide. Especially the houses built on the steeper side of Batali Hill faces hill erosion every year. As Motijharna informal settlement is at the valley it generally goes under the debris of slided mud and destroyed houses, which increases the vulnerability.

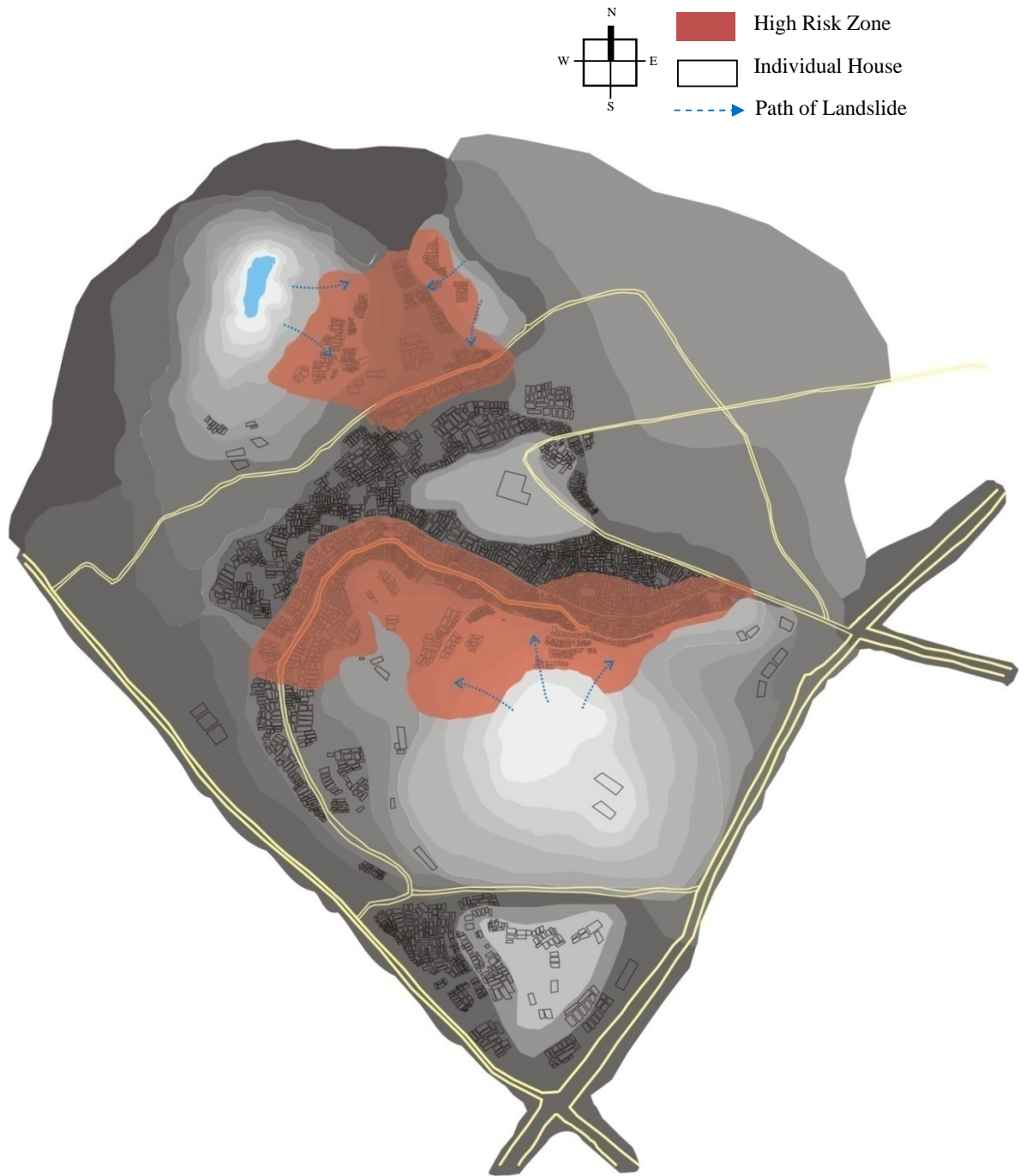


Fig: 4.9 Risky living along the path of landslide  
Source: Author, 2013



## 4.5 Access to Basic Services

As informal settlements are considered ‘illegal’, populations who live in these settlements often have no official addresses and are commonly denied basic rights and entitlements, including the right to access water, sanitation, healthcare services, and education. During the study, it is found that neither Batali Hill nor Motijharna informal settlements have access to these basic services. The lack of governance and accountability in slum settlements results in residents paying heavily for access to basic services. Usually, local musclemen (local-level leaders/thugs who control slum settlements) or other influential leaders within the slum settlement extort money for water and access to other facilities.

### 4.5.1 Water

The studied informal settlements rely mainly on municipal taps and on tube wells for water. The musclemen take control of the taps by paying low level government employees for access to the illegal connections and diverting the water to a connection inside a household or compound, where they sell it to the residents at exorbitant prices (Tk 8 per bucket, or Tk 3-5 for a bath). Only inhabitants who can afford the price are able to access the water. Profit is shared between the government officials and the musclemen. Women and young girls stood in long queues daily under the hot sun to access water from these few water lines where water is available for few hours in a day.



Fig: 4.10 Long queue for water collection  
Source: Author, 2013



Fig: 4.11 Illegal stand pipe of water  
Source: URB.im

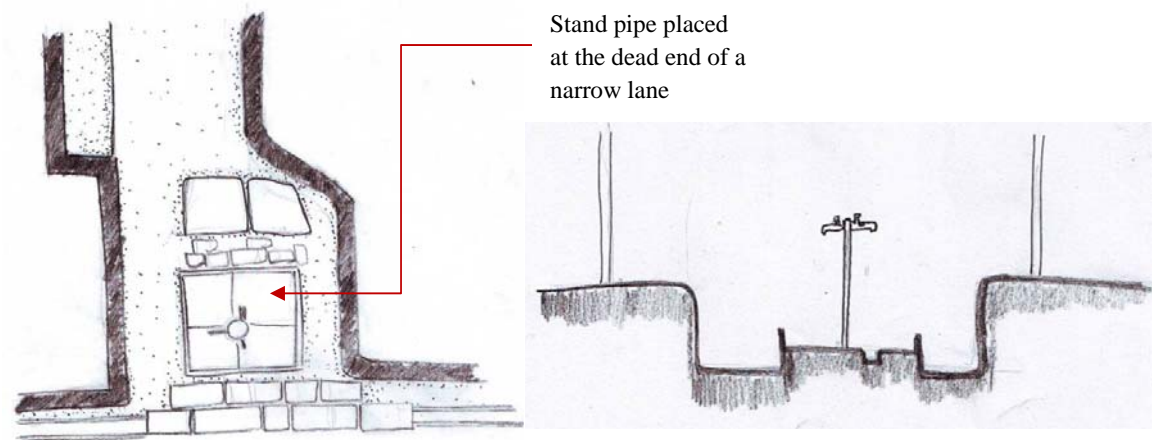
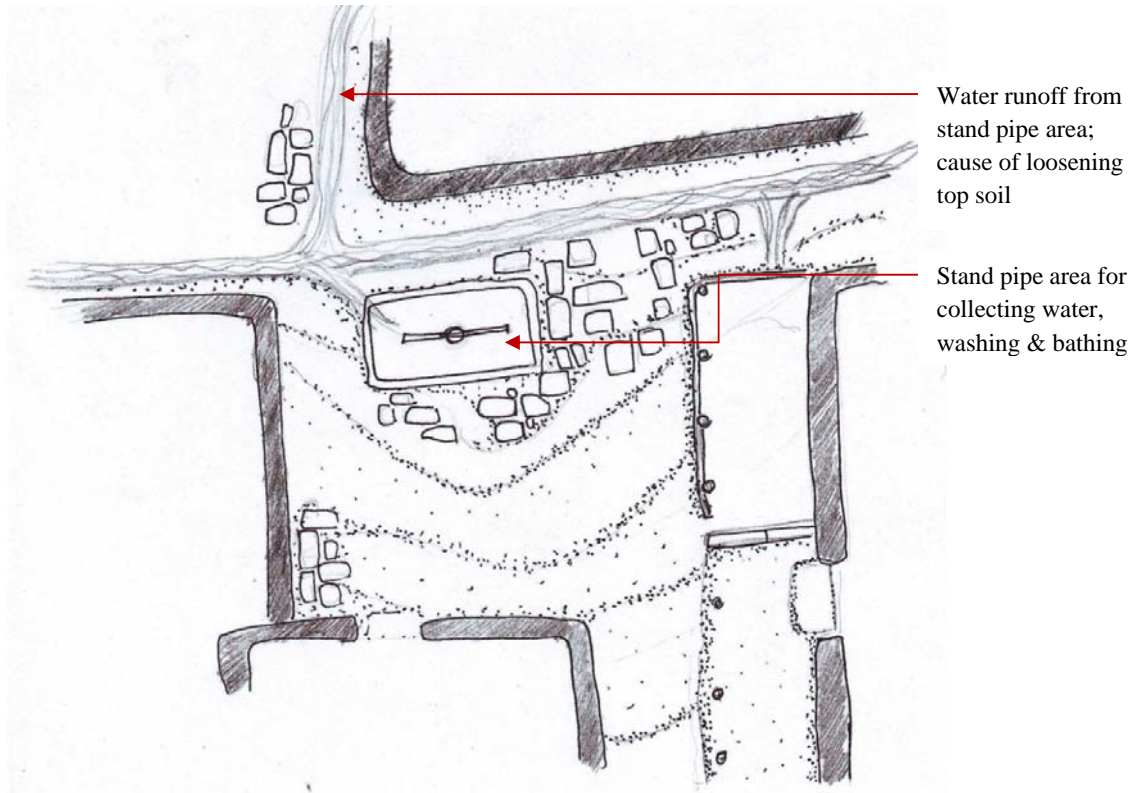


Fig: 4.12 Stand Pipes at Site  
 Source: Author, 2013

### 4.5.2 Electricity

Electricity is available in Batali Hill and Motijharna informal settlements but illegally and at extorted prices. The internal slum settlement price for electricity, noted by Coalition for the Urban Poor (CUP—an umbrella organization of urban NGOs with 44 members (23)) is three times higher than what those who have legal access would pay. The studied area

is no exception to it. The regular price is around Tk 20 per month for one light-bulb while people who live in these settlements are asked to pay Tk 50-70/month for one light-bulb.

Electricity is supplied to every house by from the main electric poles by threatened connections. Electric connections dangle here and there with in human height. Casualties and injuries are caused by electric shocks and sudden sparks followed by fire. During landslide all these connections cause more damage. The electric poles posted on the hill edge get ruptured or are ripped apart when landslide takes place and make post disaster rescue work troublesome. Torne down electric connection sometimes sets fire, electrocutes and adds to the death toll of landslide victims.

