Prospects of Climate Resilient Infrastructure in the Low-Income Informal Settlements of Dhaka - A Community Approach

A thesis

submitted in partial fulfilment

of the requirements for the degree

of

Master of Environmental Planning

at

The University of Waikato

by

SOWMEN RAHMAN

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

2018

Abstract

This thesis focuses on the prospects of climate resilient infrastructure in the low-income settlements of Dhaka city. Numerous research findings show that low-income communities of Dhaka are living in the hazard prone areas with poor housing, sanitation and drainage facilities. These communities are at high risk of predicted climate change impacts and may be unable to avoid the direct and indirect impacts of climatic disasters. Most of the houses are below the ground level of Dhaka city and remain inundated after heavy rainfall or flood. In this context, this research undertook a community approach to explore the required measures for building climate resilience in the infrastructures of low-income settlements. Special attention was given on the impacts of heavy rainfall and storms and how they affect the infrastructure system.

This study selected Beguntila slum and New Purba Kurmitola Camp as a sample after carefully evaluating the selection criteria for this research. To derive information from the field, this study applied qualitative data collection techniques. Reconnaissance surveys were conducted on both slums to get a primary idea about the vulnerabilities of these slums. In this study, separate male and female focus group discussions were conducted in both slums. Ten key community experts were also selected for the key informant interviews. Drawing on qualitative data collected through focus group discussions and key informant interviews, this study examines the infrastructural vulnerabilities of these slums due to climate change impacts. It then identifies the root causes for these vulnerabilities. Finally, it outlines the required measures for establishing climate resilient infrastructure in these settlements.

The findings demonstrate that the key reason for these vulnerabilities on infrastructure due to heavy rainfall is inefficiency of current drainage system in the slum areas. This situation becomes even worse in absence of a functioning sewerage system. The tin-shed houses were found to be very weak and unable to withstand strong winds during storms. It was also found that electric poles could collapse on tin-shed houses and roads causing injuries to slum dwellers. The analysis finds that poverty is the most impeding factor for the advancement of the slum infrastructure. To conclude, the study urges the need for collective effort by government and NGOs to address the issues and take a range of structural and non-structural measures to build climate resilience in the low-income settlements of Dhaka city.

Acknowledgements

I would like to express my debt of gratitude to my supervisor, Professor Iain White. I have been privileged to conduct this research under your supervision. Thank you for all your time and encouragement. Your directions gave me the momentum and helped me to complete this research work within the timeframe.

I have been very fortunate to be part of the Environmental Planning programme at the University of Waikato. I am greatly indebted to Kate Mackness for her valuable guidelines and support at different stages of this research. I am thankful to Dr Pip Wallace for her continuous support and encouragement. My deepest thanks go to Dr Colin McLeay for supporting me in my ethics application.

My heartfelt thanks go to all the community members of Beguntila and New Purba Kurmitola Camp slums. Thank you all for your valuable information and participation. I am grateful to all the key informants of this research for enriching this study with their valuable information.

Sincere thanks to Habitat for Humanity Bangladesh for supporting me and for introducing me to the slum communities. Special thanks to the participant members of Centre for Urban Studies, Dhaka; Bangladesh Bureau of Statistics and Housing and Building Research Institutes Bangladesh for providing valuable information.

I am thankful to almighty Allah for blessing me with such wonderful parents. I owe my father Dr Ataur Rahman and mother Akterunnessa for providing ever-encouraging support all through my student life.

Table of Contents

List of Figures

List of Maps

List of Tables

Abbreviations

CBO	Community Based Organization
DOHS	Defense Officers Housing Society
FGD	Focus Group Discussion
IFRC	International Federation of Red Cross
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
PAR	Pressure and Release
SMS	Short Message Service
UNISDR	United Nations International Strategy for Disaster Risk Reduction
WSUP	Water & Sanitation for the Urban Poor

Chapter One - Introduction

1.1 Background: Climate Change Impacts in Low Income Settlements

The urban poor living in the low-income settlements of Dhaka are characterized by the lack of basic human rights of having acceptable housing and safe access to water and sanitation facilities. Moreover, these settlements are affected by multiple climate change impacts which directly affect their lives and livelihoods. Although a lot of interventions have taken place in the field of water supply, sanitation and hygiene considering quality and quantity of the provided services; however, less importance were given to climate change resilience issues in relation to these services. So urban slum communities experience severe consequences when infrastructure services do not function properly and create other problems such as sanitary leakage, faecal contamination, overflow of sanitary wastes, scarcity of fresh water etc. after an intense rainfall or flood. This often causes massive suffering to the urban poor living in the slums, squatters and other informal settlements (Chowdhury & Amin, 2006; Hoque, Sarkertarna, Karim, & Khan, 2013; Hossain, Habib, Islam, & Sharmin, 2013; Rashid, 2009).

A major barrier in the process of strengthening resilience to combat climate change impacts is the lack of security of tenure (Ahmed, 2014; Rahman, Atkins, & McFarlane, 2014). Local development bodies and NGOs are not particularly interested in taking a long-term development initiative as the slum dwellers or informal settlement dwellers have no legal entity over the land. As there is a constant fear of eviction in absence of any legal entity, the slum dwellers also hesitate to invest their hard-earned savings for the development of infrastructure and services. This dilemma raises the need for research on climate resilient infrastructure development addressing affordability, security, safety and sustainability issues in the low-income settlements of Dhaka city.

There is an increased acknowledgement of the importance of basic services provision to reduce the negative impacts of climate change particularly in the low-income settlements. Having 1.06 million people living in the urban slums (Bangladesh Bureau of Statistics, 2014) frequently exposed to negative impacts of climate change, Dhaka city requires more data regarding climate resilient infrastructure solutions to address this problem. In this context, this research undertakes a community approach to explore the alternatives of building climate resilient infrastructure in the low-income settlements of Dhaka. Special concentration has been given on two major climatic hazards - heavy rainfall and storms on how they affect the infrastructure

services such as water supply, sanitation and drainage facilities, and how to build resilience against these climatic hazards.

1.2 Aim of the Research

The aim of this research is to delineate the impacts of climate change on infrastructure and work with community to design a climate resilient infrastructure solution in the low-income settlements of Dhaka City.

To meet this aim, this study addresses following research questions.

Research Questions

- What are the existing vulnerabilities and problems of climate change in the low income settlements of Dhaka? (Chapter 2 and chapter 5)
- What are the factors contribute to enhance climate resilience to infrastructural vulnerabilities in the low-income settlements? (Chapter 3)
- What are the underlying causes and consequences for these vulnerabilities in the low-income settlements in terms of infrastructure services and management system? (Chapter 5)
- What measures should be taken in order to establish climate resilient infrastructure for the urban poor based on existing situation and past experiences? (Chapter 6 and Chapter 7)

1.3 Scope of the Thesis

This research outlines the possibility of climate resilience in the low-income settlements of Dhaka city through consulting with communities. It identifies the increased vulnerabilities in infrastructure services such as water supply, sanitation and drainage facilities of these settlements due to climatic hazards such as heavy rainfall and storm. It highlights the root causes for these vulnerabilities and the consequences in the infrastructure system. The research developed realistic and climate resilient solutions to address these concerns in conjunction with community through a series of focus group discussions and key informant interviews. It allowed community participants from the study area to share a common platform to exchange experiences and ideas. The research highlighted recommendations of community experts having diverse background. This can be regarded as useful guidelines for local governments, NGOs and community organizations working in the field of climate resilient infrastructure in slums and other informal settlements.

1.4 Outline of the Thesis

This thesis is constructed in six chapters.

Chapter one contains the general introduction on barriers in building climate resilient infrastructure in the low-income settlements. It covers the consequences of climatic hazards in absence of climate resilient infrastructure in these settlements. It specifies the aim of this research and research questions to be addressed.

Chapter two contains the background information gained through reviewing various literatures. It contains the environmental profile of Bangladesh and geographical disadvantages. It depicts the climate change vulnerability of Dhaka and defines low-income communities as the vulnerable groups. The chapter describes the housing conditions in these settlements, coping behavior against climatic adversities and key policies to address this issue.

Chapter three outlines the theoretical framework for this research. It contains the theories and models studied to develop the framework of this research. It connects climate change, vulnerability, adaptation and resilience. It highlights urban climate resilience and the key characteristics of resilient communities. It outlines relevant provisions in the sustainable development goals to tackle climate change impacts.

Chapter four discusses the two step methodology employed in this research. It describes the process of study area selection and collection of qualitative data. It elaborates the tools applied to collect primary data and how these data are analyzed. It includes the key challenges faced during the study and the techniques applied to address these challenges.

Chapter five analyses the data received from focus groups, key informants and field observation. It summarizes the root causes of the vulnerabilities and consequences on infrastructure system. It briefs the key actors and their roles in the study area.

Chapter six reflects on the opinions of community people and stakeholders to address the existing vulnerabilities and enhance resilience. It highlights the process for building climate resilient infrastructure as per suggested by community people and experts. It discusses how community people can be engaged in the infrastructure development activities and foreseeable challenges that needs to be considered.

Chapter seven summarizes the outcomes achieved through researching the prospects and challenges of building climate resilient infrastructure in the low-income settlements of Dhaka

city. It evaluates the key findings of this research against the research questions. It includes a number of suggestions for enhancing infrastructural resilience. It provides guideline on the opportunities for further research on improving climate resilience in the low-income settlements of Dhaka.

1.5 Conclusion

The need for climate resilient infrastructure in the low-income settlement is becoming more evident with the increasing number of climatic events. This chapter introduces the challenges of building climate resilience in the infrastructure of low-income settlements. As Dhaka city is frequently exposed to impacts of climate change, this research is an attempt to work with community to explore the ways of building climate resilient infrastructure in the low-income settlements of Dhaka. This study provides a broad range of scope to understand the current challenges due to climatic extremes and guideline to develop the present scenario of low-income informal settlements of Dhaka city.

2. Introduction

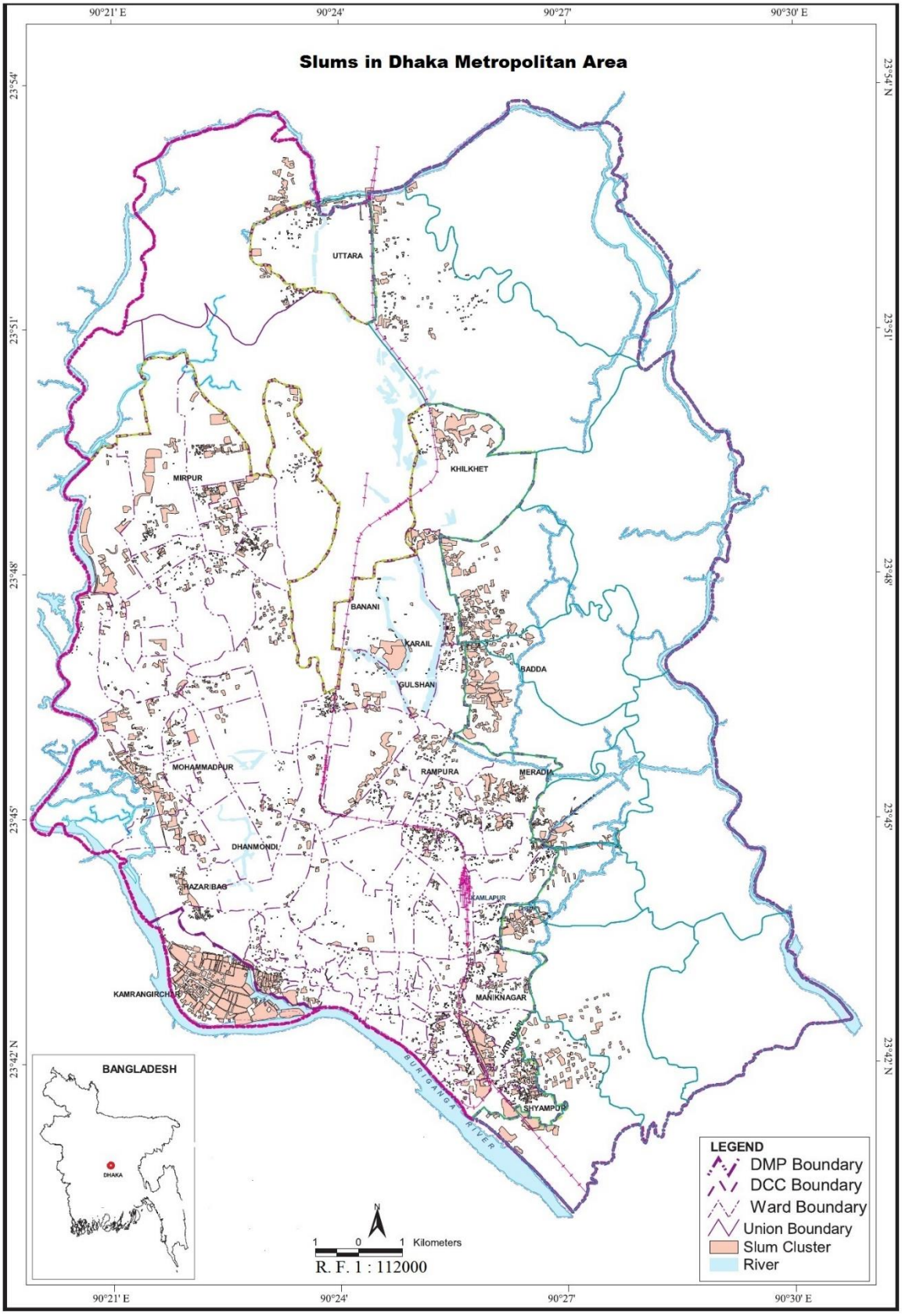
This chapter outlines the main focus and problem of this thesis. A wide range of existing literatures related to low income settlements of Dhaka were studied with a special focus on impacts of climate change and building resilience in the infrastructure. It includes research publications, journals and reports from government organizations, NGOs and individual researchers. Specific vulnerabilities and problems due to impacts of climate change in the low-income settlements are highlighted. To understand and relate socio-demographic profile, the reports by Bangladesh Bureau of Statistics (BBS) and Centre for Urban Studies (CUS) were reviewed. The constitutional provision by the Government of Bangladesh regarding informal settlements were also studied to conceptualize the legal limits.