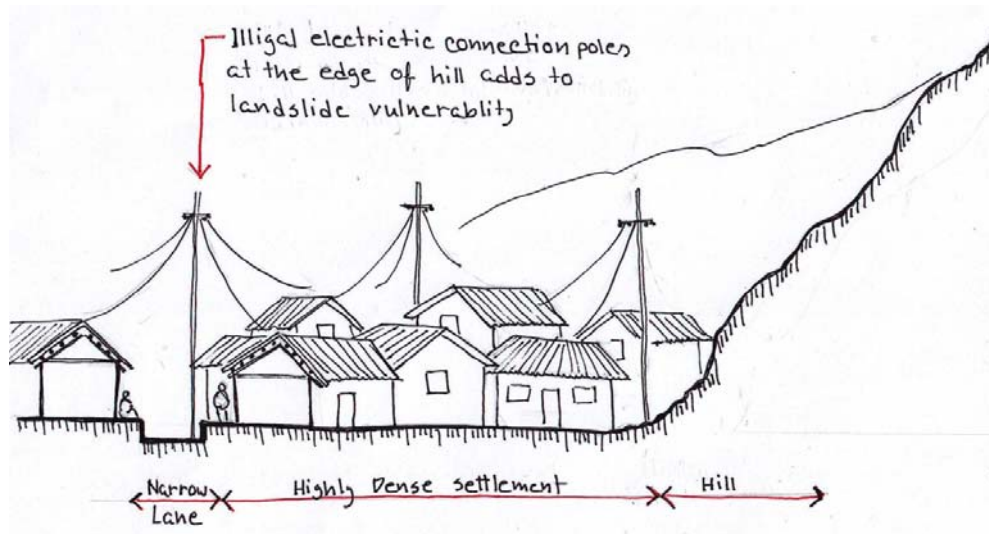


Fig: 4.13 Risky electric connections

Source: Author, 2013



Fig: 4.14 Multiple illegal connections from a single pole

Source: Author, 2013



Fig: 4.15 Electric connections at unsafe position

Source: Author, 2013

### 4.5.3 Sanitation

Safe sanitary latrines are rare in informal settlements in Bangladesh. A 2006 survey of 9,048 slum settlements in six cities of the country found that 70% of slum settlements had no access to safe latrines. In Batali Hill and Motijharna informal settlements, latrines were shared by a number of households; in half of the cases, the latrines were shared by at least six families (30 or more persons). Problems of poor sanitation and drainage are endemic, and often experience flash flooding during the rainy season. The situation is made worse by the high density of population in these settlements, which have considerable implications for transmission of communicable diseases and other public-health problem.

Poor drainage system causes water to spread in the entire settlement. This keeps the top soil wet and mushy. During monsoon, this loose, wet soil gets easily saturated in rain water and turns into a liquid form of mud which triggers the possibility of landslide. It's been found during the study that, if the everyday used water could have been properly drained out and the top soil of the hill slope kept dry and compressed, to some extent risk of landslide will be reduced.



Fig: 4.16 Poor Drainage  
Source: Author, 2013



Fig: 4.17 Unsafe latrine  
Source: Author, 2013

**CHAPTER 05:**  
**ANALYSIS**

## **5.1 Probable Measures Incompetent to Reduce Risk**

Vulnerability, as a concept is dynamic and cuts across disciplines. A range of parameters are included for assessing the exposure of social- ecological systems to hazard and its capacity to adapt. Several researchers argued that vulnerability to any hazard is not only the outcome of natural forces; but also, depends on institutional settings that determine the social and economic possessions of affected communities and their ultimate coping capacity (Adger 2000, Wisner et al. 2003).

Vulnerability to landslide depends on location, land use, land cover, rainfall as well as weather, geological structure and type of human activities. Because of all these external and internal phenomena, it is not possible to prevent the landslide of Chittagong city completely. However, after the landslide of 2007, a national level Ministerial Order came to the DC office to look into the major causes of landslides and prepare mitigation measures (Technical Report 2008). Accordingly, a technical committee was formed to identify the priorities for mitigation action.

The committee had emphasized the necessity of integrated hill management policy with urban planning and different institutional reforms such as; Environmental Act 1995, building Construction Act 1952. Finally two mitigation policies: relocation and adjustment are available for vulnerability reduction to landslides. Besides taking these mitigation measures, both of them found to be incompetent to reduce risk in landslide incidences later on.

### **5.1.1Relocation**

The relocations of houses and structures are one of the major instruments for reducing the vulnerability and risk of landslide disaster. A relocation policy has been prepared for extremely vulnerable people living along the hill slope informal settlements (Ahammad 2009). The authority has been provided to the CCC and DC for selection of relocation point. Two sites have been selected for relocation of 2, 00,000 people of Chittagong city.

A study in the city of La Paz, Bolivia showed that after landslide in 1996, mostly impoverished informal settlers were relocated to less risky hill slopes and provided only adjustment to landslide slopes through land terracing and reforestation by municipal government (O'Hare and Rivas 2005). However, those informal settlers had poor quality housings, sub-standard drainage facilities during heavy rainfall and in particular they faced more uncertainty on their land tenure right. Other studies also revealed that

relocation of informal settlers was not successful in the cities such as Manila, Philippines and Kanpur, India (Porio and Crisol 2004, Milbert 2006).

In those cities, though people from informal settlements were relocated to less risky places, yet these informal settlers were more aware of their tenure security and afraid of eviction from the government. From those case studies, it is obvious that the current institutional arrangement for relocation should ensure land tenure rights for the informal settlers in Chittagong city.

Lin (1989) refers to institutional change as imposed rules or policies from the government. The present relocation policy seems imposed as government tries to evict people from informal settlements neglecting their claims on land tenure in Chittagong city. Eventually, this hastily designed institutional arrangement from the government has diminished trust between government agencies and the informal settlers to the long-term institutional changes. In fact, during the FGD in the study area, it is found that informal settlers want assurance of better income opportunities and their land tenure security before relocation.

However, Lin argues for formal government agencies to enhance voluntary arrangement for implementing imposed rules (*ibid.*). According to Kingston and Caballero (2006), benefits from a proposed institution should be equally distributed, otherwise the losers will try to oppose in accepting new change. In Chittagong city, informal settlers are reluctant to appropriate the relocation scheme, as they understand new policy is not improving their land tenure security or income opportunities in the end. Therefore, government agencies should coordinate with informal settlers to ensure their tenure security before relocation.

Other studies showed that though landslide affected people experience higher impacts of landslides than general public; they have less willingness to adapt to mitigation measures. They explored that mostly trust, socio-economic status (education, income) and powerlessness inhibit those populations in accepting new institutional arrangement like relocation. In fact, growing distrust due to land tenure conflict between the government and informal settlers has particular implications for vulnerability to landslides in Chittagong city. The conflict has tightened pre-landslides institutional limitations that already affected the social vulnerability of informal settlers in 2007 & 2012.

### **5.1.2 Adjustment through Structural Mitigation**

Structural measures considering the safety measures, building codes and better drainage facilities are inevitable for mitigation of landslide disaster risk. The mitigation policies for landslide disaster allowed the informal settlements upon fulfilling some prerequisites including satisfactory risk and vulnerability assessment by the city level vigilance team and taking required structural measures. A committee involving representatives from CCC, CDA, and IEB also created for establishing measures like reinforcement walls along hill slopes.

Building reinforcement wall along the foot hill can never be the only structural mitigation measure for risk reduction of landslide prone area. However, there is usually no standard rule of thumb solution because formulation of mitigation measure is often unique for each site and requires proper technical evolution of causative factors. There are different approaches of dealing with landslides, depending on needs, risks and available funds. The selection of appropriate mitigation measures should be based on an assessment risk, uncertainty, possible consequences, constructability and environmental impacts.

The mere act of constructing mitigation measure does not always stop ground movements or hill erosion. Often cracks caused by landslides leave voids in the ground that takes time to compress or fill-in. Following structural mitigation, slide movements tend to slow down and eventually reach final stability. The maintenance requirements associated with each mitigation option should be considered to understand the potential long-term impacts and costs.

### **5.2 Addressing Poverty & Migration Issues at Source**

Nearly one billion residents in cities of developing world are estimated to be poor, and the trend of urbanization and poverty increasingly alarming (Mehta, 2000). The number of people living in urban slums is expected to be double within 2025. Like other developing countries, the number of migrant dwellers is increasing very rapidly in urban societies of Bangladesh. At present, Bangladesh is 7th most populous country in the world. Based on the current rate of growth of population, the country's population (currently at 158 million) is expected to reach 206 million in 2025 (ESCAP, 2007).

If it is critically observed, a correlation will be found between the "landslide victims" and the "poverty". As mentioned earlier, the poor people are living in the landslide-prone



areas who cannot afford a safer place to stay. Therefore, addressing poverty issue should be considered as a priority to deal with the issue.

The rapid growth of urban population is fuelled by migration of the rural poor to the city, drawn by perceived chances of finding cash employment in the industrial sector and pushed by the limited opportunities in rural areas. On arrival, many are unable to afford proper housing and so, turn to live in informal settlements, footpaths, rail stations and other scattered places. Like most of cities of Bangladesh, informal settlements in Chittagong tend to be built on vacant government land or private vacant land located in low-lying areas, foothills and valleys vulnerable to natural disasters. Many informal settlements are built on waste or polluted spaces, exposing residents to industrial noxious wastes. Urban informal settlements are generally excluded from public sector resources, severely limiting access of residents to formal education, healthcare services and water and sanitation.

Migration has long been an important livelihood strategy for the people of Bangladesh. Broadly it is a relocation of residence of various duration and various natures. Every year, thousands of destitute victims of natural disasters pour into the cities from rural areas. Others come in the hope of a better life whenever the population rise to such an extent that people can no longer secure a livelihood, they migrated elsewhere. Several studies (Deshingkar and Grimm, 2005; Narayan et al., 2002) also suggest that an increasing number of poor migrant every year migrate either permanently or seasonally. They move on their own, in groups or with siblings in search for job opportunities available in the city or to escape from unemployment and poverty situations at rural areas. The poverty argument in Bangladesh is strong, where many poor and land less migrants are forced to migrate to support themselves or their families (Ahmad, 2004). In recent years, most of the cities in Bangladesh are experiencing rapid but unplanned urbanization. While the annual population growth rate is 1.7 per cent at national level, the percentage of urban growth is increasing faster and it is expected that more than 50% of the population in Bangladesh will live in urban areas by the year 2025 ( ESCAP, 2007). In general, the decision of migration comes to be the function of variables like the income differential between the countryside and the town, the chance of getting a job, the risk attitude of the migrant, and information on availability of jobs in urban locations. Thus a migrant may often fail to find an appropriate job in the city. Before migration one might have had a rural sector job which may be of a very low productivity, but after migration it often happens that he ends up getting no job whatsoever, thus becoming unemployed.

According to the available empirical studies and evidences, the migration is always a selective process in which, the community, family or individuals fall into a certain category or characteristics and it varies extensively from culture to culture. Several studies reported that migration varies depending on socio-economic, demographic and cultural factors. That is lack of work availabilities, unemployment, poverty, natural disaster i.e., flood, drought, river erosion, cyclone etc.; and others socio-cultural factors like, marriage, family conflict, better living, better education facilities, social discrimination, social prejudice, fanaticism, political chaos etc. also act as motivational factors of migration.

Migration is a natural process where normally surplus manpower released from the rural sector is needed for urban industrial growth. Although migrant poor in cities gain greater employment and cash-earning opportunities, they face intense competition and scarcity in meeting their basic needs. Thus despite economic growth, although the incidence of poverty in urban areas is lower than that in the country as a whole, the risks of health hazards and environmental pollution are greater in urban areas than in rural areas.

Several studies reveal that rural-urban migration and hence urbanization in Bangladesh is poverty driven, caused by extreme entitlement contraction among a sizeable segment of the rural population, who happen to be among the marginalized peasantry and the landless poor. The migration of the rural poor to the urban centers has caused a direct transmission of rural poverty and backwardness to the towns, engendering the process of 'ruralization' of the urban areas. The pull factors, which attract the rural people and induce them to migration to urban locations, are in a large measure the direct or indirect results of government's development policy and effort, that have always been biased towards the urban areas. Thus, allocation of public funds in the successive five year plans has been consistently biased towards the urban, and against the rural sectors.

However, alleviation of poverty in Bangladesh has been at the heart of the Government's development strategy, particularly since independence of the country. Implicitly, one objective of such strategy has also been to slow down the pace of rural-urban migration, and for that matter to reduce the problems associated with excessive urbanization. Unfortunately that strategy was unable to do much in this sector.

In order to stop poor people from migration, therefore, the essential pre-conditions seem to be the expansion of employment opportunities, as mentioned above, and also the

creation of better living conditions through improved availability of essential health care and occupational services. Unless the like of the amenities enjoyed by migrants in the cities can be made available in the rural areas, at least partly, if not to the fullest extent, the idea of alleviation of poverty through inducing and sustaining the process of reverse migration will hardly be translated into reality.