2.1 Environmental Profile of Bangladesh

Bangladesh lies between 20˚43'13" to 23˚43' north latitude and 88˚45' to 92˚42'50" east longitude. It has a total land area of 143998 sq km, of which 1379 sq km is rivers (Hossain, 2010). In south, there is Bay of Bengal. In her North, there is the Himalayan Mountains. The country is situated at the confluence of three major rivers of the world – the Ganges, the Brahmaputra and the Meghna, which all originated from the Himalayan Mountain. With 93% of water that passes through her boundary, Bangladesh is one of the world's largest deltas created by the Ganges, the Brahmaputra and the Meghna (Hossain, 2010). As such, Bangladesh is highly vulnerable to climate change impacts due to its geographic location (Jabeen, Johnson, & Allen, 2010). Due to low and almost flat topography, abundance of rivers and the monsoon climate the country is highly vulnerable to natural hazards (Rahman & Rahman, 2015). Practically every part of country is vulnerable to some sort of disaster. According to Global Climate Risk Index (CRI) 2017 Bangladesh ranked in sixth position in its Long-Term Climate Risk Index (CRI) among the 10 countries most affected from 1996 to 2015, with 185 number of events and losses of 2283.38 million US$ PPP (Kreft, Eckstein, & Melchior, 2016). Due to her location, almost every year floods and cyclones strike Bangladesh. Cyclone and tide waves destroy physical infrastructure, kill people and animals as well as destroy forests (Rahman, 2013; Reid, Simms, &Johnson, 2007). Flood changes soil properties and changes river channels. Salt water intrudes fresh water. For all of these reasons Bangladesh has been identified as one of the most disaster prone countries in the world.

2.2 Climate Change Vulnerability of Dhaka

Dhaka, the capital city and one of the largest megacities in the world is located in the center of Bangladesh. The city is surrounded by rivers and canals. The mighty river Buriganga is located to the southwest of Dhaka city, the Balu and Shitalakhya river to the east, Turag to the west and the Tongi canal to the north (Alam and Rabbani, 2007). A minimum of 1500 new migrants arrive daily in this city making it one of the fastest growing megacities in the world (European Commission Humanitarian Aid Office, 2010). The majority of these new migrants settle in slums contributing to an alarming growth rate of about 7% per year (Streatfield and Karar 2008). According to a report of Centre for Urban Studies (2006), the slum population of Dhaka doubled between 1996 and 2005, from 1.5 to 3.4 million people, and the number of slum communities increased by almost 70% (from 3,007 to 4,966). More than half were typically fully or partially flooded during general flood conditions within the country. According to Alam and Rabbani (2007), Dhaka experienced several major flood events since its early days. Buriganga River flood embankment was built in 1864 as a result of these frequent flood occurrences. A combination of inadequate infrastructure and the destruction of natural water bodies is primarily responsible for frequent flood occurrences (Yahya, Shams, Islam, & Mahmud, 2010). Water logging due to poor drainage coupled with overflows from surrounding rivers that flows within the city are also the reasons for these flood events. Dhaka experienced nine major floods in 1954, 1955, 1970, 1974, 1980, 1987, 1988, 1998 and 2004 due to overflow of adjacent rivers. The floods in 1988, 1998 and 2004 were the most devastating (Alam and Rabbani, 2007). It is a very common scenario that the city submerges under water after heavy rainfall for few days. In 2004, the city experienced a record rainfall of 341mm within 24 hours which inundated more than two thirds of the capital city (Ahasan, Chowdhury, & Quadir, 2011).



Map 2.1: Slums located in Dhaka Metropolitan Area
Source: CUS (2006)

2.3 Vulnerable Groups of Climate Change Impacts

It is believed that people having better access to adequate food, clean water, healthcare and education will be better prepared to cope with impacts of climate change (Dodman, Ayers, & Huq, 2009). Conversely, lack of basic utility services increases the vulnerability of the poor to the impacts of climate change (Baker, 2012; Huq, Kovats, Reid, & Satterthwaite, 2007). The people living in the hazard prone areas unable to avoid direct and indirect impacts of climatic disasters are at most risk of the climate change impacts (Huq et al., 2007). Numerous research findings reported that low-income groups are especially living in the urban slums since they typically have low-quality housing, poor sanitation and drainage facilities (Huq et al., 2007; Baker, 2012). It is also difficult for them to move to a better place or change their occupation if climatic hazards affect their livelihood (Huq et al., 2007).

2.4 Housing Conditions

The housing conditions in the low-income informal settlements is very poor as most of the residents live below the poverty line. Tin-shed houses with bamboo supports are very common which are vulnerable to storms or hailstorms. The hailstorms cause holes in the tin roof while strong winds can blow away the roof (Alam, Alam, & Rahman, 2015). A study on mapping and slum census on urban areas of Bangladesh conducted by Centre for Urban Studies, Dhaka in 2005 found that only 10% of slums had sufficient drainage to avoid water-logging during heavy rains (CUS, 2006). Many shelters are below the ground level of Dhaka city and remain inundated after heavy rain or flood during rainy seasons. One of the common characteristics of the houses is very high population density or crowding in one room. About 4-7 people share one house or room on average in a miserable condition (Hoque et al., 2013). Nearly 80% of the slum residents are dependent on municipal tap water and about 18% are relying on tube-well water (BBS, 2015). Sanitary water sealed latrines having connection with sewers and septic tanks are considered as safe and hygienic (CUS, 2006). Distribution of latrines and use pattern (in percentages) according to the Census of Slum Areas and Floating Population 2014 is outlined in the following table.

Table 2.1: Distribution of types of latrines and use patterns in percentages

Locality	Sanitary Water Sealed (%)	Pit (%)	Tin (%)	Hanged (%)	Open (%)	Use Pattern	
						Single Household (%)	Multiple Household (%)
Dhaka North City Corporation	20.62	44.15	25.59	8.99	0.66	4.91	95.09
Dhaka South City Corporation	20.18	45.95	28.30	4.29	1.28	1.56	98.44

Source: BBS (2015)

According to the survey of Centre for Urban Studies (CUS), 74% of the slums were privately owned while 26% were squatter settlements in government land. The squatter occupants live under the threat of eviction. Privately owned slum dwellers live in a sub-standard housing condition and tenants are often forced to vacate their room if they cannot meet increased rent (CUS, 2005).

2.5 Coping Behaviour

The communities living in the low income informal settlements take several coping strategies to either prevent or to reduce the impacts. However, in many cases these poverty stricken communities are unable take any coping measure during climatic hazards (UNISDR, 2015). For instance, the dwellers change their location and move to a safer place as a preventive strategy. Sometimes they take help of NGOs to build drains, repair houses, and construct new roads. The dwellers near the canals build stilt bamboo houses to avoid flood water. Sometimes the NGOs provide toilets, tube-wells and municipal taps in the elevated platforms. During flood affected slum dwellers move to shelters provided by NGOs or stay in relative's houses. It is commonly found in slum areas that sacks of sands, brick bats or bricks are used to avoid clogged water in the roads (Alam et al., 2015).

2.6 Key Institutions and policies

The Government of Bangladesh developed the National Adaptation Program of Action (NAPA) in 2005. Although urban climate change resilience issues were not covered in this policy document, projects for improving climate resilience of urban infrastructure and industries was mentioned under capacity building (Alam et al., 2015). The Bangladesh Climate Change Strategy and Action Plan (BCCSAP) was published in 2009 to strengthen food security, social protection and health; comprehensive disaster management; infrastructure; research and

knowledge management; mitigation and low carbon development; and capacity building and institutional strengthening (MoEF, 2009). It included provision for flood protection and drainage schemes to protect urban areas from flooding under the infrastructure theme.

One of the major barriers to development of climate resilient infrastructure is fear of eviction (Rahman et al., 2014; Ahmed 2014). It has been stated in The National Housing Policy 1993 under clause 5.7.1 that no eviction should be made without adequate rehabilitation. The National Housing Policy 2016 also included rehabilitation for the removal of slum squatters (MoHW, GoB, 2017). Lack of social cohesion and local institutions increases vulnerability of a community (Blaikie, Cannon, Davis, & Wisner., 1994). Community based associations can play a vital role in building climate resilient infrastructure in the low income settlements. The constitution of Bangladesh encourages its citizens to form associations for good reasons in its Article 38. It allows slum dwellers to organize their own associations and collective forums (CUS, 2017).

2.7 Conclusion

The evidence gained through reviewing studies confirm the extreme climate change vulnerability of Bangladesh. As Bangladesh is located in the confluence of three major rivers, it results in frequent flood events. The capital of Bangladesh Dhaka has witnessed devastating flood events in the past. The vulnerable groups are the poor living in the informal settlements who are hardly capable to cope with disaster. The settlements are densely crowded and mostly below the ground level. The literature findings outlined in this chapter urge the need for enhancing climate resilience in the low-income settlements.

3.1 Introduction

This chapter contains the conceptual framework of this thesis. A wide range of literature has been reviewed to develop the understanding on theoretical terms around the topic of climate resilient infrastructure in the low-income settlements. To understand climate change and vulnerability context, vulnerability and its major components were studied. The Pressure and Release Model has been reviewed as a tool for vulnerability analysis. This chapter included climate change adaptation and urban climate resilience. It illustrates the interrelation among climate change, vulnerability, adaptation and resilience. It outlines the characteristics of safe and resilient community as well as role of infrastructure and community participation to build urban climate resilience in the low-income informal settlements.

3.2 Climate Change and Vulnerability

3.2.1 Vulnerability and its Components

Vulnerability is the incapability to withstand a hazard or to react when a disaster takes place (UNISDR, 2004). Sherbinin, Schiller and Pulsipher (2007) defined vulnerability as the degree to which a system or unit is expected to face damage caused by perturbations or stresses. Wisner et al. (2004) defined it as the features of an individual or group and their condition that effect their capability to expect, handle, counter and recover from the impact of a natural hazard. The idea of vulnerability started in research groups exploring risks and hazards, climate change impacts and resilience (Sherbinin et al. 2007). According to UNISDR (2004), vulnerability relies upon a few variables such as individuals' age and health condition, environment and sanitary conditions, and on the quality and condition of local structures and their location regarding any hazards. Low-income families often live in high-risk regions around urban communities being unable to pay for more secure places, which can be termed as economic vulnerability (UNISDR, 2004).

The Australian Greenhouse Office (2005) indicated three major components for assessing vulnerability namely exposure, sensitivity and adaptive capacity. Exposure links to the powers or impetuses that influence a system (Australian Greenhouse Office, 2005). A system can be exposed to and affected by significant climatic events. Sensitivity indicates how a system responds to climatic events. It is the degree to which a system is likely to be affected by climate change. Adaptive capacity refers to the ability of a system to cope with the consequences of climate change with minimum amount of loss. It is the ability of a system that makes it well

equipped to deal with external forces. Philander (2012) related exposure, sensitivity and adaptive capacity to define vulnerability as per following equation.

Vulnerability (V) = Exposure (E) + Sensitivity (S) – Adaptive Capacity (AC)

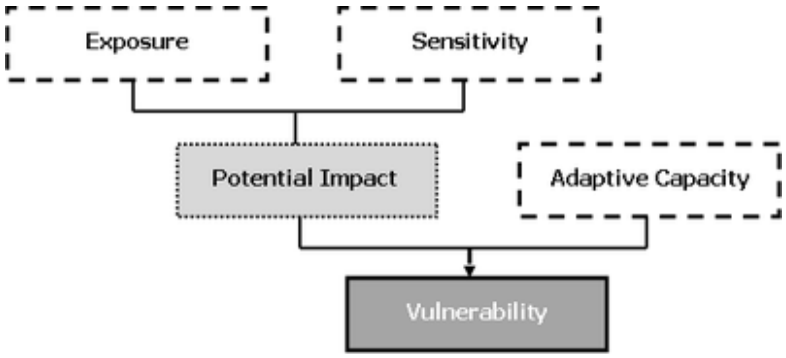


Figure 3.1 Vulnerability and its components
Source: Australian Greenhouse Office (2005)

Understanding vulnerability and its components helped to define the vulnerability of the study areas, which has been covered in the chapter five of this research. It assisted in developing tools for qualitative data collection i.e. focus group discussion checklist and key informant interview schedule.

3.2.2 Vulnerability Analysis Framework – Pressure and Release Model

The Pressure and Release Model relates progression of vulnerability and climatic disaster (Awal, 2015). It relates to minimalizing disaster risks by applying preventive and mitigation measures (Ashgar, Alahakoon, & Churilov, 2006). At first, it addresses the root causes and then analyses the nature of the disaster. This ends in more secure conditions that assist in an effort to prepare the community to deal disasters.

The PAR Model comprehends a disaster as the convergence between socio-economic stress and external exposure. Risk is defined as a feature of the perturbation or stress and the vulnerability of the exposed unit (Blaikie et al., 1994). It guides interest to the situations that allow exposure unsafe which further leads to vulnerability and to the reasons developing these situations. The model is principally used to cope with communities facing disaster events. It also underlines differences in vulnerability by various exposure units that may include social

class and ethnicity. The model elaborates a disaster by tracing a progression that links the effect of a hazard through a chain of social factors that cause vulnerability (Singh, Eghdami, & Singh, 2014). A complex interaction between natural hazard and vulnerable society can explain a disaster event. Predominant underlying causes consist of monetary, demographic and political strategies, which have an effect on the allocation and distribution of assets among different groups. Dynamic pressures interpret economic and political procedures in local situations. Unsafe conditions are the particular structures in which vulnerability is expressed in time and space, which includes those induced via the physical surroundings, local economy or social relations (Blaikie et al. 1994).

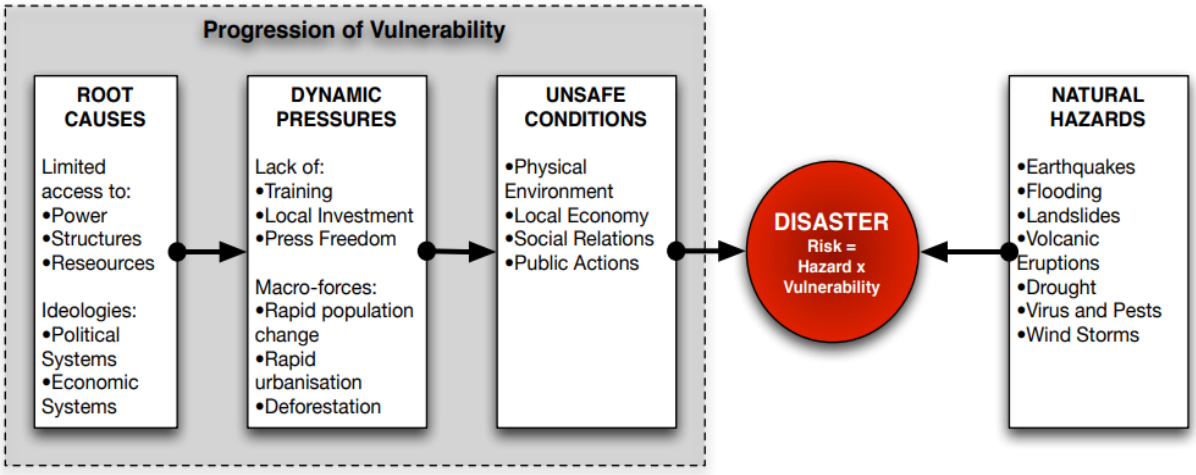


Figure 3.2: Pressure and Release Model
Source: Blaikie et al. (1994)

In this research, the PAR model helped to conceptualize the idea of progression of vulnerability through root causes, dynamic pressure and unsafe condition leading to disaster from hazard like flood. In chapter five, the underlying causes and consequences of these have been outlined.

3.3 Adaptation and Resilience

3.3.1 Adaptation

Adaptation to climate change is considered as a complex process as it requires assessing various dimensions of vulnerability and possible actions. In a more practical term, adaptation is a set of coping strategies (McCarthy, Canziani, Leary, Dokken, & White, 2001). Each strategy concentrates on a specific threat. Some of these actions are taken in the individual or

community level in respond to climatic hazards. Some actions are taken under governmental or institutional level in the form of policies or actions (McCarthy et al., 2001).

Smit and Pilifosova (2001) defined adaptation as the adjustment in social, economic or ecological structures in regards to climatic influences and their impacts. The process includes adjustments to minimize the vulnerability of groups, regions or actions to climatic change and variability. There are important aspects of adaptations, one is the assessment of vulnerabilities and impacts, and the other is evaluation and development of the response actions.

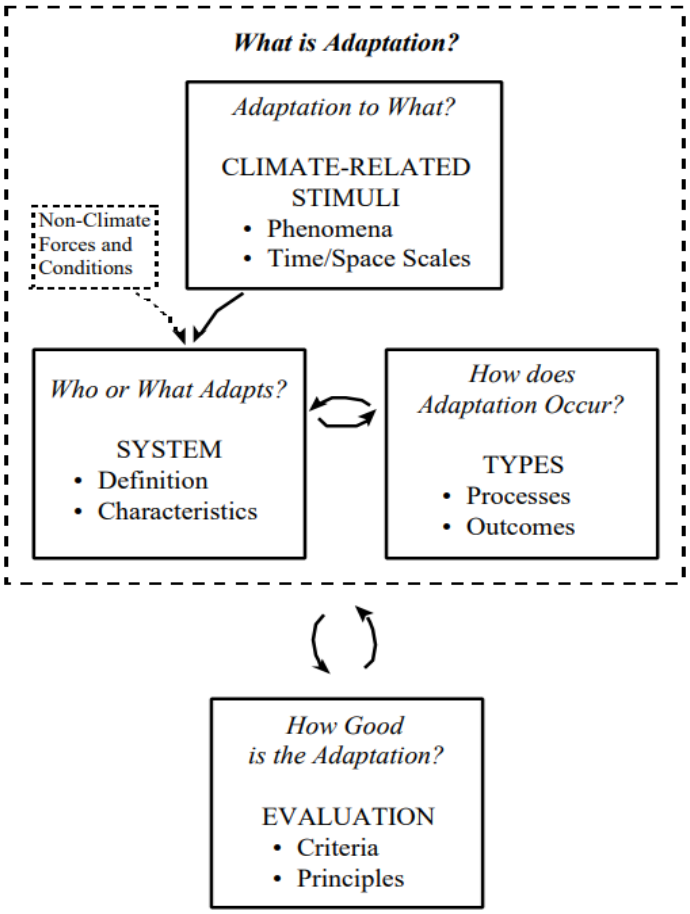


Figure 3.3: Adaptation to climate change (Source: Smit et al., 2000)

The Food and Agriculture Organization (2015) grouped the types of adaptation into four categories: anticipatory, reactive, spontaneous and planned adaptation. Anticipatory adaptation is based on preventive measures while reactive adaptation is based on actions taken after the occurrence of an event. In spontaneous or autonomous adaptation process, actions are taken in

response to changes in environment. Planned adaptation is based on awareness on likely occurrences and decision on possible actions.

The types of adaptation are helpful to understand different type of adaptation measures taken by the community to cope up with climatic extremes. It provides an understanding on what type of adaptation strategies can be taken by the community to face the upcoming extreme events due to climate change. Chapter six covers possible adaptation strategies that can be taken to minimize climate change vulnerabilities according to the community people and experts.

Binder and Snover (2011) also defined 4-As of adaptation planning in order to attain climate resilience as per shown in the following figure.

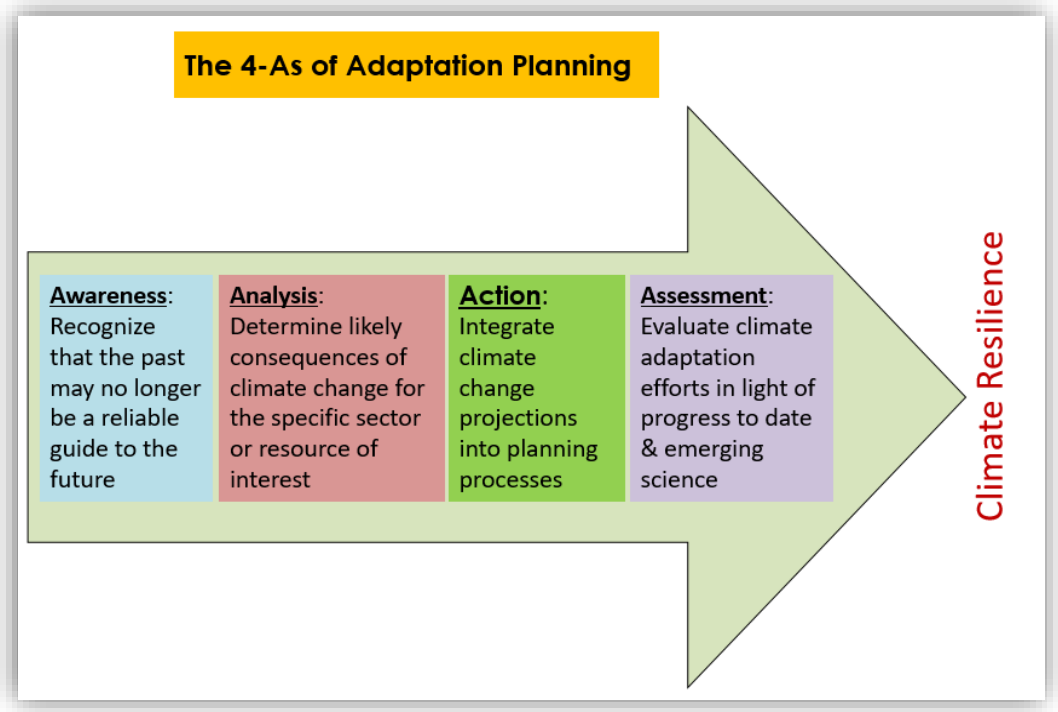


Figure 3.4: The 4-As of Adaptation Planning

Source: Binder and Snover (2011)

The 4-As of adaptation planning helped to frame the analysis in chapter six that covers the adaptation strategies against climate change vulnerabilities. It provided the understanding on how to progress towards climate resilience through adaptation strategies such as awareness, analysis, action and assessment.

3.3.2 Resilience

Resilience is an idea concerned primarily with how a system, group or individual can manage external influence, disturbance, shock, uncertain events or change. The term “resilience” is derived from the Latin word ‘resiliere’ which means ‘to bounce back’ (Paton, 2007). In everyday language, resilience is frequently used to refer the ability to bounce back.

The idea of resilience was first introduced in the work of C.S. Hollings in 1973 (Brand & Jax, 2007). His work on resilience of ecological systems had major contribution on natural and social science. This concept has developed as a combination of concepts from multidisciplinary backgrounds including sustainability of ecosystem (Holling, 1973; Gunderson, 2009), engineering and infrastructure (Tierney & Bruneau, 2007), psychology and (Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008; Lee, Shen, & Tran, 2009) and disaster risk reduction (Cutter et al., 2008).

A resilient pathway is one that continues to function in spite of stresses and shocks. Suitable adaptation consisting of countermeasures to address each stress or shock can help to maintain the resilience (Mitchel & Harris, 2012). International Council for Local Environmental Initiatives (ICLEI) defined resilience as follows.

> "Resilience is the capacity and ability of a community to withstand stress, survives, adapt, bounce back from a crisis or disaster and rapidly move on. Resilience needs to be understood as the societal benefit of collective efforts to build collective capacity and the ability to withstand stress." (ICLEI, 2011)

Bahadur, Ibrahim and Tanner (2010) identified ten characteristics of a resilient system that can be summarized as follows:

1. A greater diversity in groups carrying out different roles in an ecosystem, economic opportunities, natural resources, participation in a resilience-building policy, and in preparation, response and recovery activities.
2. A high level of community cohesion through functional, decentralized and flexible governance and institutions that can assist in system-wide learning and execute other tasks such as interpreting scientific data on climate change to guide policymakers.

3. The unavoidable existence of uncertainty is acknowledged and attempts to bring stability through increased capacity of systems to cope with, adapt to and transform changes.
4. Community engagement and the adoption of local knowledge allows community enjoy sense of belonging to natural resources.
5. Awareness activities allows community to prepare to live in unavoidable circumstances and helps to build redundancy within the system.
6. Socio-economic justice and equity exists in a great extent within the resilience programs to distribute risks within community.
7. The significance of social values and structures is recognized.
8. Since systems do not return to previous state after a disturbance or shock, hence non-equilibrium dynamics of a system are acknowledged.
9. It allows repetitive and effective learning in the form of organizational learning, iterative policy, thoughtful practice and adaptive management.
10. A cross-scalar approach of occurrences and events is taken in resilient systems. To build resilience, a series of social, economic, political and cultural networks from local to global scale help to form it.