### **5.3 Climate Change Adaptation of Urban Poor**

Rapid urbanization combined with the impacts of climate change is increasing human vulnerability in many cities in low-and middle-income nations (Moser & Satterthwaite 2008). Much of the physical expansion of housing in cities in these nations occurs on hazardous sites such as flood plains, coastal areas and unstable hill slopes. Most of the housing on such sites is of poor quality, built on land that is occupied illegally and that lacks the necessary infrastructure to protect inhabitants from flooding and landslides. Bangladesh is no exception to that. Like capital Dhaka, the second largest city of the country is experiencing rapid growth of urban population fuelled by migration of the rural poor to the city, drawn by perceived chances of finding cash employment in the industrial sector and pushed by the limited opportunities in rural areas. On arrival, many are unable to afford proper housing and so, turn to live in informal settlements, footpaths, rail stations and other scattered places.

The case studies show that as a result of living in high risk locations with little or no protective infrastructure, a high proportion of urban dwellers in these settlements are severely affected by heavy rainfall. The risks are increasing, as climate change brings rising temperatures and more intense and often erratic rainfall, as well as sea level rise in coastal cities (Satterthwaite 2008). Climate change can create or exacerbate risks for urban areas, and adaptation to climate change needs to address the risks faced by low-income groups in general and the poorest groups in particular.

Although the risks of urban flooding and water logging, and the vulnerability of poorer groups to these informal settlements have been widely recognized and documented in Bangladesh; city and local governments all over the country face many barriers in taking the necessary actions towards long-term pro-poor adaptation. Poor communities, for the most part, are ill-prepared to cope with these shocks and to adapt to climate change. In Chittagong, there has been limited assessment of likely local climate change impacts, and there is little information available to either the government institutions with responsibility for adaptation or to poor communities in the city. Local government

agencies and NGOs have particular initiatives for improving water and sanitation (as well as providing educational facilities), which may, to some extent, improve the environment in informal settlements. Yet there is no consideration given to climate change adaptation for integrating measures to build resilience into urban settlements and governance.

In response to climate-related impacts, in 2005 the government of Bangladesh prepared a National Adaptation Programme of Action (NAPA). This focused on reducing poverty and securing livelihoods while also addressing gender aspects in the implementation of NAPA recommendations. The NAPA also emphasized engaging diverse stakeholders, including policy makers, research organizations and academics, and drawing on the local knowledge of residents. The cross-linkages between different development sectors were prioritized to integrate comprehensive goals such as water management for crop production, sustainable livelihoods for achieving poverty reduction, and improving structural and non-structural measures for adapting to climate change.

Ahammad (2011) confirmed that, to implement the adaptation policy with its set goals, a list of projects was selected. “Enhancing Resilience of Urban Infrastructure and Industries to Impacts of Climate Change” is the only one of these projects proposed for urban adaptation. But no special provision for urban poor communities was mentioned in either the Bangladesh NAPA or the recently prepared Bangladesh Climate Change Strategy Action Plan (BCCSAP). Indeed, no explanation has been given of how to address climate change adaptation in ways that benefit urban poor groups in Chittagong.

Success in climate change adaptation depends on urban infrastructure development and thus on the capacity of urban government departments. But government agencies in Chittagong have very limited budgets and also lack the logistical support and skilled staff necessary to address adaptation. These agencies are also unaware of how climate-related risks are likely to impact the city, and they have given little consideration to the need for integrated action across all sectors for adaptation. In addition, the high risks that such a large proportion of the low-income population faces from extreme weather events have been largely ignored in the national policy implementation process and are thus missed in the NAPA. National development programmes such as cash-for-work projects for low-income groups are not undertaken in urban areas.

This is partly the result of a lack of any strong commitment by national policy makers to address urban poverty, and included in this is any concern to reduce climate-related risks.

Even if local government agencies have some slum improvement programmes, in Chittagong these are not integrated with adaptation.

#### **5.4 Land Use Pattern and Urbanization**

Urbanization is accompanied by increasingly larger-scale urban spatial expansion as cities and towns swell and grow outwards in order to accommodate population increases. Urban expansion alters the natural landscape, land uses and land cover, for example by changing water flows and increasing impermeable areas, thereby adding to the flood hazard problems, water logging, soil saturation induced landslide (Satterthwaite 2011). In the mid-1970s, when urbanization was just starting to accelerate, a study by Hollis (1975) showed that the occurrence of small floods might increase up to 10 times with rapid urbanization, whilst more severe floods, with return periods 100 years or over, might double in size if 30 percent of roads were paved.

The changes in land use associated with urbanization affect soil conditions and the nature of run-off in an area. Increased development of impermeable surfaces leads to enhanced overland flow and reduced infiltration. It also affects the natural storage of water and causes modification of run-off streams (Wheater and Evans 2009). Urban centers also change the local environment by reducing rainfall and increasing night-time temperatures. Urban micro-climates, especially urban heat islands caused by lack of vegetation, can modify the hydrology of an area.

Though Bangladesh is going through rapid urbanization from a long period of time, prior to 1953, urban planning in Bangladesh was developed without taking environmental considerations into account. The Town Improvement Act was first promulgated in 1953 to regulate land development in urban areas, (Begum 2007) but only provided policy guidelines for municipal authorities to execute land use control and a building plan. It was the responsibility of the respective municipalities to develop these – and municipal authorities did not address the growing and emerging range of risks from land use patterns within the growing and expanding cities. Any measures to address these issues were constrained by the lack of legal frameworks for regulating urban land use – and so informal settlements grew rapidly with little or no provision to address climate-related risks (Islam 1994). The risk of landslides is one of the consequences of this inability to manage urban expansion.

To some extent, the adaptation capacity of low-income groups in Chittagong is linked to the quality of their housing and the sites on which it is located. Most available land for housing is either owned by government agencies or is privately owned, and is developed by housing companies. In the city's current detailed area plan, the selection of suitable land sites for low-income communities has been identified as an important policy issue. The aim of the policy is to make the allocation of houses and jobs to lower- and middle-income groups more equitable. It recommends that new sites be developed by government and the private sector for relocation and that provision be made for a range of unit sizes that are accessible to low-income groups. However, the role of urban government organizations in implementing these measures is not clear at the moment.

Urban government departments lack the capacity to take any initiative towards providing safe and well-located sites for relocating communities at risk. But they have also not engaged these communities in developing their capacity. Local government agencies have not yet undertaken any survey to identify the target people for relocation, or considered key issues relating to the incomes and livelihoods of the poorest groups or their housing needs. Consequently, the risks facing the urban poor in their homes and neighborhoods remain unattended by any government agency.

Measures to reduce climate-related risks need to be integrated into urban planning. In this regard, urban stakeholders, including government departments, private sector organizations and individuals, have particular roles for ensuring compliance with land use policy, so that landslide risks are addressed when housing structures are built on hillsides. Different studies recommend incorporating adaptation measures within existing planned urban development and through provision of safe housing for low-income groups; also improved infrastructure, including drainage channels and a sewerage system. In other cities in Asia, there are examples of urban governments that have built partnerships with community-based organizations formed by residents of "slums" or informal settlements to reduce disaster risk. These include organizing relocation for vulnerable groups and involving them in designing their houses, thereby strengthening formal and informal institutional networks and reducing disaster risk.

**CHAPTER 06:**  
**RECOMMENDATION**

## **6.1 Planning Measure**

Every year during the monsoon, occurrence of landslide is common in Chittagong City, Bangladesh. These landslides cause closure to roads, affect settlements and worse cause casualties. The potential economic loss and loss of life could escalate if the causes of landslides of Chittagong are not identified and addressed properly by all parties, stake holders especially by the government, planners, contractors, engineers and developers directly or indirectly involved in the development of buildings and roads over the hilly terrain. Development and construction on slopes are inevitable in hill slopes as a small country like Bangladesh develops and flat land becomes scarce. In situations where landslides occur, immediate risk reduction, emergency response and repairs are required. There are different approaches of dealing landslides depending on needs, risks and available funds.

The selection of appropriate mitigation measure should be based on assessment of risk, uncertainty, possible consequences, constructability, environmental impacts and costs. A final enhancement approach usually consists of a creative combination of several methods. Environmental constraints and requirements can influence the selection and overall design of mitigation measures. When selecting a specific mitigation and stabilization method, it is best to keep it simple to match the capabilities of contractors and availability of materials. Constructability and construction requirements should be evaluated, including sequencing, temporary support and protection of nearby property, facilities, utilities, traffic and the public.

The maintenance requirements associated with each risk lessening option should be considered to understand the potential long-term impacts and costs. This includes identifying procedures, equipment, frequency and level of effort that would be required for maintenance and the consequences when such maintenance is not performed. Another consideration is to evaluate whether the mitigation measure will experience a reduction in effectiveness over time due to potential damage, weakening, plugging, and vandalism or due to indirect effects of nearby development and activities.

## **6.2 Considerations**

Motijharna- Batali Hill informal settlement is a populous hill slope & foot hill settlement, severely affected by landslides of 2007, 2011, 2012. Landslide mitigation works are needed to be conducted in order to stop or reduce the landslide movement so that the



resulting damages can be minimized. With a clear understanding of the causes and mechanics of the landslide of the study area, the landslide control works can be implemented. For this a number of issues are considered:

### **6.2.1 Informal Settlers**

Over the last few years, low income people occupied unused railway owned hills illegally and built Motijharna- Batali Hill informal settlement in Chittagong City. It is one of the dense informal settlements of Chittagong city. It is the biggest amongst all the informal settlements and situated at the center of the city. The informal settlers mainly work at nearby places and live here in cheap rate. Though the area was severely damaged by landslide of 2007 and 2012, none of the inhabitants want to leave this place. Their livelihood is deeply rooted with this location and feels threatened when ever government wanted to relocate them. While designing the mitigation measure this issue has been seriously considered and the proposal prepared for immediate risk reduction needs least eviction and relocation.

Motijharna informal settlement is oldest of all the informal settlement and is badly reputed to be the shelter home of anti-social activists. Introvert nature of the settlement induces this type of activity more. Providing a community space and making the space open to all sorts of people may reduce this type of activities. Law makers and protectors may ensure the security of the inhabitants and also the outsider beneficiaries.

### **6.2.2 Inadequate Basic Facilities**

As informal settlements are considered ‘illegal’, populations who live in these settlements often have no official addresses and are commonly denied basic rights and entitlements, including the right to access water, sanitation, healthcare services, and education. During the study, it is found that neither Batali Hill nor Motijharna informal settlements have access to these basic services. Even after the disastrous event of 2007, none of the settlements have been included in the “Detail Area Plan”. This made the inhabitants more vulnerable to landslides. As a design consideration it’s been kept in mind to provide at least some of the basic facilities along with the mitigation measure to make it a part of the community. This consideration will lead to a well maintained strategic design measure where government or local authority will not be needed to maintain the structure but supervise.

### **6.2.3 Degraded Environment**

Batali hill and Motirjharna used to be a place of scenic beauty and once one of the major sources of water before piped water was introduced in Chittagong city. Because of unplanned growth of the informal settlement and unsustainable land use pattern both of the places degraded environmentally. A comprehensive designed measure must ensure a balance between man and nature and ruptured hill ecosystem has been considered as a major factor while designing the planning measure.

### **6.3 Strategic Design**

By linking the findings in the light of research questions and relevant literatures, the risk reduction arrangements like adjustment and relocation has been found out to be incompetent to reduce landslide vulnerability of the informal settlers of Chittagong city. After considering and analyzing all the factors, an immediate mitigation measure is proposed on the basis of risk assessment, uncertainty, constructability, environmental impacts, communal use and cost. The final strategic design approach is a creative combination of several methods. The landslide mitigation works are broadly classified into two categories:

- Control works
- Restraint works

The control works involve modifications of the natural conditions of landslides such as topography, geology, ground water, and other conditions that indirectly control portions of the entire landslide movement. The restraint works rely directly on the construction of structural elements.

Core idea of the mitigation measure is to reduce risk of the affected informal settlement without eviction of the settlers by incorporating both control and restrain works. In the design proposal, a new foot hill is proposed below ground level which will hold maximum amount of landslide debris, an elevated green belt will serve as a buffer for the informal settlement, and the road beside the green will give an easy access to the settlement during post disaster rescue work.