The term resilience and characteristics of resilience is particularly important for this research to understand the requirements for climate resilient infrastructure in the low-income settlements. It helped to define the required non-structural measures for building resilience in the study areas. Chapter six discusses how to build climate resilience in the low-income settlements.

3.4 Urban Climate Resilience

Climate resilience is defined as the ability for a socio-ecological structure to absorb stresses due to climate change and continue functioning when exposed to external influences (Folke, 2006). It is the capability to adapt, organize and progress into better configurations that increase the sustainability of the system and makes it well organized for upcoming climate change impacts.

Revi et al. (2014) define urban climate resilience as a method to develop the capacity of an urban centre to reduce the impacts of climate change through infrastructural development and land use management. A significant amount of literature has addressed the issue of resilience to climate change in urban centres and the issues that contribute to resilience (Muller, 2007;

Brown, Dayal, & Rumbaitis, 2012; Moench, Tyler, & Lage, 2011; Leichenko, 2011; Pelling, 2011; da Silva, Kernaghan, & Luque, 2012). Studies show that numerous systematic characteristics contribute to the city resilience, these are "flexibility, redundancy, responsiveness, capacity to learn and safe failure" (Tyler, Reed, Macclune, & Chopde 2010; Moench et al., 2011, Brown et al., 2012; da Silva et al., 2012 and Revi et al., 2014).

Due to rising concern among the national and international bodies with regards to climate change and its possible impacts, building climate resilient future has become one of the major priorities worldwide. The key focus of the climate resilience is to address vulnerabilities of the communities (Abuodha & Woodroffe, 2006). The International Council for Local Environmental Initiatives (2015) defined resilient city as follows.

> "A city that is prepared to absorb and recover from any shock or stress while maintaining its essential functions, structures, and identity as well as adapting and thriving in the face of continual change. Building resilience requires identifying and assessing hazard risks, reducing vulnerability and exposure, and lastly, increasing resistance, adaptive capacity, and emergency preparedness."

The World Bank in its Guide to Climate Change Adaptation in Cities defined resilient cities according to the ability to adapt to present and future climate change impacts.

> "A resilient city is one that is able to adapt to disaster and climate impacts now and in the future, thereby limiting the magnitude and severity of those impacts. Once an impact occurs, a resilient city is able to evolve cost-effectively and equitably for all stakeholders. Building resilience towards climate change requires robust decision making by those in positions of formal authority, as well as a strong web of institutional and social relationships that provides formal and informal safety nets for the most vulnerable populations." (The World Bank Group, 2011)

Long-term resilience building activities include comprehending the level of exposure and sensitivity to a given set of impacts, developing policies and making investments to limit vulnerabilities, and improving adaptive capacity (The World Bank Group, 2011).

Developing understanding on urban climate resilience is particularly important to conceptualize the requirements for building long-term resilience in the city infrastructure. The requirements for infrastructural resilience in the study area has been covered in chapter six.

3.5 Relation between Climate Change, Vulnerability, Adaptation and Resilience

The impacts of climate change leads to vulnerability within the community and arises the need to adopt adaptation measures and build resilience. Climate change is inevitable and the impacts are evolving. In order to tackle the negative impacts of climate change, it is essential to reduce vulnerability by adaptation measures and improving resilience. There is a long debate regarding the precise definition of climate resilience and its relation to climate change adaptation whether it should cover actor-based or system-based approaches to improve stability (Folke, 2006). According to Nelson, Adger and Brown (2007), climate resilience covers a dual function of absorbing shock and self-renewal which distinguishes it from climate adaptation. Adaptation is a set of processes and actions helping a system to absorb changes that already occurred or will occur later. Moreover, there is an argument that in case of environmental change and climate adaptation, there should be strict definition including active decision-making processes and actions of deliberate changes made in response to climate change only.

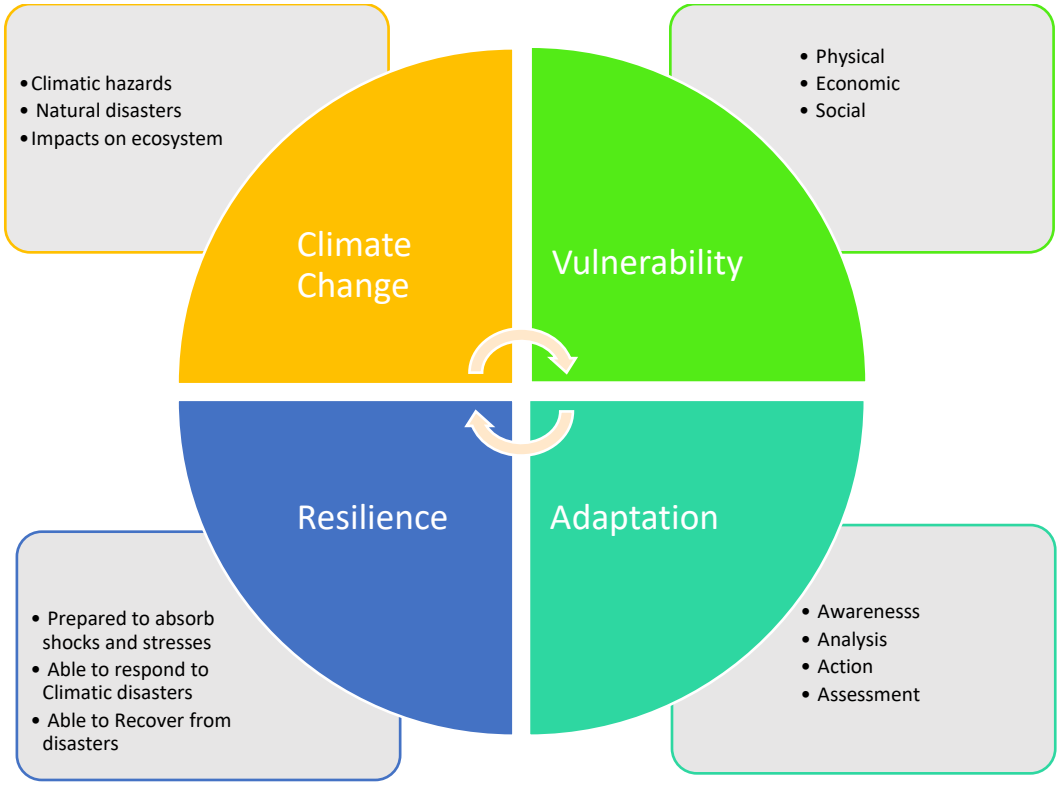


Figure 3.5: Interrelation among climate change, vulnerability, adaptation and resilience
Source: Author (2018)

The above figure illustrates the interrelation among climate change, vulnerability, adaptation and resilience. Changes in climate such as changes in precipitation, increased temperatures, sea-level rise and increased climate extreme events result in frequent climatic hazards, natural disasters and negative impacts on eco-systems. Climate change thereby causes social, economic and physical vulnerability in the human settlements. Addressing these vulnerabilities requires undertaking various adaptation strategies, such as awareness, analysis, action and assessment as depicted in figure 3.4. Successful adoption of adaptation strategies would help to build resilience in these settlements. The resilient communities will become prepared to absorb external shocks and stresses, and respond to and recover from climatic disasters.

In this research the climate change and vulnerability context has been covered in the chapter five. The possible adaptation measures and ways to build climate resilience in the infrastructure system of low-income communities has been discussed in chapter six and chapter seven.

3.6 Characteristics of Resilient Community

The International Federation of the Red Cross and Red Crescent Societies – IFRC (2012) found six characteristics of a safe and resilient community in its Community Based Disaster Risk Reduction Study. According to this report, the resilient communities are knowledgeable and healthy, organized, connected, have strong infrastructure and services, have economic opportunities, and can protect and enhance natural resources. The key characteristics of safe and resilient community derived from the result of the study are illustrated in the following table.

The characteristics of a safe and resilient community
A safe and resilient community...
1. …is knowledgeable and healthy. It has the ability to assess, manage and monitor its risks. It can learn new skills and build on past experiences.
2. …is organised. It has the capacity to identify problems, establish priorities and act.
3. …is connected. It has relationships with external actors who provide a wider supportive environment, and supply goods and services when needed.
4. …has infrastructure and services. It has strong housing, transport, power, water and sanitation systems. It has the ability to maintain, repair and renovate them.
5. …has economic opportunities. It has a diverse range of employment opportunities, income and financial services. It is flexible, resourceful and has the capacity to accept uncertainty and respond (proactively) to change.
6. …can manage its natural assets. It recognizes their value and has the ability to protect, enhance and maintain them.

Table 3.1: Characteristics of a safe and resilient community (Source: IFRC, 2012)

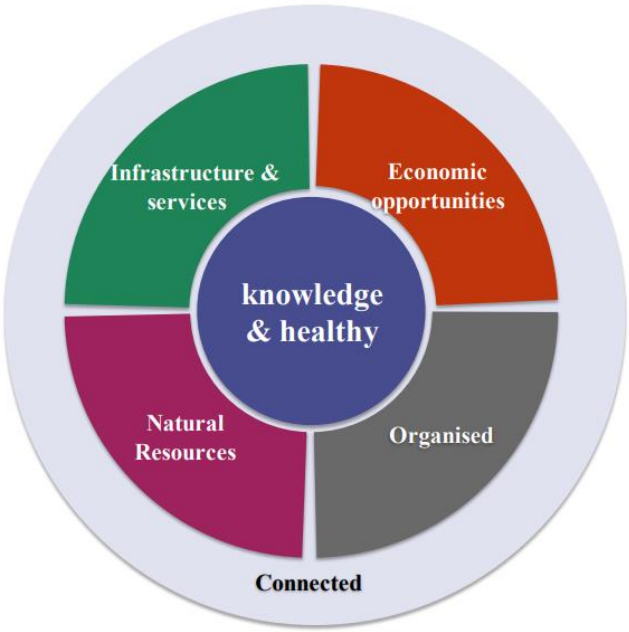


Figure 3.6: The Characteristics of a Safe and Resilient Community

Source: IFRC (2012)

In the figure, the central integral part identified for a safe and resilient community is the "knowledge and healthy" character of a community. It denotes the human health and well being as well as knowledge and awareness activities as the key characteristics. It increase the capability of household to "prepare, prevent, respond to and recover from shocks and stresses" (IFRC, 2012). The importance of access to asset and resources, condition of infrastructure and services and organization are also among the identified characteristics within these communities.

The understanding on characteristics of safe and resilient community helped to comprehend the requirements for building safe and resilient low-income community. It was useful to understand the need of access to wealth, condition of infrastructure, community knowledge, hygiene and level of organization to build community resilience which is covered in chapter six.

3.7 Role of Infrastructure in Building Climate Resilience

Infrastructure can play a vital role to minimize impacts of climatic hazards. There are different types of infrastructure which can be applied to reduce the impacts. For example, flood defence and improved drainage may minimize the risk of flooding and communication infrastructures can help with early warning of upcoming threats. Diseases spread due to leakage and poor

water and sanitation system (Alam et al., 2015). Following building codes and design standards can prevent houses and other structures from being affected by extreme weather events. Application of land use regulations can help to prevent building in vulnerable areas. Existing infrastructures need regular maintenance to function during a disaster event. In the poor communities, there is a lack of adequate infrastructure (Bicknell, Dodman, & Satterthwaite, 2009). The recent urbanization trend in the developing countries show that there is an increase in the number of population living in the informal settlements. For this reason, there is an increased level of vulnerability in these areas. To address this situation, strengthening both physical infrastructure and institutional to facilitate the existing service has become essential to move forward towards building climate resilience in the infrastructure system.

3.8 Role of the Urban Poor in Building Community Resilience

Since urban poor living in the low-income settlements are the main victims of climatic hazards, hence it is important that this low-income group should be the main drivers in attaining community resilience (Ahasan et al. 2011). In a complex urban system, there are multiple stakeholders contributing to this system. It includes the governance actors of different level. Actions required to improve the basic condition of the vulnerable low-income population is found to be insufficient (da Silva et al. 2012). It shows the need to address the vulnerability to groups who are least able to address shocks and stresses.

3.9 Climate Change Resilience and Sustainable Development Goals (SDG)

The United Nations set 17 goals to transform the world known as Sustainable Development Goals. Among the goals, immediate action against climate change and its impacts was under Goal 13. To address this global challenge, it provides a roadmap to build climate resilience and low carbon economy as part of Paris Agreement at COP21 in Paris, 2015 (United Nations, 2015). This goal targets to achieve improved resilience and adaptive capacity to climatic hazards and natural disasters by 2030. It also aims to integrate climate change actions into national policy, strategy and planning. Advancing education and awareness activities and improving human and institutional capacity on mitigation, adaptation and early warning of climate change impacts by 2030 covered under this goal. Goal 11 of Sustainable Development Goals is to “Make cities inclusive, safe, resilient and sustainable” by 2030 (United Nations, 2015). This goal aims to achieve adequate, safe and affordable housing and basic services for all and upgradation of slums. It put emphasis on participatory, integrated and sustainable human settlement planning and management. The goal aims to increase the quantity of

settlements embracing integrated policies towards inclusion, resourcefulness, mitigation and climate change adaptation, disaster resilience, and develop and implement in accordance with the Sendai Framework for Disaster Risk Reduction 2015-2030 (United Nations, 2015). This 2030 agenda for sustainable development aims at reasonable and scalable results to allow countries to advance to cleaner and resilient future.