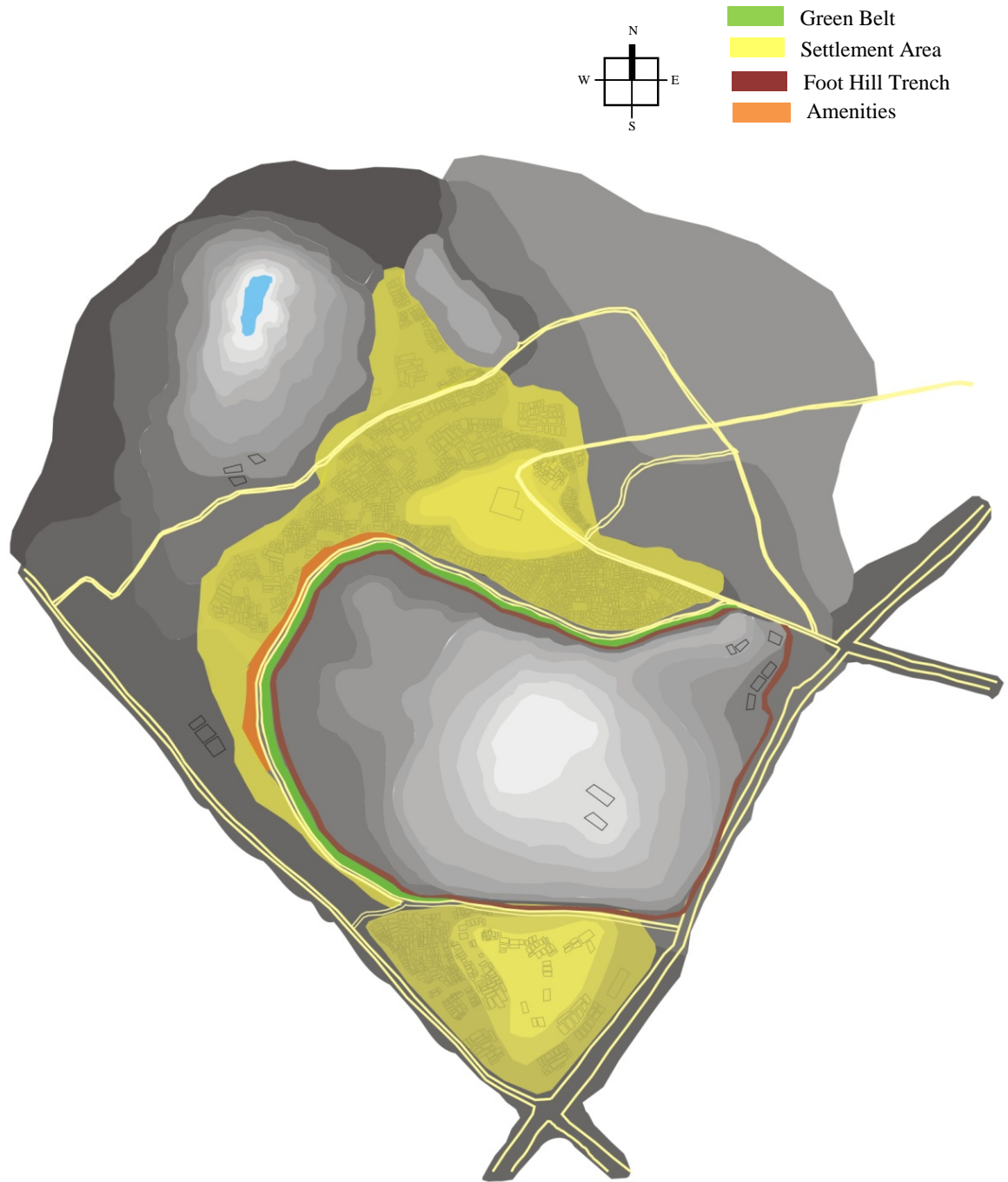


Fig: 6.1 Zoning of strategic design measure

Source: Author, 2013

As hill types and level of damage varies from each other, two types of strategic design in proposed. One is for the hills which have an intact or are little modified foot hill and another one for those which have went through massive hill cutting. In case of intact hill

toe, a drain trench is proposed which will elongate hill slope down ward and hold landslide debris during disaster. On the other hand, in a deformed hill toe, part of the hill will be retained with proper structural measure and then the trench will be placed. In this case, immediate flat land of the restored part will be restricted for any type of human intervention but afforestation.

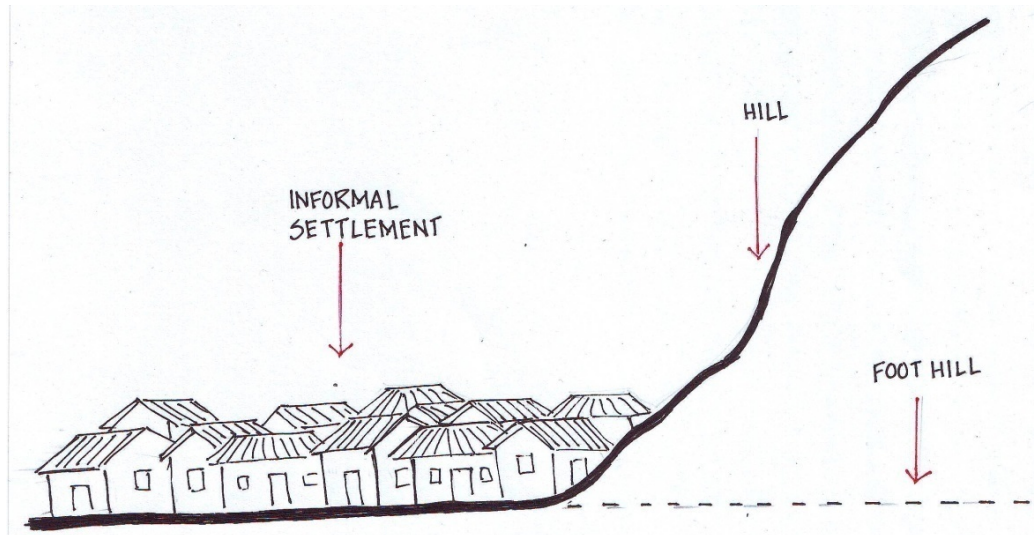


Fig: 6.2 Existing condition of intact or little modified hill  
Source: Author, 2013

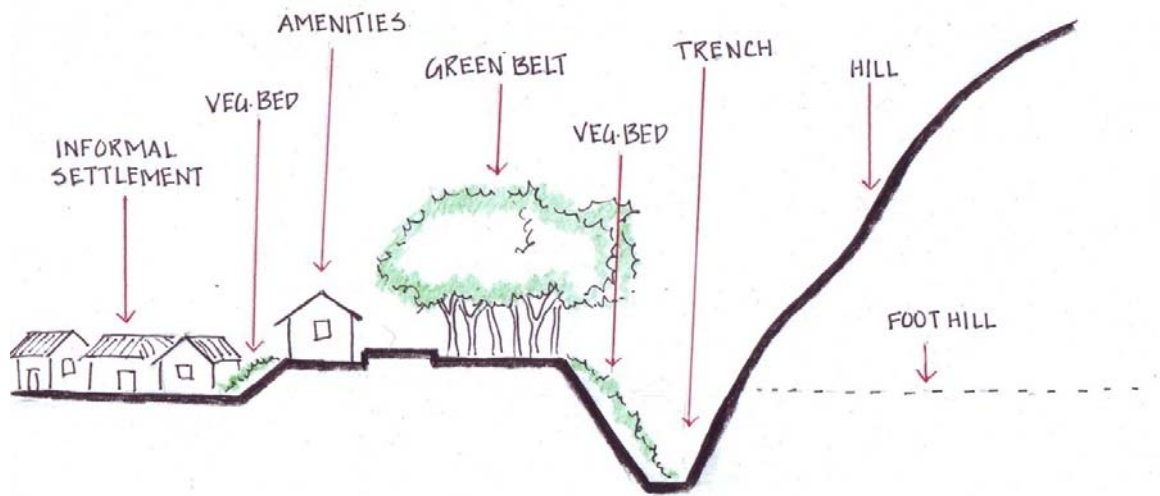


Fig: 6.3 Strategic design for intact or little modified hill  
Source: Author, 2013

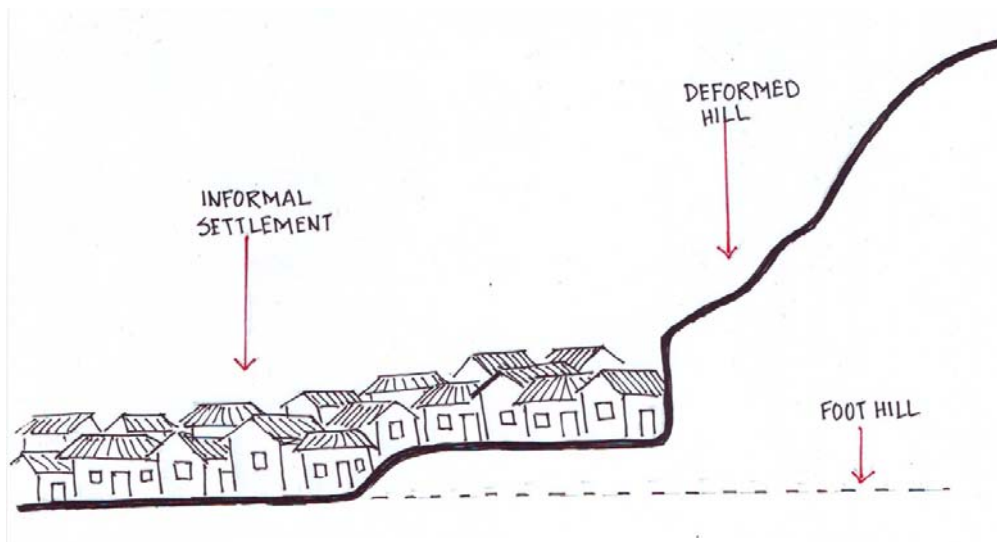


Fig: 6.4 Existing condition of deformed hill  
 Source: Author, 2013

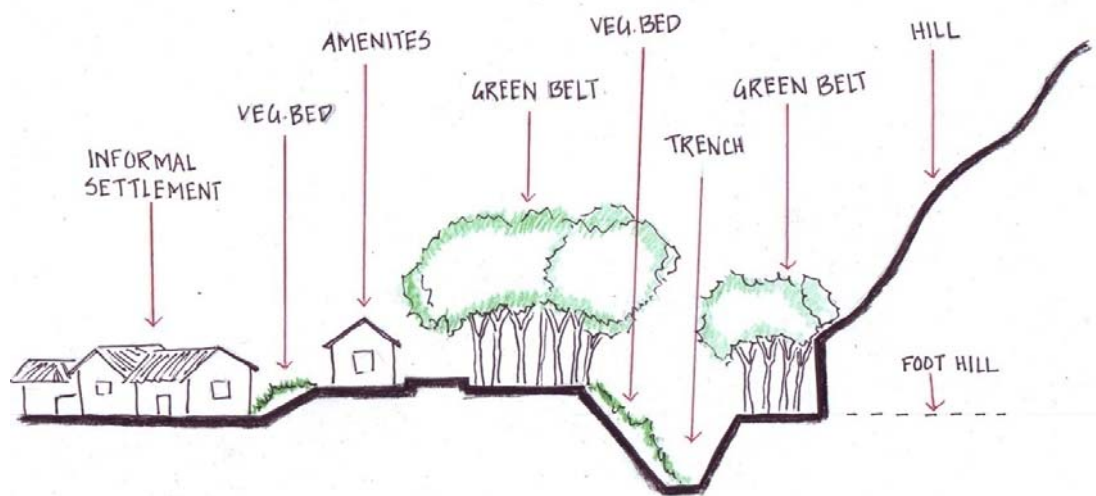


Fig: 6.5 Strategic design for deformed hill  
 Source: Author

As mentioned earlier, soil properties of Chittagong City hills are easily susceptible to water and controlling water seepage to ground is an integral part of the design. For this, basic control work is proposed to be done by surface water drainage system. The surface drainage control works are implemented to control the movement of landslides accomplished by infiltration of rain water. The surface drainage control work will consist of 2 major works: drainage collection works and drainage channel works. The drainage collection works will collect surface flows and connect directly with the drainage channel.

The drainage channels works are designed to remove the collected water out of the landslide zone as quickly as possible. At the bottom of the hill a trench drain is designed, which will collect all the water disposed by the surface drainage control works. After a certain period of time, when the collected water will attain a maximum height, the water will be delivered to some of the water wells posted within the settlement. This will help the informal settlers to reduce their dependency on piped water and they can do their daily chores like, washing, bathing etc with this water.

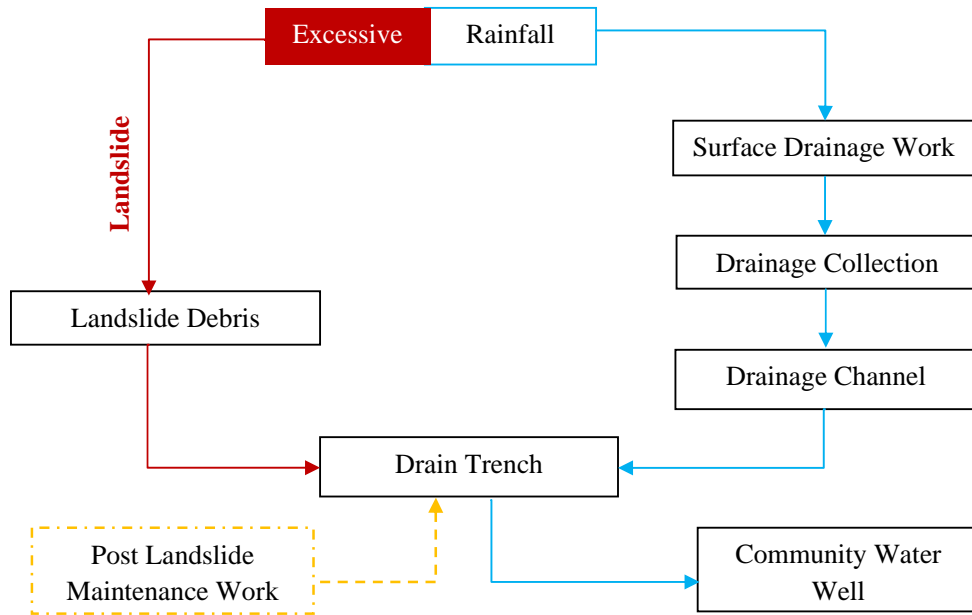


Fig: 6.6 Mechanism of the proposed risk reduction measure  
Source: Author, 2013

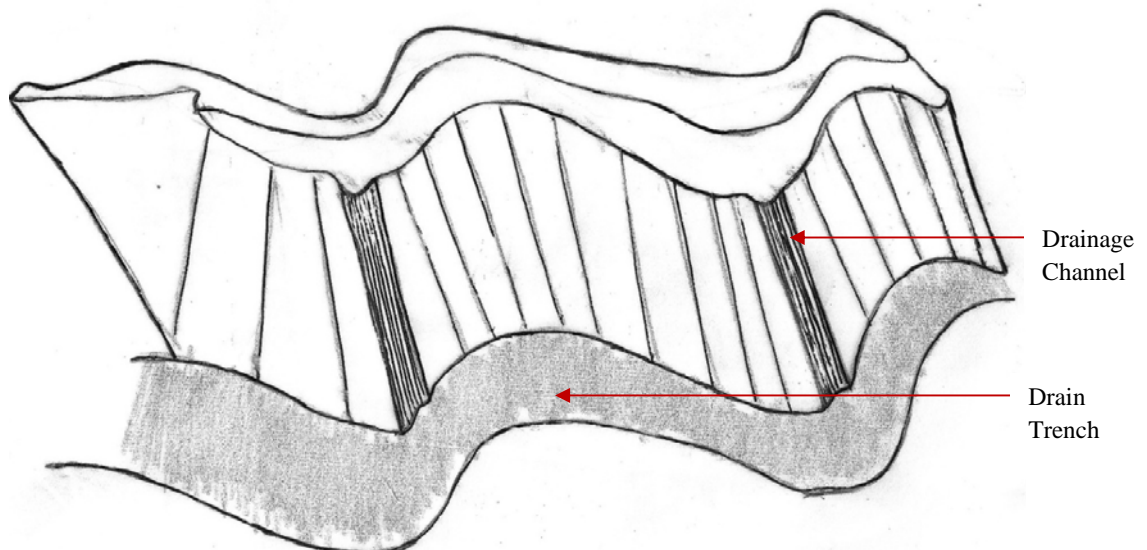


Fig: 6.7 Proposed Control Works  
Source: Author, 2013

On the other hand during the time of landslide, the trench will hold the maximum amount of landslide debris and reduce the risk of the foot hill informal settlement. Collecting mud and other debris is not enough to reduce the risk of such density informal settlement. A thick layer of green around the drain trench will work as a buffer. Closely planted trees will create a natural wall and keep the informal settlement least vulnerable to landslide.

It's been observed from previous landslide incidences that post-disaster rescue works were delayed and hampered because of less accessibility to the affected area. A road is proposed running along the "Green Belt" connecting two of the main roads; Ambagan Road & Tiger Pass Road at Lalkhan Bazar circle. Some amenities for the settlement are proposed to be placed on the elevated part to serve the entire settlement. Some restrain work will be done by building a retaining wall from the base of Batali Hill foot hill trench. For this type of restrain work, crib walls are recommended as they are largely used around the world instead of conventional reinforced concrete retaining walls.

The whole idea is to keep the informal settlement safe from the landslide disaster in multiple layers of planning measures. Different layers provide different services to the informal settlement around the year and during disaster not only reduce the risk of being directly exposed to the hazard, but also ease the rescue work if needed.

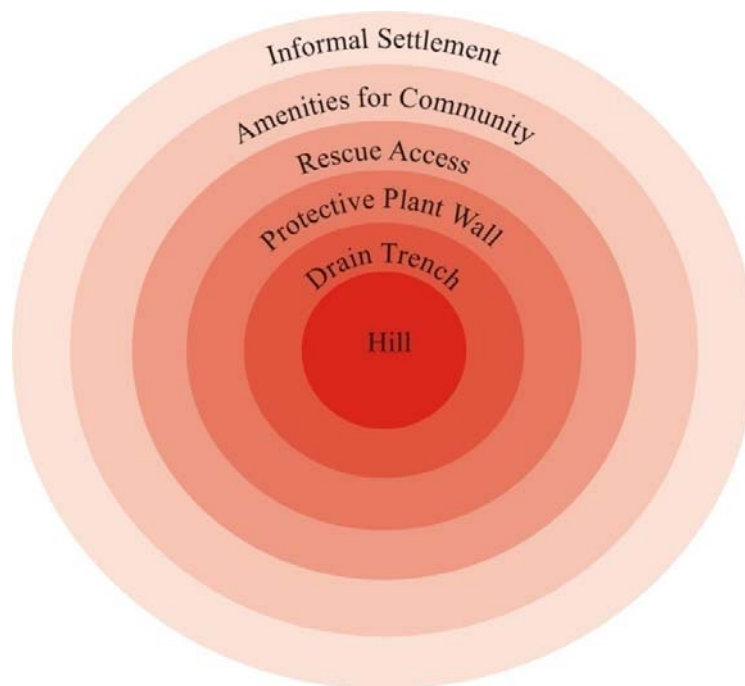


Fig: 6.8 Layers of measures keeping the settlement safe  
Source: Author, 2013

During landslide, the trench works as the first layer of protection. It holds most of the landslide debris. If a massive landslide takes place and the drain trench over flows, the thick layer of trees will work as a wall. It will reduce the speed and most of the debris will get trapped within the green belt. Layers of the connecting road and amenities will provide extra protection. As the proposed design is kept simple in terms of planning and technology, it is easily understandable to the local people. They will enthusiastically participate in the construction and restoration process.