3.10 Conclusion

This chapter outlines the theories and models studied to develop the analytical framework of this research. It provides the support to develop understanding on vulnerability and its components. Vulnerability is the incapability of a system or unit to withstand a hazard or disaster. Vulnerabilities of an individual or group rely upon a few variables such as environment, health condition, sanitary condition, quality of structures and location. Vulnerability can be assessed by levels of exposure, sensitivity and adaptive capacity. The PAR model enables us to understand the progression of vulnerability through underlying causes, dynamic pressures, unsafe conditions, disasters, and hazards. A complex interaction between a vulnerable society and a natural hazard explains a disaster event. The PAR model addresses the underlying causes and dynamic pressures, and applies preventive measures to create secure conditions by minimizing disaster risks.

Adaptation planning has been described as a set of coping strategies to combat climatic disasters. Adaptation can be done in four stages through awareness, analysis, action and assessment to minimize vulnerability and attain resilience. Resilience has been defined as the ability to prepare for, respond to and recover from climatic hazards. Improving climate resilience requires identifying and assessing risks of hazard, addressing vulnerability, increasing resistance and adaptation planning. The safe and resilient communities are knowledgeable and have ability to assess, manage and monitor its risk. These communities are organized and connected. Resilient communities have strong infrastructure and utility services, diverse range of economic opportunities and have the ability to protect natural resources.

Chapter Four – Selection of Study Area and Methodology

4.1 Introduction

This chapter contains the methodology of this research. The purpose of this chapter is to explain and justify the approaches taken for conducting this study. In particular, it explains the methods employed in this research to achieve the aim of this research: **to delineate the impacts of climate change on infrastructure and work with community to design a climate resilient infrastructure solution in the low-income settlements of Dhaka City**. This chapter describes tools and techniques applied in obtaining information in different stages of the study. It outlines the process of selecting site for conducting the study and explains how the participants were engaged in this study. It elaborates how the information were collected from the participants applying the research tools.

4.2 Methodology

4.2.1 Selection of Study Area

Dhaka city, the capital of Bangladesh has been chosen for this research considering its locational vulnerabilities, frequent exposer to climate change impacts, conglomeration of slum areas and rapid growth of slum population. The detailed description of climate change vulnerability and vulnerable groups in the low-income settlements of Dhaka is outlined in the chapter two. This study applied qualitative criteria by purposive sampling - a non-probability sampling technique rather than probability sampling technique. To select the slums for this study from numerous slums in Dhaka, a number of selection criteria have been taken into consideration. It was useful to consult with climate change experts, experienced researchers, NGO professionals and academicians prior to visit the slums. To consult with climate change experts and researchers, two renowned research organizations were visited. These were the International Centre for Climate Change and Development (ICCCAD) and Centre for Urban Studies (CUS). One senior researcher of urban climate change programme of ICCCAD helped to understand the picture of climate change impacts in the low-income settlements of Dhaka. The researcher provided the names of slums that are affected by climatic hazards and are safe to conduct field investigation. The chairman of Centre for Urban Studies shared their publications on urban slum mapping and provided general information on the infrastructure and sanitation conditions of different slums in Dhaka. I visited the office of Habitat for Humanity International Bangladesh, a reputed NGO in Bangladesh working on infrastructure development in slum communities and consulted with two programme managers who are

currently supervising slum development projects in Dhaka. I also attended the 4th Gobeshona Annual Conference for Research on Climate Change in Bangladesh to meet the climate change experts and academicians in Dhaka. This platform provided me the opportunity to discuss vulnerable slums with the participants and develop a network for further consultation.

Consultation with the experts of diverse profession helped to get a brief idea about the location of the slums that are vulnerable to climate change impacts and mark out these slums for field exploration. To measure the site selection criteria and select the slums, the slums located in low lying areas near lake, river and water bodies were visited. The criteria for the selection of study area were -

1. Frequent exposure to climate change impacts due to heavy rainfall and storm.
2. Slums which remain inundated most of the rainy season.
3. Slums which got affected by storm and heavy wind.
4. Current infrastructures are highly vulnerable to impacts of torrential rain or storm.
5. Located in low lying area near floodplain, lake or other waterbodies.
6. Secured area to visit to conduct field survey.
7. Local representatives of Community Based Organizations and Non-Government Organizations are available and eager to participate in this research.

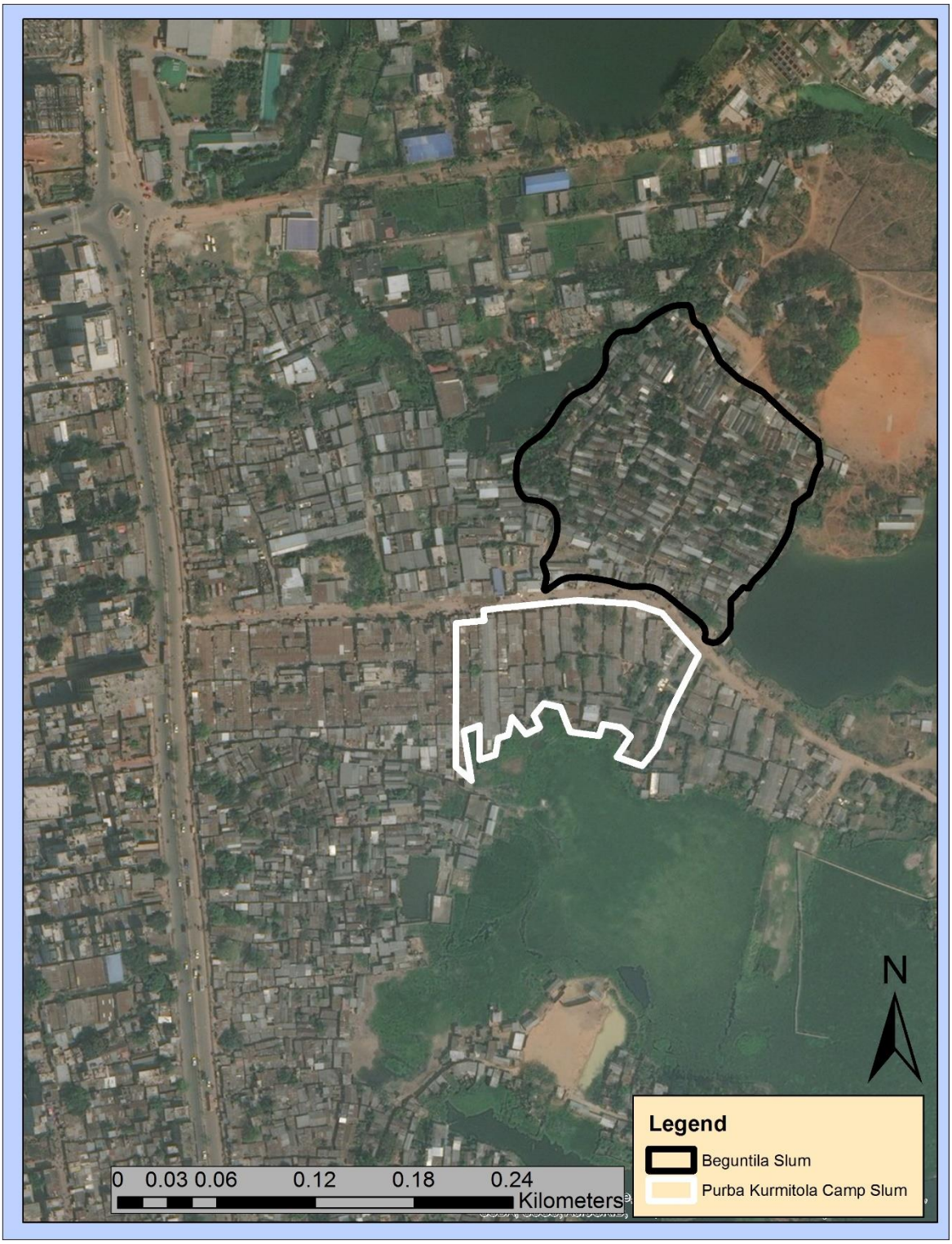
After measuring the selection criteria through visiting the slums, two slums have been selected for this study namely Beguntila slum and New Purba Kurmitola Camp. The reason for selecting two slums is to go for an in-depth study with small and focused samples considering the time and budget limit. The slums are located in a low-lying land on the edge of Shaheen Lake at Ward 2, Section 12 in Mirpur under the Dhaka City Corporation. A reconnaissance survey was conducted prior to final selection to check suitability of the area for this research. In Dhaka city, slums can be classified into two types based on coverage by development organizations. The Beguntila slum is receiving assistance of multiple NGOs and the community leadership is well organised. Conversely, the New Purba Kurmitola Camp is a contrasting example having limited development organizations providing assistance for infrastructure development support. The purpose for selecting two contrasting communities is to delineate the differences of dealing climate change impacts.

The community leaders of both slums were contacted prior to visit through assistance of Habitat for Humanity International – Bangladesh, an NGO working for developing

infrastructure and sanitation services in the slum areas of Mirpur. I, along with a field assistant visited these two slums and carefully observed the present condition of the slum infrastructure. To understand the effect of rain and hear from the community people about the impacts of heavy rainfall, the slums were visited during the days of continuous intense rainfall. Visiting the slum during rain was helpful to draw attention of the slum dwellers and they expressed their interest to contribute to this research. The roads, drainage and houses were carefully investigated in particular and relevant photographs were taken. These two slums were finalized for this research as the impacts of heavy rainfall and storm were evident and fulfilled the criteria of selection mentioned above.

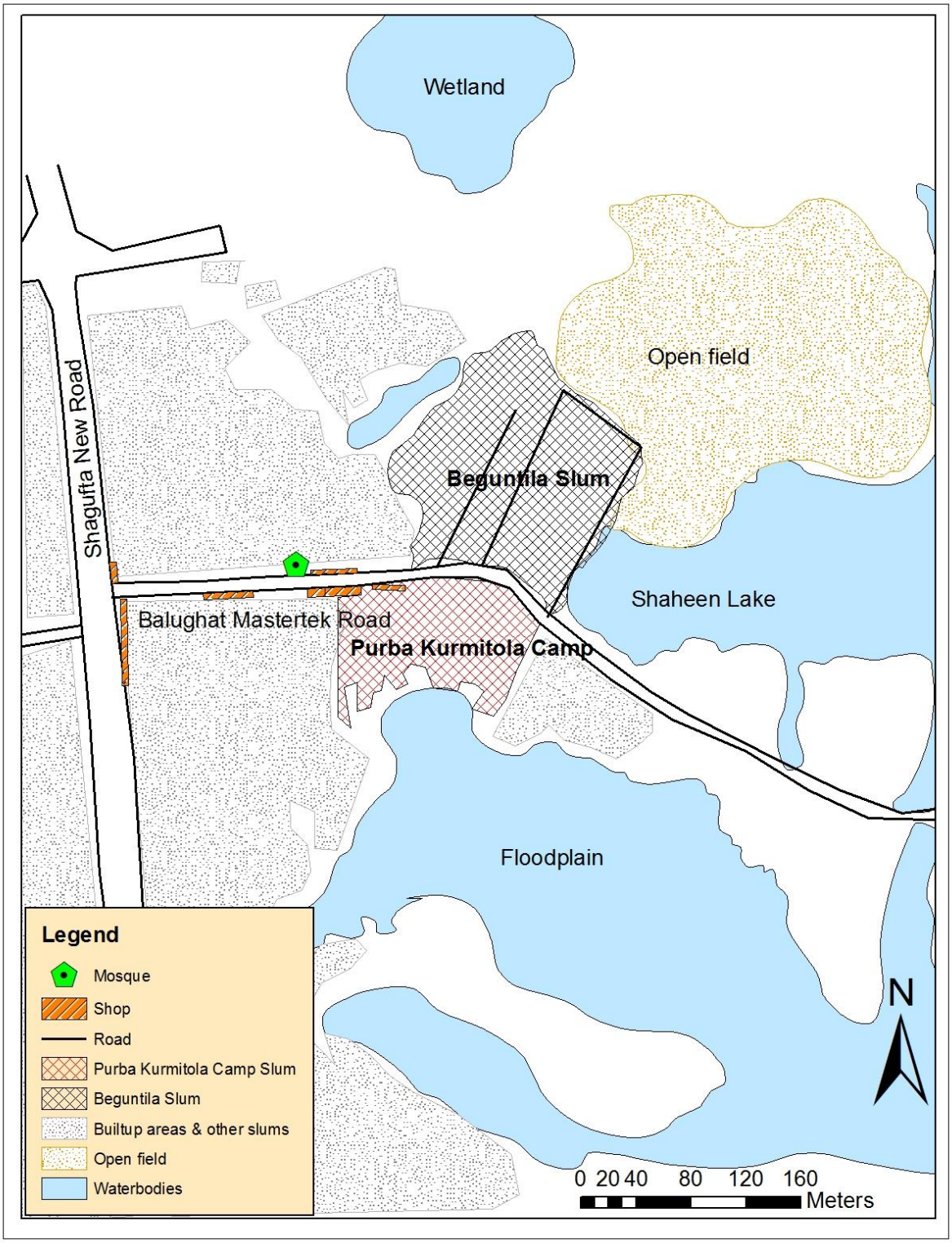
The satellite image of these two slums including the surroundings has been processed to delineate the locational features. To appreciate the visualization capability of Geographic Information System, ArcGIS 10.5 application has been used to visualize the study area and its settings. The ArcGIS online Basemap has been used to mark out Beguntila Slum and New Purba Kurmitola Camp slum as shown in the map 4.1. This satellite map has been digitized using ArcGIS application to depict the locational vulnerability of these areas to climate change impacts as shown in the map 4.2.