Fig: 6.9 Landslide risk in existing condition  
Source: Author, 2013

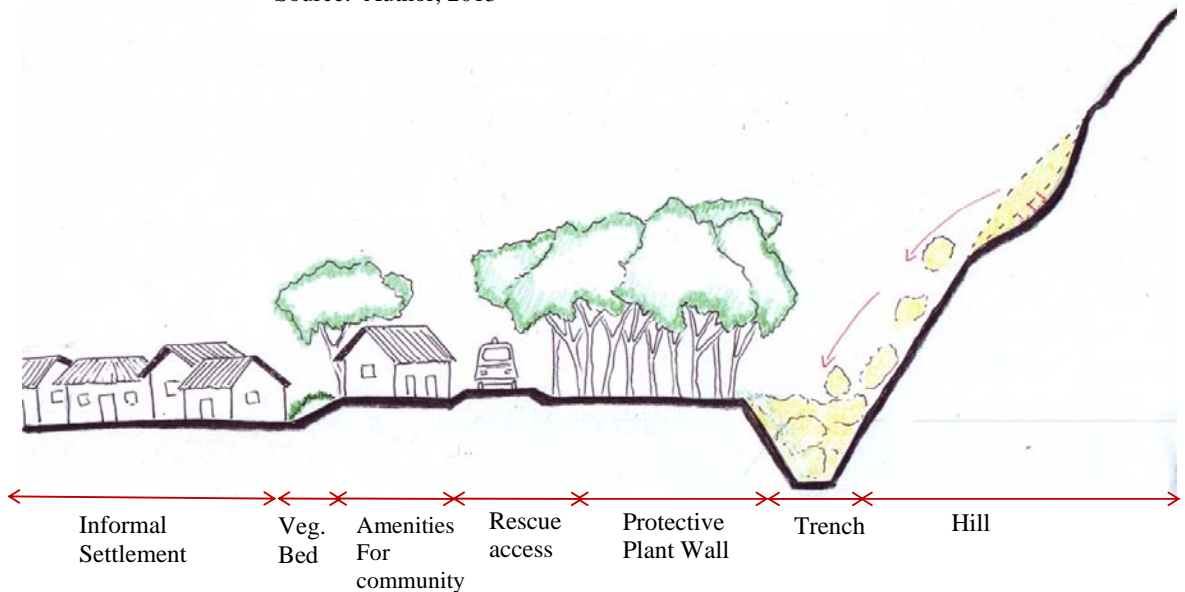


Fig: 6.10 Proposed design reducing landslide risk  
Source: Author, 2013



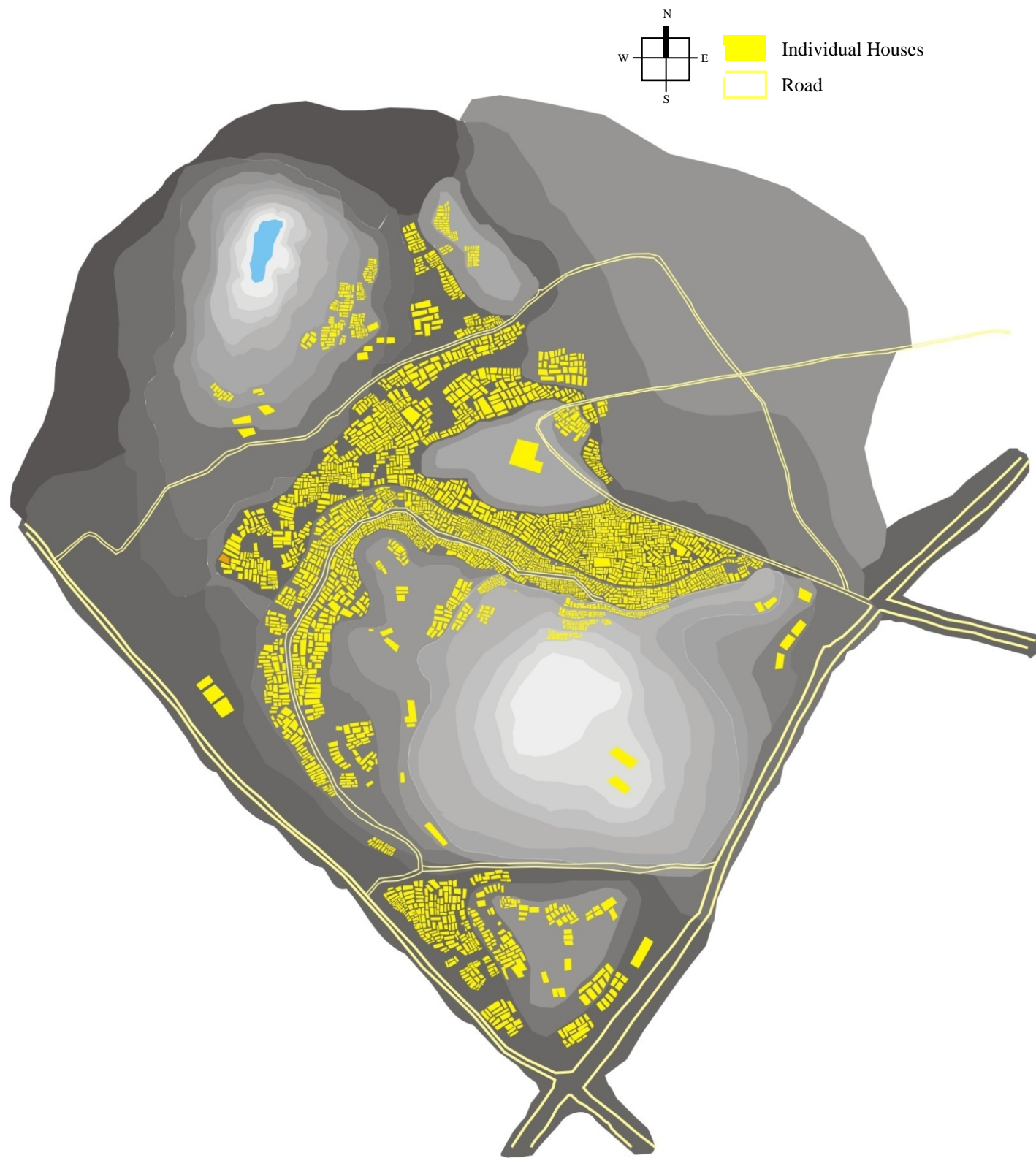


Fig: 6.11 Existing situation  
Source: Author, 2013

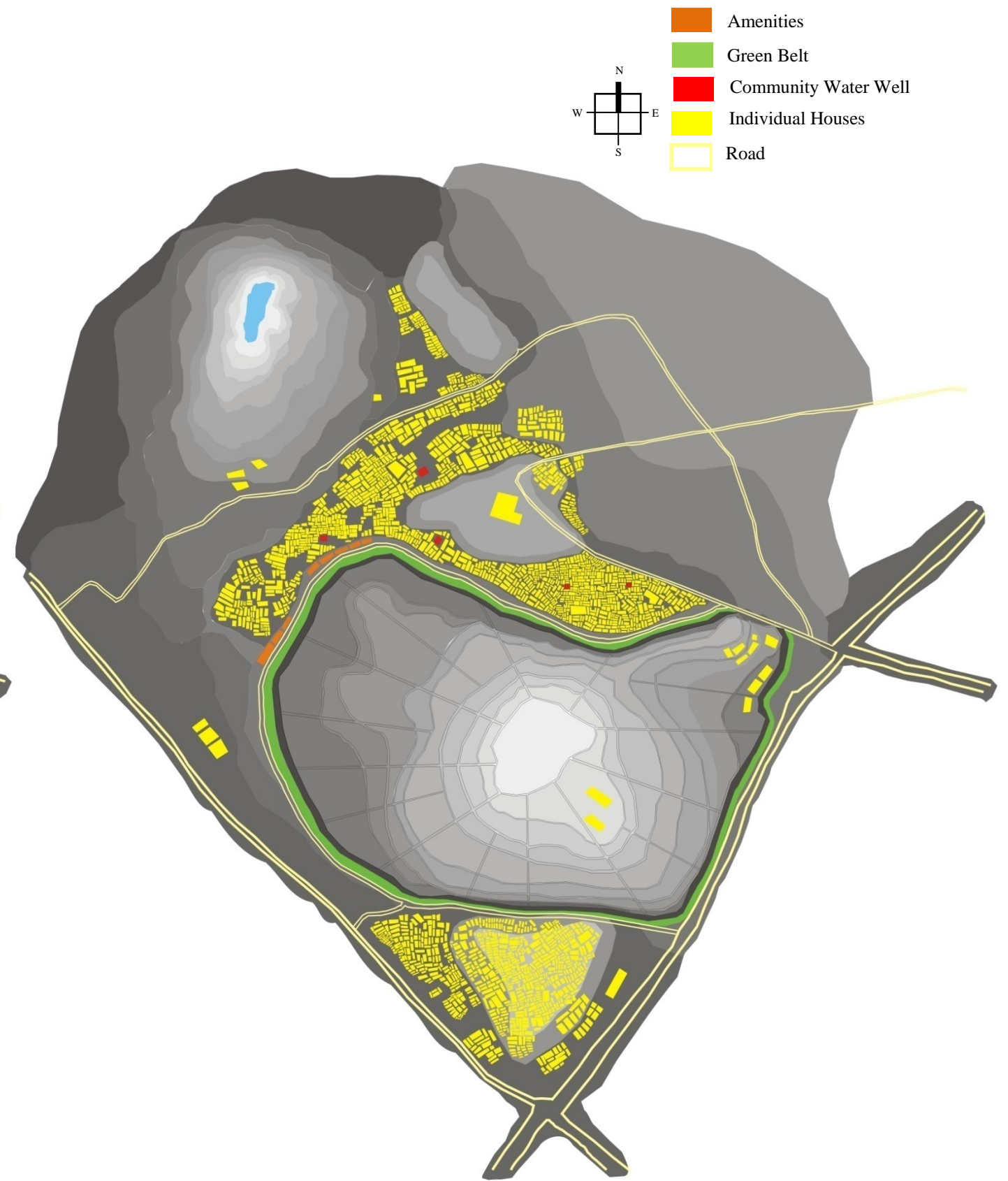


Fig: 6.12 Proposed Strategic Design  
Source: Author, 2013

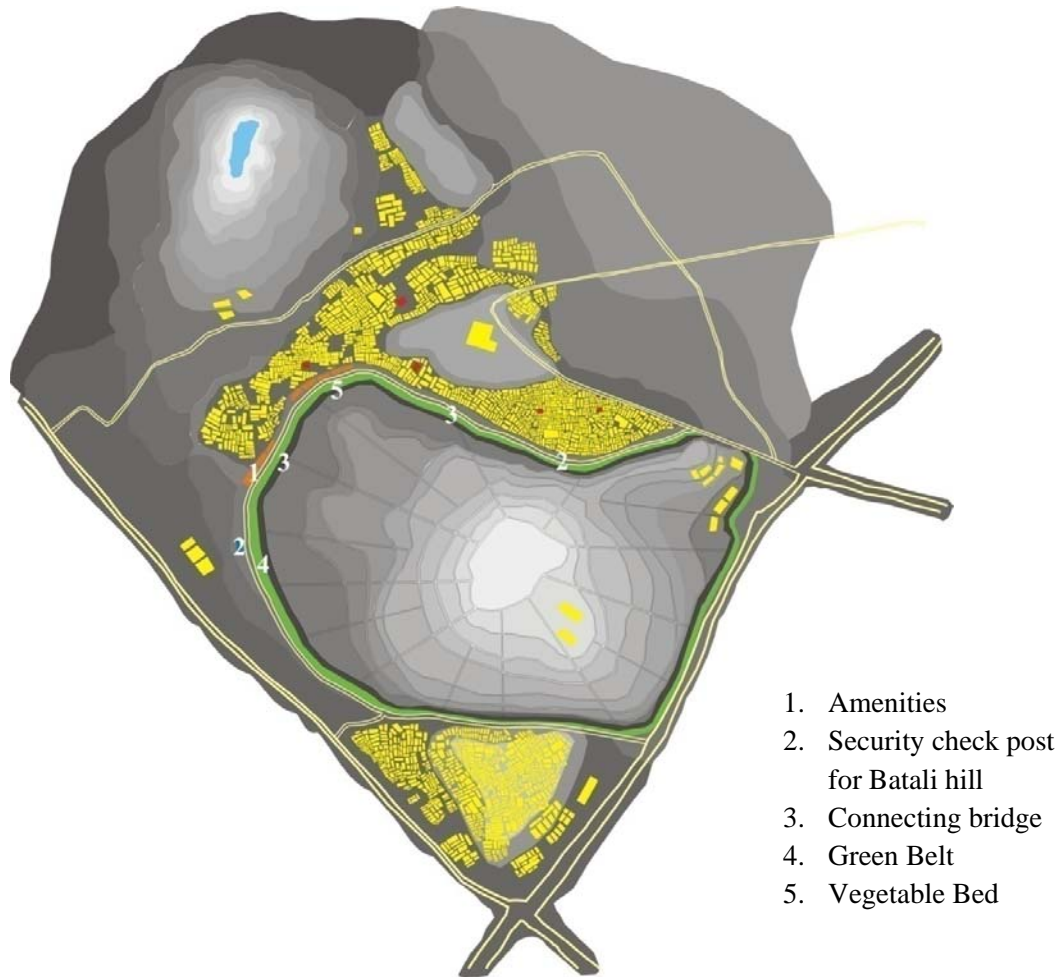


Fig: 6.13 Activities around proposed measure  
 Source: Author, 2013



Fig: 6.14 Multiple use of risk reduction design  
 Source: Author, 2013

### 6.3.1 Moving to Comparatively Safe Place within the Site

To keep the informal settlers safe from landslide risks, moving some of the houses is essential. From the study, the houses built on the hill slopes are identified as the most vulnerable. These houses face the first blow of a landslide. In last few landslides it's been observed that, soil usually shifts near to the steep slopes which are cut to construct human settlements. During disaster houses on hill slopes lose their ground and add up with the landslide debris and cause more damages to the foothill settlement.



Fig: 6.15 During disaster condition

Source: Author, 2013

Relocation of the informal settlement from the hill slope is the least preferred option by both informal settlers and author. At the same time, providing safety to them is important. For this, almost flattened part of Batali Hill which is now separated from the main hill is selected to move the informal settlers. This part is comparatively safe from the hill slope and with proper safety measures settlers will be able to live without landslide risk.

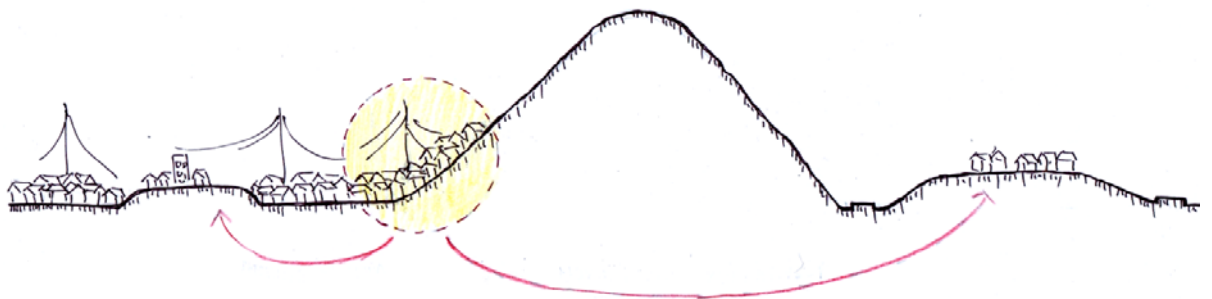


Fig: 6.16 Moving to comparatively safe place

Source: Author, 2013

### 6.3.2 Restoration of Batali Hill

The Batali Hill is the highest hill within the Chittagong Metropolitan area. The hill is about 280 feet high. From the peak of the Batali Hill one can have a clear bird's eye view of the city. Aperture of the river Karnafuli, a comprehensive portion of the Bay of Bengal, Jetties of the Chittagong Sea port and a large portion of the city can be seen.

Due to unplanned hill cutting and unsustainable land use Batali Hill has lost its scenic beauty. To bring back its glorious past, restoration of hill ecosystem is proposed. The proposal consists of proper afforestation program by understanding local soil characteristics and plants suitable for the area. Reintroduction of local flora and fauna to the hill will help to retrieve the lost bio-diversity and balance the ecosystem. Some urban facilities like; walkway, jogging track, watch tower etc. will bring a balance between men and nature. By these facilities, Motijharna- Batalihill informal settlement community may come out of their introvert nature and blend with the rest of the city dwellers. Anti-social activities of the community may also come to an end with this.



Fig: 6.17 Harmonious coherence of men & nature  
Source: [www.google.com](http://www.google.com)

### **6.3.3 Community Water Well**

Traditional housing areas of Bangladesh contain religious structures, sitting platforms, stairs, water bodies, arcades and entry gates. These public structures – as opposed to private house extensions- play an important role in establishing neighborhood identity and are important landmarks and visual reference points (How the other half builds, vol. 01).

In the studied area, it's been observed that, though the human settlement is successful as individual houses, but often exhibits a high degree of ingenuity and lacks many of the environmental qualities that are essential for a successful housing environment. Almost absent public spaces are disorienting and lack personal definition. The planning is barrack-like; streets are nothing but simple movement spaces. Need of public spaces was felt throughout the settlement area. Introvert nature of the community and reputation of wrong doers is also a result of less communication amongst themselves and with the outsiders.

At this point, it could be argued that in a “basic shelter” like Motijharna- Batali Hill informal settlement, anything more would be a luxury and would, in any case not be required by the low-income users. Though traditional public structures are absent in the study area, but there are other signs of attempts to introduce identity into the public environment. In the proposed planed measure, an effort has been given to extend the minimum attempt of the settlers by introducing community wells.

According to Charles Correa, in Indian Sub-continent a human settlement needs four major elements and amongst them a neighborhood meeting place is third. It is the place which human beings need beside their own private cell and door steps. In our condition a neighborhood meeting place is where one becomes part of the community. For centuries sources of water has served this purpose and in the proposal same provision is attempted to reintroduce.

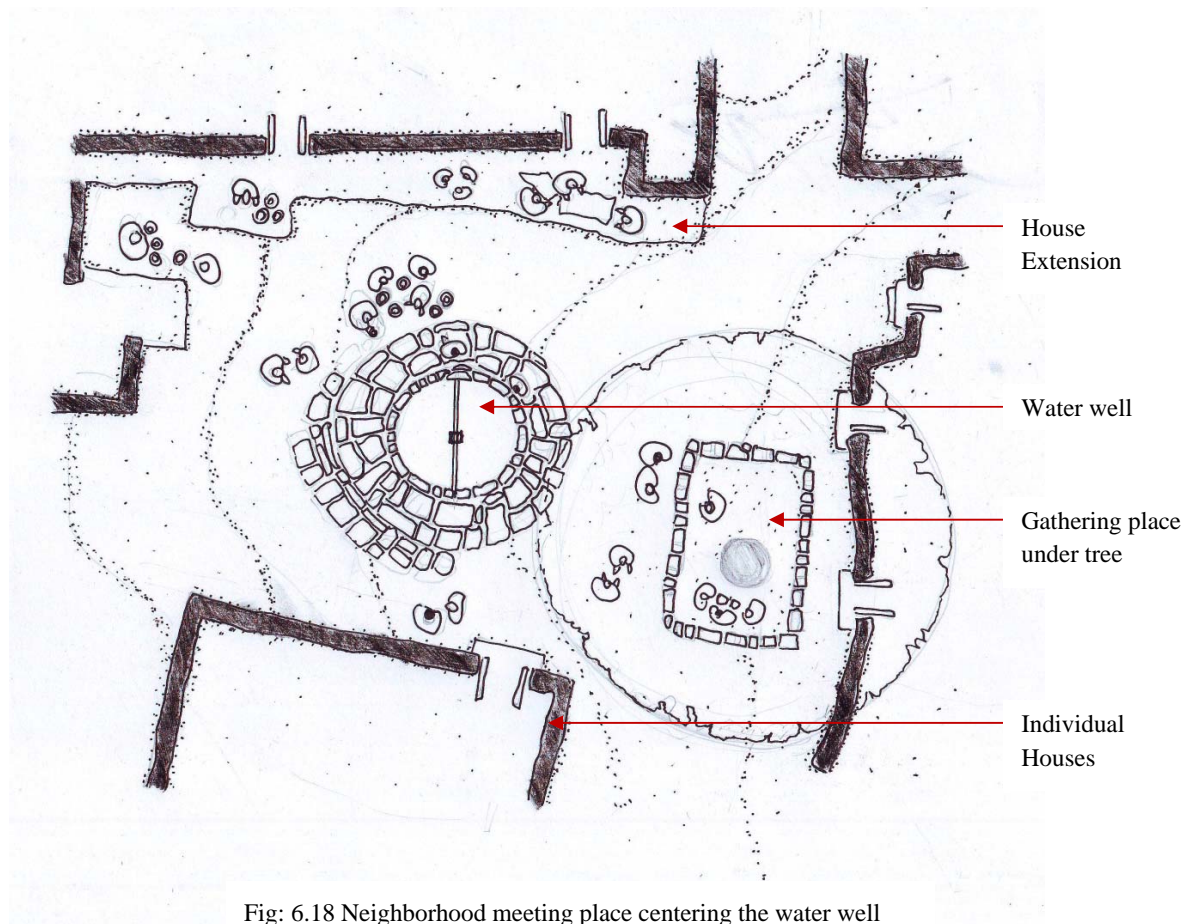


Fig: 6.18 Neighborhood meeting place centering the water well  
 Source: Author, 2013

Inhabitants of the informal settlement do not have any legal water supply system and suffers from water scarcity round the year. To reduce their suffering, idea of community well has been proposed which will be filled with the water collected from the surface runoff of the hill. During monsoon, precipitation rate of Chittagong is very high. At that time the surface drainage collection and control works will collect maximum amount of rain water and pass to drain trench. The drain trench will collect water and after attaining a certain amount, water will be distributed to the community wells through underground pipes. This water will serve the community people to do their everyday works like bathing, washing etc. After supplying water wells the excess water will be drained off from the trench. This will limit water saturation of the trench soil. During monsoon and excessive rain fall, excess water from the wells will go direct to the city's storm water collection drain. By this the informal settlement will be saved from the risk of flash flood.

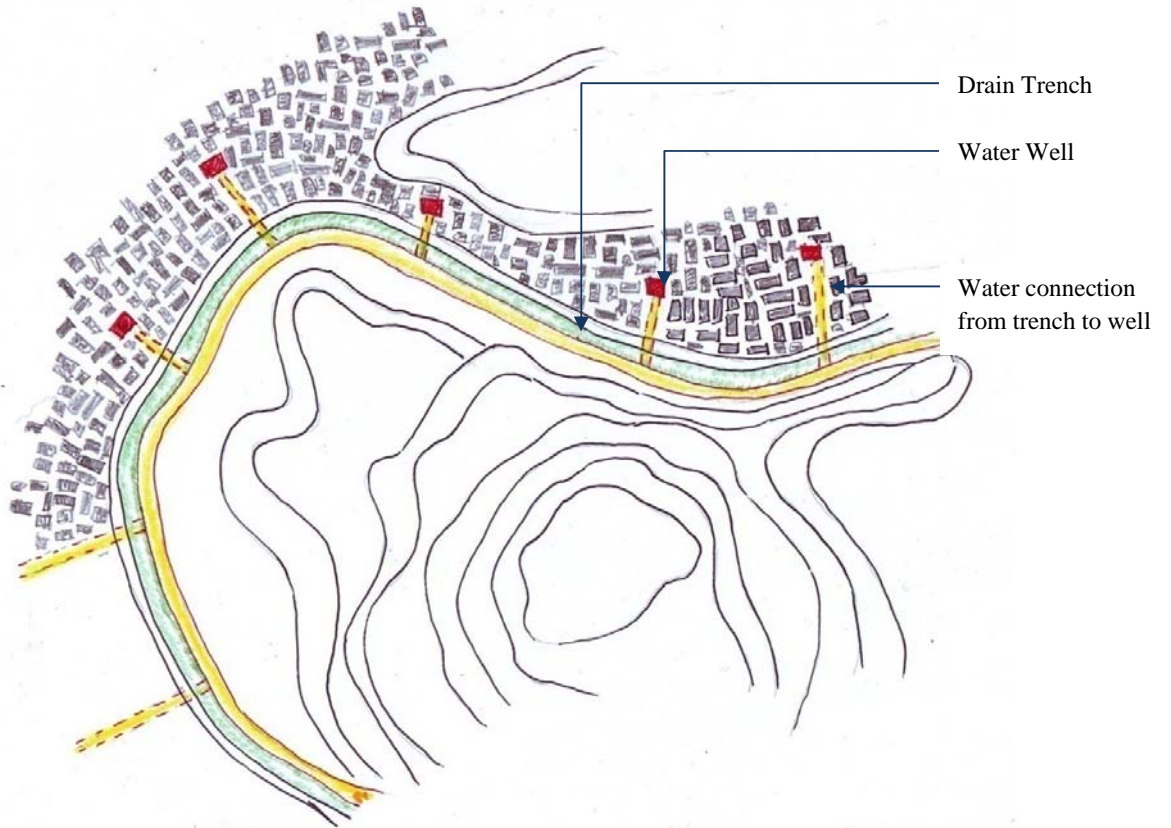


Fig: 6.19 Connection between drain trench and community well  
 Source: Author, 2013

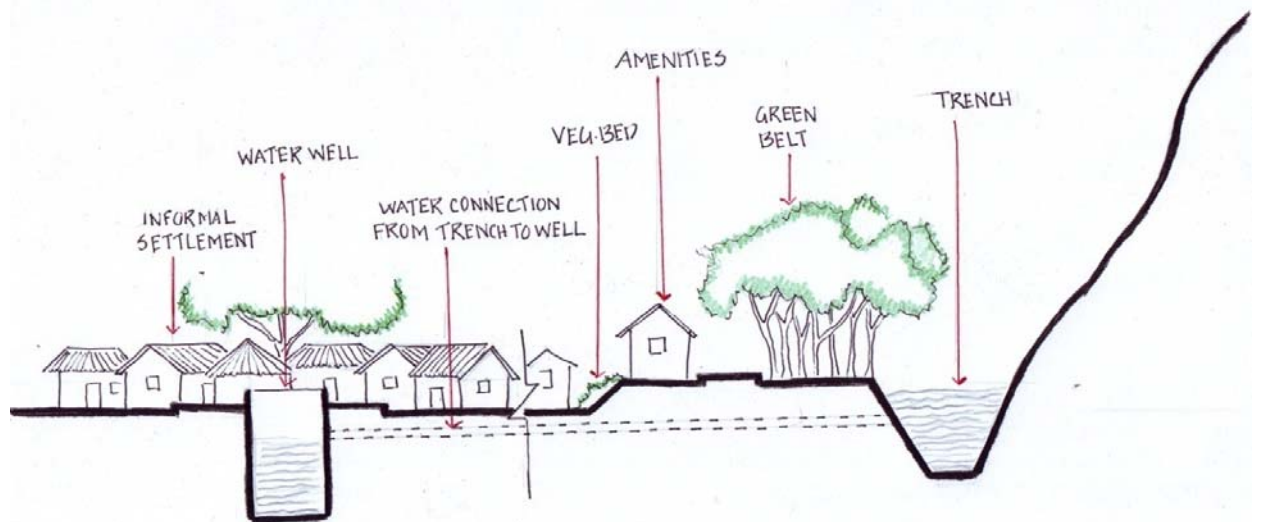


Fig: 6.20 Flow of water from drain trench to community well  
 Source: Author, 2013

## **6.4 Maintenance**

Maintenance is a vital part of any successful mitigation measure. Landslides occur during monsoon in Bangladesh and take place once in a year. For this, proper maintenance is needed to keep the measure workable when needed. In existing mitigation measures, lack of maintenance is found. This is caused because of the weak connection and co-ordination between local level authorities. Other case studies show that, maintaining risk reduction measures in developing countries is a big challenge. It costs a lot, as the government has to appoint a group of people to monitor and keep measures workable on regular basis.