Map 4.1: ArcGIS Basemap showing Beguntila and New Purba Kurmitola Camp Slum



Source: ArcGIS Base Map (modified by author)

Map 4.2: ArcGIS Basemap showing locational settings of Beguntila and New Purba Kurmitola Camp Slum



Source: Author (2018) based on ArcGIS Base Map

The map 4.2 clearly depicts the locational vulnerability of Beguntila Slum and New Purba Kurmitola Camp. The study areas are developed by the side of floodplains and wetlands in its east side. As they are situated in the low lying areas by the side of Shaheen Lake, it is highly vulnerable to inundation after torrential rain.

The step by step process of selecting these two study areas has been illustrated in the following flowchart.

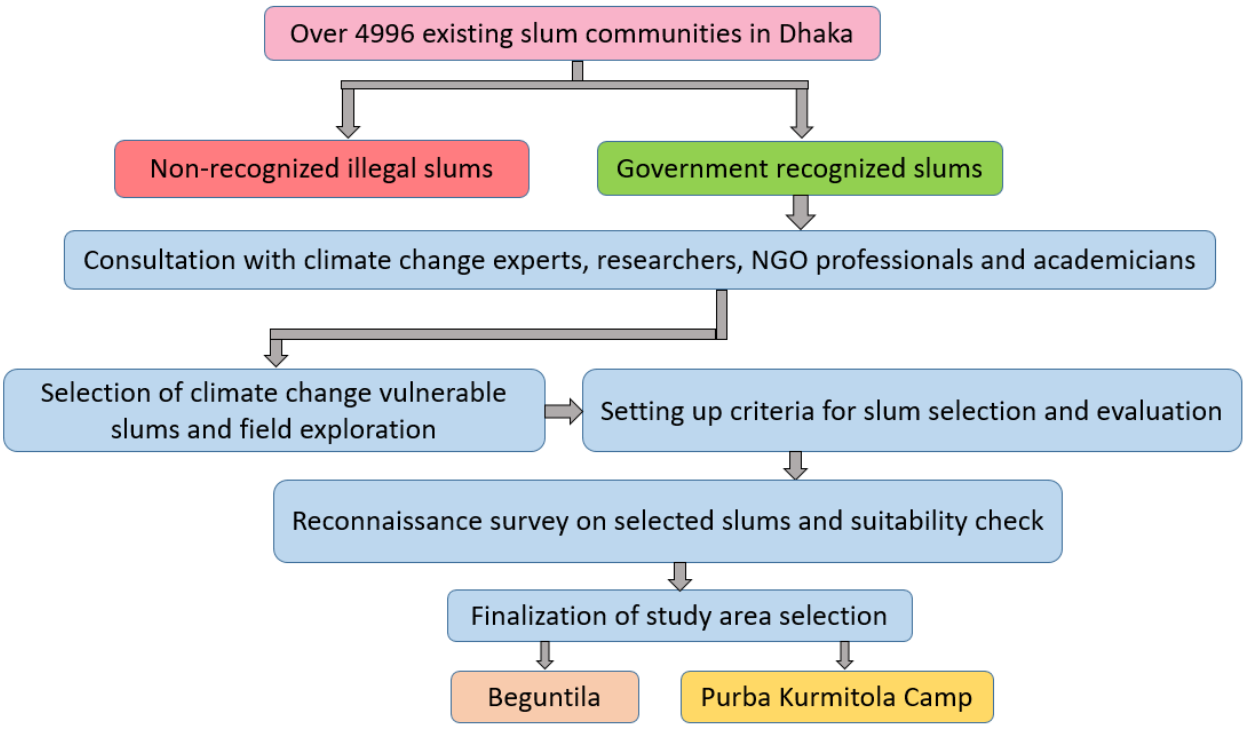


Figure 4.1: Process of selection of study areas
Source: Author (2018)

4.2.2 Qualitative vs Quantitative Approach

Research methods are categorized into two broad types in social science – quantitative and qualitative methods. The quantitative approach uses numbers to define, deduce and solve problems (Herbst & Coldwell, 2004). On the other hand, qualitative approach uses non-numerical elements and deals with unquantifiable data, especially answering 'why' and 'how' questions of human experience (Given, 2008). Qualitative method is preferred by social researchers to explore human life and behaviour (Flick, 1998, Silverman, 2013). However quantitative methods are sometimes more appropriate to address research problems such as showing statistics, numerical relation within the data, trend analysis etc. Nevertheless, purely

quantitative approach would exclude the study from exploring people's daily behaviours, perceptions, choices and experiences (Silverman, 2013). Qualitative approaches are applied to develop interconnected concepts and models (Strauss and Corbin, 1990) and explore areas where little is known (Stern, 1980). This research deals with community to understand their problems and work with community to design climate resilient infrastructure potentials. Considering the nature of this study, the qualitative method is more suitable approach than the quantitative one. Hence, the qualitative approach has been adopted in this research.

4.2.3 Research Method

This research followed a two-step methodology to meet the aim of this research by addressing the research questions. The first step of this research is conceptualization of existing situation through literature review from secondary sources. Books, journal articles and reports from government and non-government organisations as well as independent research papers were reviewed to collect information on climate change impacts and relevant statistical information on low income settlements of Dhaka. This information was helpful for developing the primary data collection. In the second step, qualitative data was collected within the case studies applying two qualitative research techniques i.e. Focus Group Discussions (FGD) and Key informant Interviews (KII). This stage involves establishing the effects of climate change on infrastructure and work with community to design a solution. A primary field observation was done before conducting Key Informant Interviews and Focus Group Discussions to become familiar with the area. The information gathered from the Key Informant Interviews and Focus Group Discussions are the primary sources of information for answering the second and third research question i.e. "what are the existing problems and underlying causes of infrastructural vulnerability due to climate change impacts in the low-income settlements" and "What measures should be taken in order to establish climate resilient infrastructure". The obtained information from FGD and KII has been presented in chapter five and chapter six of this thesis. The two step methodology of this research has been illustrated in the following figure.

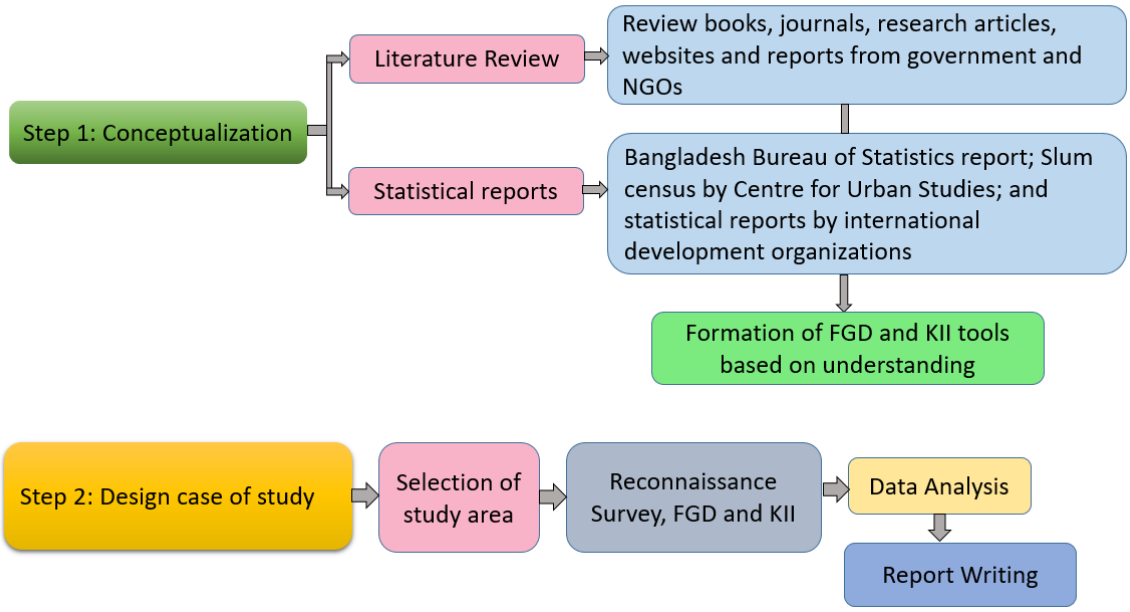


Figure 4.2: Two-step methodology of the research

Source: Author (2018)

4.2.4 Key Informant Interviews (KIIs)

Key Informant interviews are one-on-one qualitative in-depth interviews with key stakeholders who have first-hand information about the topic of interest (Caroll, Perez, & Toy, 2004). The interviews are loosely structured conversations depending on a list of issues (USAID, 1996). The key informants technique has long been used as a methodological approach (Campbell 1955; Tremblay 1957; Poggie 1972; Young & Young, 1961). As the methodology is found to be suitable and pragmatic for gaining privileged information, the technique has become quite common in the field of community research and planning (Anderson & Theodori, 2009; Claude, Bridger, & Luloff, 2000; Krannich & Humphrey, 1986; Schwartz, Bridger, & Hyman 2001). Key informants provide useful information about important characteristics of community that cannot be gained from secondary data (Claude et al. 2000; Fetterman 1989; Krannich & Humphrey 1986; Schwartz et al. 2001). The technique is advantageous for decision making or making recommendation through qualitative and descriptive information (USAID, 1996). It allows to obtain information directly from the people who have background knowledge on the particular issue. The method is flexible to new ideas to emerge, less expensive and simple to conduct (Kumar, 1989; USAID, 1996).

In this research, community experts having diverse background e.g. community leaders within the study area, representative of international development organisations and local Non-Government Offices (NGOs) and residents were selected for the Key Informant Interviews. A total of 10 key informants were selected for interview considering the time and budget limit. The informants were selected based on their expertise, involvement in infrastructural development, profession, leadership, experience and availability. Interviews were conducted face-to-face in the convenient locations of the participants. The participants were reached in their location to take the interviews after communicating over the phone or in person making it sure that the place is safe and comfortable for both parties. Most of the interviews were taken place in the workplace of community based organizations or NGOs; and in a safe and quiet public space. Each interview took 40 minutes to 1 hour at most depending on the nature of information and knowledge base of the informant regarding the subject matter. An interview schedule has been attached (appendix – six) outlining the areas covered in the interviews. The number of participants for the key informant interviews has been shown in the following table.

Table 4.1: Number of Key Informant Interview participants

Background of Expertise	Number of Participants
NGO Professional	3
Community leaders	6
Senior resident	1

All the participants were provided an information sheet and consent form (appendix – one) clearly mentioning the nature and purpose of the research and interview schedule prior to interview. It helped them to take time to give consent and also to think about the questions. It also allowed the participants to skip any questions they do not wish to answer. The information obtained from Key Informant Interviews were useful source of information to delineate the current infrastructural problems and root causes (Chapter 5), and also how to provide a climate resilient solution (Chapter 6).

4.2.5 Focus Group Discussions

Focus Group Discussion (FGD) is a form of qualitative research method where a small group of participants gathers in an interactive discussion focusing on a specific issue of interest guided by a moderator (Wong, 2008; Hennink, 2013). It adds another dimension to individual interviews by allowing interaction among the group participants (Wong, 2008). The focus

groups consist between 5 to 10 preselected participants having similar background or shared experiences related to the research issues (Hennink, 2013). The rationale behind this approach is that the group process allows to reach and clarify areas which are not usually accessible in individual interviews (Manoranjitham, 2007). The benefits of Focus Group Discussion methods are many. It is particularly useful to generate wide range of data in a very short time (Hennink, 2013). Focus groups have high validity of information as it is obtained from multiple participants (Rahman, 2012). It encourages individuals to participate who are intimated by the formality and isolation in an individual interview (Manoranjitham, 2007). It allows the researcher to obtain in-depth responses and opinions.

Focus Group Discussions (FGDs) have been conducted in this research to obtain detailed information about group perceptions and opinions regarding climate change impacts on infrastructure, underlying causes and possible solutions. A total of four Focus Group Discussions were conducted in the selected slums. To obtain the gender dimension of the information, separate male and female groups having 10 participants in each group were selected for the group discussion. A total of 40 participants attended on four Focus Groups. The number of participants in the focus groups has been shown in the following table.