Though there is no “public authority” in Motijharna-Batali Hill informal settlement, maintaining landslide mitigation measure will not be a tough job, because the proposed measure is designed in way to become a communal property. Several issues regarding workability and safeguarding are kept in mind while suggesting the strategic design.

### **6.4.1 Visibility**

Apparently the role of clear vigilance of a space may not be recognized in maintenance work, but is deeply rooted in inventive policies on human psychology. A dented, disused place is often found to lack clear visibility from roads, human settlements and other principal urban spaces. People tend to impair and desolate a space when it's out of sight of the mass population. This leads to poor maintenance and eventually that space loses its workability. In a landslide mitigation measure, keeping it functional and well conserved is the utmost important part.

Usually clearly perceptible places get more public attention and chances of abundance and derelict are low. In the proposed measure visibility is ensured. As the settlement is developed in a haphazard manner, it may require relocation of some of the houses to ensure a clear view of the trench and adjacent area from the settlement. For being a communal property, informal settlers themselves can decide which of the houses to relocate and provide clear vigilance from the settlement. This will also help to create pocket spaces throughout the area and settlers will get more breathing places.





Fig: 6.21 Visibility from the informal settlement  
 Source: Author, 2013

The drain trench and green belt is easily noticeable from the surrounding roads; Tiger pass road, Ambagan Road, Motijharna lane and High level road. From the contours of Batali hill the entire measure is visible effortlessly.

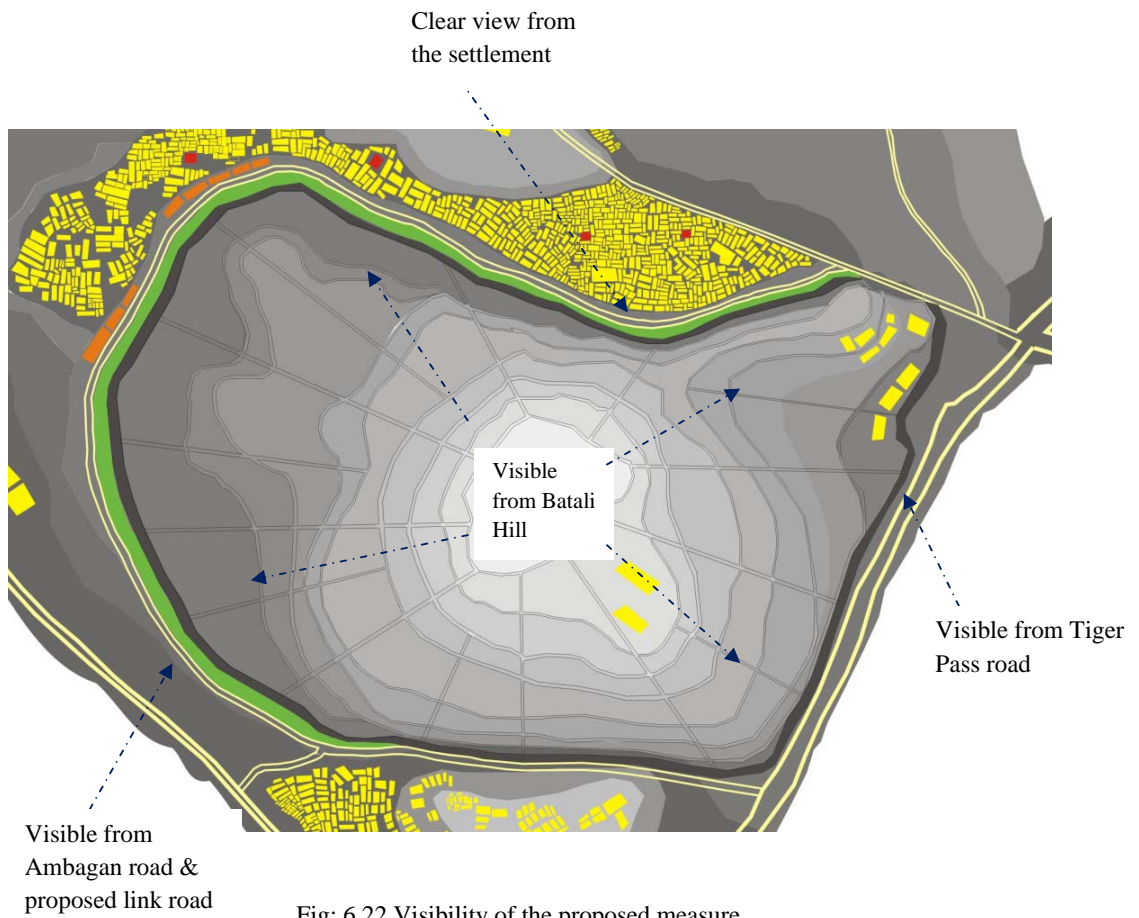


Fig: 6.22 Visibility of the proposed measure  
 Source: Author, 2013

### **6.4.2 Accessibility**

Easy access is required to repair any measure in post and pre disaster condition. Regular cleansing and safeguarding also needs clear access. These are well thought-out in the proposed measure. The drain trench and surface drainage works are easily reachable from surrounding roads and Batali hill itself. For any type of maintenance work, informal settlers can use all of the four roads; Tiger Pass road, Motijharna road, Tiger Pass-Ambagan link road and proposed Ambagan-Motijharna link road. Finding any damage and repairing it at soonest possible time will be ensured by these easy ways in. As Batali hill is proposed to be restored and attract a good number of nature lovers, any unnatural congestion, damage or crack in the surface drainage work will be noticed and traced easily. This will make the maintenance work and post-disaster rescue work done at ease. Because of easy mechanism, informal settlers can maintain the design measure of their own without any official training.

### **6.4.3 Communal Property**

Maintenance work becomes easy and effective when the introduced measure becomes an integral part of the served community. In the planned measure, it not only works as a risk reduction system but also serves the community almost throughout the year. As the entire drainage system and the trench holds water for a long period of time and supplies to the water wells which partially fulfills the demand of water, the informal settlers will welcome the new measure whole heartedly.

As the inhabitants of the informal settlement do not have any legal water supply system and suffers from water scarcity round the year, they will also try to understand the means and mechanism of preservation work enthusiastically. If the settlers do not keep the drain trench and connecting drain channels clean they will not get the extra facility of getting water from the water wells. The benefit of getting a secondary source of water followed by a neighborhood meeting place along with landslide mitigation measure will encourage the informal settlers to maintain those. Supervision from the local disaster management will be needed to ensure absolute safety from landslide disaster.

**CHAPTER 07:**  
**CONCLUSION**

## 7.1 Conclusion

Chittagong, a developing city of Bangladesh is associated with natural disasters, mostly climate change induced, which have a substantial impact on the residents of the informal settlements. By now excessive rain fall, a outcome of climate change has increased the already high levels of risk of landslides and water logging in informal settlements in Chittagong. Despite a disaster management committee working in the city on disaster risk reduction, there is little coordination amongst government agencies and little support from these agencies for community level actions. In Chittagong, urban government agencies lack adequate climate-related information, so have yet to assess risk levels and possible adaptation options that serve those most at risk (including those living in informal settlements). To some extent, formal governance structures and the lack of provision for participation by vulnerable poor people in decision-making creates barriers to pre-disaster risk assessment and to develop needed adaptation measures. For informal settlements, this also relates to the lack of specific roles and responsibilities within city government for providing them with infrastructure and services.

The reduction of vulnerability of informal settlers to landslides in Chittagong city largely depends on long-term physical mitigation measures and institutional changes. Current structural adjustment and relocation policies mainly emphasize reducing physical vulnerability of informal settlers to landslides without paying much attention to their needs and social aspects. Therefore, these policies may not reduce vulnerability in real unless land tenure right and livelihoods of informal settlers are well addressed.

Rural-urban migration, social inequality and very weak, ineffective hill management policy shape present informal settlement in Chittagong city. Indeed, institutional change may succeed if past and present social and economic aspects of informal settlers can be integrated into current institutional arrangement, as well as, long-term vulnerability reduction policy. However, due to land tenure conflict between informal settlers and local authorities, weak coordination mechanisms among organizations in the existing framework, institutional change process faces uncertainty in Chittagong city. Nevertheless, implementing current policies like adjustment and relocation requires shared responsibility of diverse actors from the formal institutionalized organizations at the national and local level to other agencies like NGOs and target informal settlers and little or less connections amongst the organizations have left this uncertain.

As this case study shows, formal institutions emerge rapidly with short term responses to reduce vulnerability from landslides in Chittagong city without considering the future threats and needs of the local people. However, this study suggests that these hastily designed policies will not contribute to long-run institutional changes required for landslide vulnerability reduction until concerned agencies and informal settlers perceive the problem and learn the crises from a common context. This will take a long time to integrate all the responsible agencies and the informal settlers as there is a mistrust and rivalry developed in last 20 years. In this circumstance, implementation of some immediate risk reduction measures is suggested by the study to save more lives.

In situations where landslides occur and impact facilities; emergency response and repairs are required. At the same time, the disaster itself needs to be dealt with risks, needs and available funds. The study also suggests that, the final mitigation approach must be a creative combination of several mitigation methods where environmental constraints and requirements can influence the selection and overall design of mitigation measures. It is best to keep the mitigation method simple and constructability of the measure should be evaluated, including sequencing, temporary support and protection of nearby property, facilities, utilities, traffic and the public.

## **7.2 Suggestion**

In many countries of the world including Bangladesh, the people who live in informal settlements are an integral part of the city; their right to live safely in the city is not recognized or protected. The lack of a comprehensive policy on urbanization and urban poor has resulted in social and structural inequalities, resulting in poor living and environmental conditions in informal settlements, weak access to basic services, and vulnerability to extortion and exploitation. Lack of residential security and poor adaptation to climate change, together with the lack of a comprehensive state policy to address their needs and vulnerabilities, leaves informal settlers bearing the brunt of structural and social inequalities on their lives, bodies, and health.

The study analyses how the absence of clear and forward-looking policies on urbanization and urban slum settlements discourages interventions to improve the long-term prospects of informal settlers. The hastily taken policies slow down the upgrading process of the informal settlements, i.e. install latrines, build better housing, pay for piped water access, etc. but also for NGOs and donors that would like to work with slum people to improve their lives. Eviction and the threat of eviction have a many-layered effect on people who

live in informal settlements. These findings will work as a base for any future research on similar topic. Only by referring the present work, anyone interested to contribute in this field can work further.

Measures to reduce climate-related risks like landslide need to be integrated into urban planning. In this regard, as per the research urban stakeholders, including government departments, private sector organizations and individuals, have particular roles for ensuring compliance with land use policy, so that landslide risks are addressed when housing structures are built on hillsides. The study recommends future researchers to incorporate adaptation measures within existing planned urban development and through provision of safe housing for low-income groups. It also suggests that improve infrastructure, including drainage channels and a sewerage system may help to reduce landslide risk. Future researchers may also consider the suggestion of building partnership amongst urban government and community-based organizations formed by residents of informal settlements to reduce disaster risk. These include organizing relocation for vulnerable groups and involving them in designing their own mitigation measure.

This study points toward fragile ecology; adaptation needs; resources and options of the vulnerable groups in urban areas. It urges a coherent pro-poor adaptation policy for cities with some decentralization of funding. Urban government can consider these and can act as a “focal point” between the urban poor and the national government policy-making process. Through an open and participatory assessment of climate-related risks and the vulnerability of low-income groups in Chittagong, the city government could find effective adaptation measures to present to national government. Through this process in Chittagong and many other cities, the views and priorities of the poorest groups and most vulnerable people could be incorporated into the NAPA and more broadly within all the national government’s climate change adaptation measures.

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