Table 4.2: Number of FGD participants

Slum	FGD Type	Number of Participants
Beguntila	Male FGD	10
	Female FGD	10
New Purba Kurmitola Camp	Male FGD	10
	Female FGD	10
		Total : 40 Participants

The groups were selected randomly based on their availability in the appointed time of group discussion and their knowledge on the slum infrastructure and development. The participants were invited through local representatives introducing them about the discussion and ensure their availability for the discussion. The local representatives were identified through contacting the Habitat for Humanity International- Bangladesh, the NGO working for the slum infrastructure development in the Mirpur area. The information sheets were distributed in both of the slums and the community people were given brief introduction about the study purpose.

The local leaders were contacted after a week and list of participants were made. The participants were provided consent form for their signature. Both the information sheet and consent form were translated into Bengali language considering the literacy status in the low-income communities. A checklist for the Focus group discussion was prepared and translated into Bengali language for the convenience of the focus group participants. The Meetings were held in a meeting room of local NGO and Community based Organisation. To ensure the quality and quantity of communications, a suitable room with enough space and privacy was selected for each discussions. The participants were ensured that confidentiality is to be protected. The discussion started with open-ended questions and followed with more specific and closed ones. The whole sessions were audio - recorded and a field assistant accompanied in taking notes of the discussions. The Focus Group Discussion Checklist has been attached (appendix - seven) outlining the questions raised during the meeting. The problems of the physical infrastructure that were raised during the FGD were observed in the field and relevant photographs were taken. The possible solutions according to their opinion were noted which is covered in the chapter six.

4.3 Earning Community Trust: Ethical Issues

Earning community trust is crucial in obtaining quality information from the study field. It requires addressing the ethical issues and confidentiality of information provided by the participants. In this research, questionnaires for interviews and checklists for focus group discussions were developed considering the social and cultural values of the communities. Being a citizen of the same country where the study is conducted allowed me to understand cultural aspects of the participants. The project was approved by the Human Research Ethics Committee of the Faculty of Arts and Social Science prior to conducting field visit. The letter of Approval was displayed to the participants of this research to ensure them that it will be used for academic purpose of fulfilling the requirements of Master of Environmental Planning. The participants were informed about my research and provided an information sheet explaining the research and their rights as participants. It was ensured that the participation is voluntary and it is highly unlikely that the recorded information can have any form of potential risks as it is about working with community to design climate resilient infrastructure solution in the low income communities. Two consent forms were provided to each of the participants. After signing the consent forms, one signed consent form was kept for my own record and the other form was returned to the participants for their record. The participants were ensured that all

collected information will remain secure at all times. Prior to conducting FGD, the participants were informed that the discussions to be recorded using a device capable of storing good quality information. The Participants of FGD and KII were confirmed to retain the ownership of data. It was clarified that the written notes from Focus Group Discussions, Key Informant Interviews and other printed documents to be stored in a locked drawer. The participants were informed that all recorded information to be stored for a duration of five years using password protections. Anonymity of the participants were ensured unless otherwise requested by any participants. The participants of the focus group discussions were requested to keep information confidential as well.

4.4 Research Timeline

This research was conducted for one year starting from July in 2017 in order to fulfil the 90 credit Masters thesis requirement. It started with development of concept and formulation of initial research proposal. The field work has been conducted from end of November in 2017 till end of February in 2018. The thesis has been submitted in July in 2018 after completion of report writing. The research time and activities has been shown in the following figure.

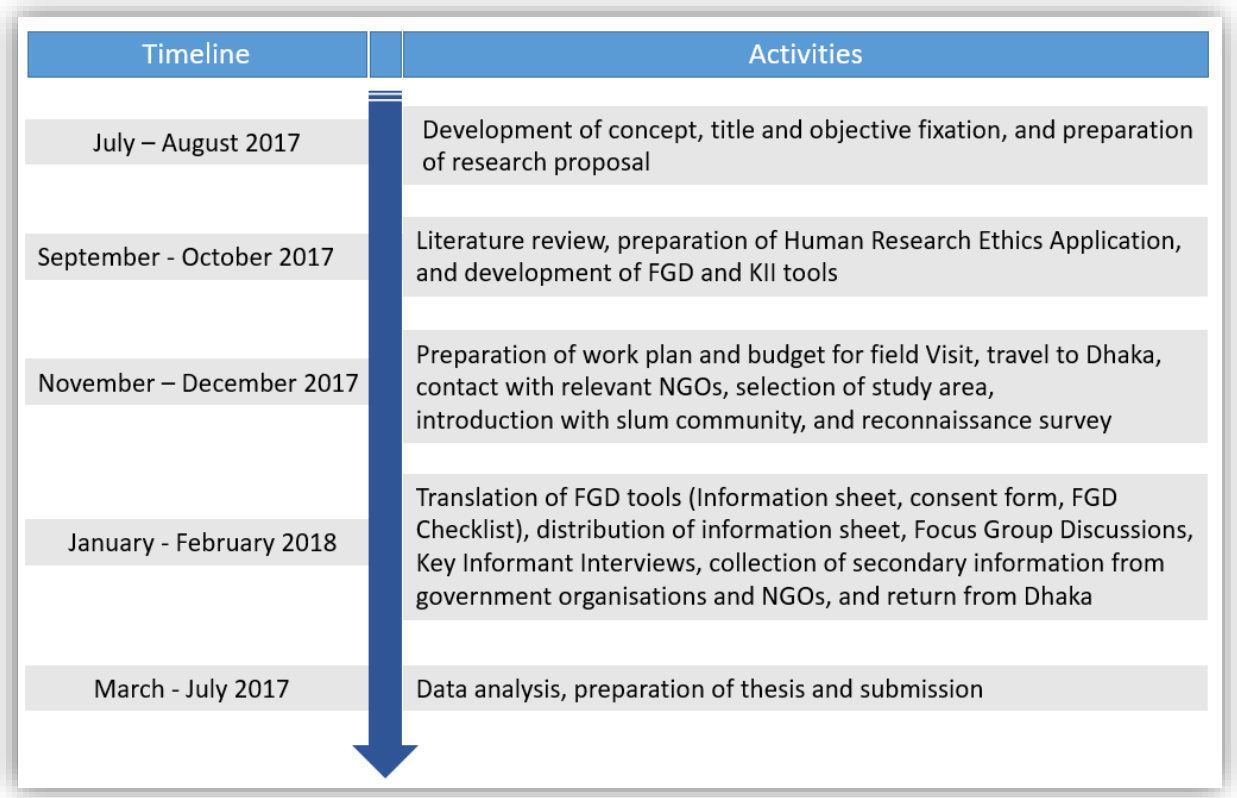


Figure 4.3: Research Timeline

Source: Author (2018)

4.5 Meeting Challenges in the Field

Conducting field study and data collection in the slum areas of a developing country like Bangladesh is always challenging considering the number of constraints such as gaining access, safety, security and budget. Fortunately, the strategy of gaining access to slum areas through contacting NGO was helpful in selecting secured study area and meeting the community leaders. The community leaders were also supportive in introducing the community the people about the research. There was local elections going on across the Dhaka city during the field study period. Keeping in contact with the local community leaders were helpful to get time-to-time information regarding the ongoing situation of the slum areas. For instance, there was a sudden fight between two groups of political parties in the Beguntila slum on the date of a Focus Group Discussion. A community leader informed about the incident before I arrive the place. The FGDs were postponed for two weeks until it became favourable for conducting the discussions. The community people were also supportive in identifying the vulnerable sites to heavy rainfall and storm. The support of NGOs, community leaders and slum dwellers allowed meeting the challenges in the field and making it successful.

4.6 Data Analysis and Recommendation

This stage involves analysis of qualitative data gained from field visit. The information obtained from the study area through field observation, focus group discussions and key informant interviews were analysed and interpreted in qualitative terms. A content analysis technique was applied to interpret the qualitative data. The responses for each topic from the key informant interviews were noted separately. Each of the responses was given a code according to number of similar responses. The audio records from Focus Group Discussions were noted on paper. Each topic of information from the FGDs were noted by separately and presented under each section of report. The qualitative information presented in the report were supported by the photographs captured from field visit as well. The recommendations collected from FGDs and KIIs were gathered separately and reported in the chapter six of this thesis.

4.7 Conclusion

This chapter has outlined the research methodology employed to address the aim of this study. Considering the aim of this research, qualitative research technique is appropriate to reflect perception of community and recommend based on their experiences. The process of study area selection considered multiple criteria that allowed selecting two distinctive slum areas. Application of both group discussions and individual interviews allowed collecting data in two

different settings. The following chapter outlines the climate change vulnerability on infrastructure, underlying causes, and role of key actors in the study areas.

Chapter Five: Theory into Practice – Understanding Vulnerability
Community Profile and Climate Change vulnerability of Beguntila and New Purba Kurmitola camp

5.1 Introduction

This chapter outlines community profile of Beguntila and New Purba Kurmitola Camp in brief. It attempts to identify the climate change vulnerability of these two slum communities according to the variables defined by UNISDR (2004) such as physical location, housing condition, sanitation and environment, and infrastructure. The root causes and consequences were identified according to the progression of vulnerability depicted in PAR model. These findings were derived from focus group discussions, key informant interviews and field observation. Community experts of diverse background have been interviewed as key informants to understand the vulnerability of the community to the impacts of heavy rainfall and storm. Separate male and female group discussions were conducted on both slums focusing on the same issue. To understand the vulnerability through observation, the study areas were carefully investigated and evaluated according to the responses of the participants. To capture the gender dimensions of climate change impacts, attention was also given to the vulnerability of women to climate change. All these information have been analysed and presented in this chapter.

5.2 Community profile

In this research, two slum communities, Beguntila and New Purba Kurmitola Camp, were selected for researching the vulnerabilities due to impacts of climate change and to work with the community to design a climate resilient solution to these vulnerabilities. The slum communities are located in the low-lying lands beside Balughat-Mastertek road under the jurisdiction of Ward 2 Pallabi Thana, section 12 in Mirpur. The actual location has been displayed in the Map 4.1 and Map 4.2 in previous chapter. The communities are located just beside the floodplains and wetlands making these settlements vulnerable to climatic hazards. In the north there is Mirpur DOHS area, in south there is Kalshi bus stand, in the east is Shaheen lake and in the west is Mirpur 12 residential area. The dwellers of these slums came from different slums commonly after facing eviction in their previous location. The literacy status of the dweller is below average. The communities consist low-income people engaged in diverse activities to earn their daily livelihood. The slums can be distinguished by the coverage of services from development organizations. The Beguntila slum is known as an ideal slum.

The community is well organised under the leadership of elected community members. The slum is also receiving support and guidance from multiple NGOs for infrastructure development and maintenance. On the other hand, the New Purba Kurmitola Camp received limited support from development organizations for infrastructure development support. The reason for selecting two different types of communities is to represent two different scenario of dealing with climate change impacts and vulnerabilities. The community profile of Beguntila slum and New Purba Kurmitola camp has been outlined in the following sections.

5.2.1 Beguntila Slum

Beguntila slum is located in the north side of Balughat-Mastertek Road beside the Shaheen Lake. In 1999, about 49 slums from different parts of Dhaka were subjected to forced eviction by the government (Joshi, Morgan & Fawcett, 2005). A large number of these displaced population led by local leaders protested for justice and rehabilitation in front of High Court in Dhaka. As a result, the government then agreed to provide temporary rehabilitation on the vacant government lands. Eventually the Beguntila slum was emerged. According to the slum dwellers of Beguntila, the dwellers were initially assured that they would secure permanent rehabilitation. However, they are not provided any security as yet. Therefore, the residents living in this slum are bearing the insecurity of getting evicted anytime. This is a reason why the slum dwellers are afraid of making substantial investment for infrastructure development. The NGOs are also not interested in big projects where there is a lack of permanency of land. At present there are about seven hundred families currently staying in this slum under this insecure condition according to local people. The total land is 9.3 acres (Habitat for Humanity Bangladesh, 2018). There are 20 lanes in the slum, most of the lanes are found to be concrete lanes except few are soil lanes in the eastern part. The houses were provided by the government and NGOs. The structures are made by corrugated iron sheet supported by bamboo and iron. The floor of the houses is clay soil. Few have cemented floors. Some of the houses were repaired by the NGOs recently. Most of the slum dwellers are Muslim by religion and some are Hindu.

The community people are engaged in various types of occupation to earn their living. There are rickshaw pullers, small grocery owners, small tea stall owners, garments workers, drivers, handicraft designers, day labourers and street beggars living in the slum. A few of the residents work in government offices and private jobs. The literacy status of the dwellers is very low. Many children are going to primary schools and NGO supported education centres. There is a

community clubhouse in the slum. It is commonly used for social gathering and arranging meeting. During time of flooding, this house is used as a temporary shelter for the dwellers who suffer from inundation. The communities use the communal toilets and bathroom constructed and repaired by the NGOs and community funding. There are water points for the community to collect drinking water.

According to the people of Beguntila slum, the community is well organised under the leadership of elected local members. The members are elected by the local people through World Vision – an International NGO providing support in the community. There are separate committees formed to monitor different community issues. The committees are headed by a chair of Community Based Organization (CBO). Currently there are Child Protection Committee; Water, Sanitation and hygiene Committee; Community Vulnerability and Adaptation Committee; and Waste Management Committee. According to them, this system allows the community to deal with community problems in an organised way. It ensures better participation among the community members and help to develop the sense of shared responsibility. The NGOs consult with the committee members for any interventions taken in the community. The committee members discuss with community people to make decision. Thus, the committee members act as a vocal for the community people.

5.2.2 New Purba Kurmitola Camp

New Purba Kurmitola Camp is located in the east side of Sagufta New Road at the edge of the floodplain as shown in the Map 4.2 in previous chapter. The slum dwellers are Bihari population. The communities speak a different language than Bengali. However, they use Bengali in daily communications. The slum community consists the evicted Bihari population from different slums. The community reported that Bangladesh Army evicted them to construct road in their previous location ten years ago. They have been relocated into this slum since then. The army constructed some houses for them as a part of temporary rehabilitation. Other houses were constructed by the dwellers. The community has no legal right over their land. Therefore, there is always a fear of eviction within the community. This fear discourages the community to invest hard-earned money for the development of housing and infrastructure. The total area of the slum is 4.40 acres (Habitat for Humanity Bangladesh, 2018). According to community, there are about 2100 people living in in 450 families in this slum. The people are Muslim by religion. They have tin shed houses supported by bamboo and iron sheet with floor made by clay soil. Only few houses have a cement floor.

The community people are involved in different types of livelihood activities. The Bihari communities have good reputation for making handicrafts. Many families are engaged in handicraft making activities. The children were also seen helping in handicrafts. There are also rickshaw pullers, small grocery owners, small tea stall owners, garments workers, drivers and day labourers living within the community.

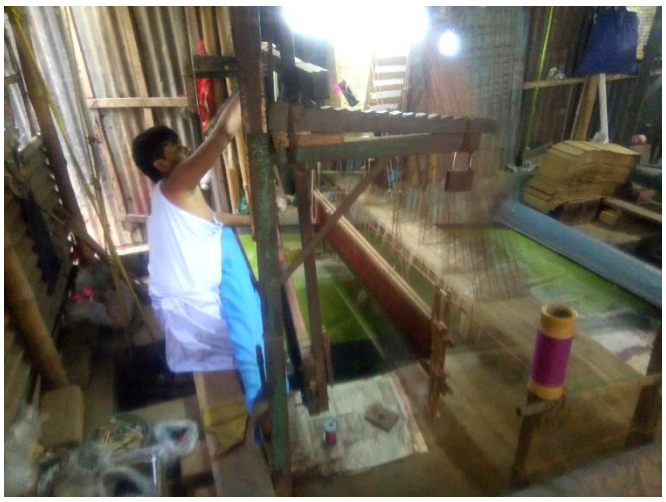



Figure 5.1 and 5.2: Handicraft activities in the Purba Kurmitola Camp slum
Source: Field survey (2018)

The literacy status of this community is very low. There is an NGO supported primary education centre within the community. However, many children attend nearby primary schools and madrasas. A female leader leads the community. The yard of her house is developed by an NGO which is used for social gathering and meeting. The communities use communal toilets and bathrooms constructed by an NGO. There are water points for the community to collect drinking water.

Being located at the edge of lake, the slum dwellers face severe inundation during the rainy season. However, at present there is no NGO working in the field of drainage and sanitation within the slum. According to community people, previously one NGO provided recycle bins and built one concrete lane having drainage underneath it. For small infrastructure development work, the community takes help of community based organization. The leader collects funds from the community for repairing infrastructure.

5.3 Climate Change Vulnerability

In this research, the climate change vulnerability of Beguntila slum and New Purba Kurmitola Camp slum has been assessed to depict the existing vulnerability, underlying causes of this and the consequences due to heavy rainfall and storm. Although we cannot say these events are direct result of climate change, these kind of events we can expect to see more of in the future. The variables defined by UNISDR (2004) i.e. physical location, housing condition, sanitation and environment, and infrastructure were assessed. The three components of vulnerability exposure, sensitivity and adaptive capacity that are defined by Australian Greenhouse Office (2005) were analysed. The exposure and sensitivity of the climatic impacts were compared to adaptive capacity to find the study area. To understand how vulnerability leads to disaster - the root causes, dynamic pressures and consequences were analysed by applying PAR model. The responses from focus group discussions and key informant interviews, and field observation are the sources of information on the community vulnerability to heavy rainfall and storm. The sites were visited during the time of continuous rainfall to understand the exposure, sensitivity and adaptive capacity.

In the beginning of field research, the dwellers of Beguntila slum and New Purba Kurmitola Camp were provided the understanding of climate change and its impacts. It is interesting that many participants have good understanding about the fact as it is becoming more evident over time. All the participants of focus group discussions and key informant interviews from both slums agreed that the selected slums are vulnerable to climate change impacts. Most of the participants from both communities recognized the severity of the damages caused by heavy rainfall and storm among the impacts. The community members can recall the massive damages caused in 1998 and 2004 flood event as they faced extreme inundation during the flood. Among the other impacts caused due to climate change, the participants shared their bitter experiences due to rise in temperature in summer and decrease of temperature in winter that brought sufferings to them. According to them, community vulnerability differs according to gender and age. Hence, it is important to understand the gender dimension of vulnerability. In this research, separate male and female focus groups were selected to discuss the issues and delineate the gender dimension of climate change vulnerability. Climate change vulnerability according to gender and age is discussed in section 5.8.

To understand the patterns of vulnerability, the root causes and the consequences - it is important to inspect each of the infrastructural features. The following sections describe the

existing vulnerability and problems of infrastructure due to climate change impacts in Beguntila and New Purba Kurmitola Camp slum respectively. It outlines the underlying causes and the consequences of these infrastructural vulnerabilities to depict the progression of vulnerability impacted by climatic hazards that leads to disaster condition.

5.4 Climate Change Vulnerability of Beguntila Community

The Beguntila slum is vulnerable to impacts of climatic hazards in many ways. Among the vulnerabilities, the location, as illustrated in the Map 4.2 in previous chapter, is a significant one. The presence of Shaheen Lake and floodplains in the eastern part of the slum makes the community highly vulnerable to severe inundation. The downward sloping Balughat-Mastertek road that starts from the Sagufta New Road meets Beguntila Slum in the low-lying areas beside the Shaheen Lake.

Figure 5.3 and 5.4: Downward sloping Balughat-Mastertek Road towards Beguntila Slum
Source: Field survey (2018)

The community people mentioned that all the dirty water from surrounding areas of Mirpur meet here. For this reason, this part is often called '*Kalapani*' which means black water. According to FGD participants and key informants, the eastern side of the slum, which is adjacent to Shaheen Lake, is highly vulnerable to inundation during rainy season. The western part is also vulnerable because of poor drainage system.

Figure 5.5 and 5.6: East side of Beguntila slum adjacent to Shaheen Lake
Source: Field survey (2018)

The community respondents indicated that poverty is triggering the existing vulnerability in multiple ways. Due to poor economic condition, the community cannot invest in the reinforcement of structures. Lack of security of tenure is another reason the community highlighted for the vulnerable condition. The constant fear of eviction discourages the community people to make a collective effort to address these vulnerabilities. According to them, the community faces inundation and some sort of infrastructural damages every year due to heavy rainfall and storm. The following section outlines the impacts climatic hazards on infrastructure of Beguntila community in brief.

5.4.1 Impacts of Climatic Hazards on Infrastructure

a) Impacts on Water, Sanitation and Drainage

According to community participants of Beguntila slum, the water, sanitation and drainage infrastructure is usually effected due to torrential rain. Intense rainfall for many days inundates the area mainly in the eastern side. Consequently, people face difficulty to access to safe water and sanitation. The tube-wells and most of the toilets were found to be well above the ground level. Hence, the inundation after the torrential rain does not hamper the availability of fresh water from the water points or tube-well. However, during the time of flood, the toilets and tube-wells become inundated. In that situation, the crisis for fresh water and sanitation arises. The community people could recall the severe flooding they faced in 2009. The toilets and tube-wells were inundated. Some of the dwellers had to leave the place and temporarily stay in

their relatives' houses. Sometimes leakage of sanitary pipe occurs during inundation. The septic tanks also overflow when these are filled up by rainwater. This results in outbreaks of diarrhoea, dysentery, cholera and skin diseases. Due to congestion of sanitary pipes during inundation, sometimes the waste backflows inside the toilet. It causes foul odour and unhygienic conditions inside the toilets. A sewerage system does not exist in Beguntila slum. Hence, the water remains for a long time until it drains out naturally.

Many participants reported severe drainage congestion after torrential rain in Beguntila slum. Since there is no screener in many drains, the wastes easily go inside the drain. It blocks the drainage system and causes overflow of water from the drain. It is sometimes responsible for odour pollution and mosquito menace. During storm, the wastes easily enter inside the drain in absence of screener or slab.

Figure 5.7 and 5.8: Broken drains in the Beguntila slum
Source: Field survey (2018)

b) Impacts on Housing

The houses in Beguntila slum are corrugated iron sheets supported by bamboo. The tin roofs are supported by wood, iron or bamboo. The ground of the houses are mostly levelled by clay soil. The ground level of the house is below the road level as the house lanes slopes upward to meet the Balughat-Mastertek Road. According to all of the participants from Beguntila community reported that the houses are inundated during severe inundation and water enters the house. The severity of this occurrence is very high during intense and continuous rainfall. According to them, the tin-shed house is highly vulnerable to storm. Some participants reported that the tins were blown away by strong wind during the storm. Hailstorms caused holes in the tin. Some of the female participants reported that the water entered into kitchen and they could not cook food. As the water entered inside house, it caused damages to the household goods. During flood, the slum dwellers had to leave their houses and take shelter in the community meeting room or relatives' house temporarily.

c) Impacts on Road and Electricity

During focus group discussion with Beguntila community, the participants reported that the roads of the eastern part and the western part of the slum are mostly inundated during the rainy season. According to the participants of the male FGD, all the roads become inundated except the central part of the slum area during severe inundation. Since the roads are made of clay soil, it becomes muddy and people are susceptible to injury during the rainy season. The male participants of the FGDs reported that it becomes very difficult for movement during rainy season, especially for the rickshaw pullers. The parents become worried for the safety of their children. The women face difficulties to move in the water. Since the water collection points and toilets are far from home, it becomes difficult for the women to get access to water and sanitation facilities. Sometimes trees fall on the road and block the road after the storm.

During a storm, the electricity is frequently interrupted. Since the poles are made by bamboo and very light, the electric connection is interrupted by storm. The community expressed their concern about the susceptibility of these electric poles. They reported injuries due to electric shock in Beguntila slum a few years ago which raised their concern. The female FGD participants reported that three goats died because of electric shock during inundation. Hence, it possesses a major threat in the upcoming rainy seasons. The community participants stated that the electricity providers are not interested in improving the poles. The electric wires were

found to be hanging in the poles haphazardly. It makes the electric poles to be highly vulnerable to storm.

Figure 5.9 and 5.10: Electric wires hanging on light bamboo poles over tin-shed house
Source: Field survey (2018)

The above figure is an example of the vulnerability of the electric poles in the Beguntila slum. It is clear that the bamboo poles are very old and the wires are hanging in a haphazard condition. Such a condition can lead to fatal accident during a storm.

5.4.2 Underlying Causes for the Vulnerabilities and Consequences on Infrastructure System

A number of factors worsen the impacts of the climatic hazards in Beguntila. These are due to infrastructural deficits and man-made vulnerabilities. These root causes have corresponding consequences on infrastructure system of the slum. The community participants of focus group discussions and key informant interviews helped to delineate the root causes of the vulnerabilities and corresponding consequences on the infrastructure of Beguntila slum.

According to the Beguntila community, the major reason for these vulnerabilities on infrastructure due to heavy rainfall is inefficiency of current drainage system. The community people stated that the drain height is too low in some places. The drain water flow is not well designed. The width of drain is narrow in most of the cases. The narrow width and low height causes delay in draining out the rainwater. There is no screener or slab found on drain apart from the new constructed drains in few lane. Since most of these drains are uncovered, the solid wastes easily fall over drain. Thus, the movement of rainwater through drain is often interrupted by the wastes. The clogged drain overflows the water and the surrounding area becomes inundated by rainwater. As the water blocked by waste remains still for many days, it results in odour pollution and a mosquito menace in the nearby area. The different height and width of the drain is another cause for inundation. It was found during field investigation that the new constructed drains have more height and width than the old drains. It was observed that the new drains have height of 3 feet and above, whereas the old drains are narrower having height of 1.5 feet to 2 feet. Since the drains from different lanes connect with the drain in the road, the new drains having more height connects with the old drain in the road which have less height. In such a case, the flow of rainwater is interrupted in the junctions. The rainwater overflows from drain and inundates the adjacent roads and houses.

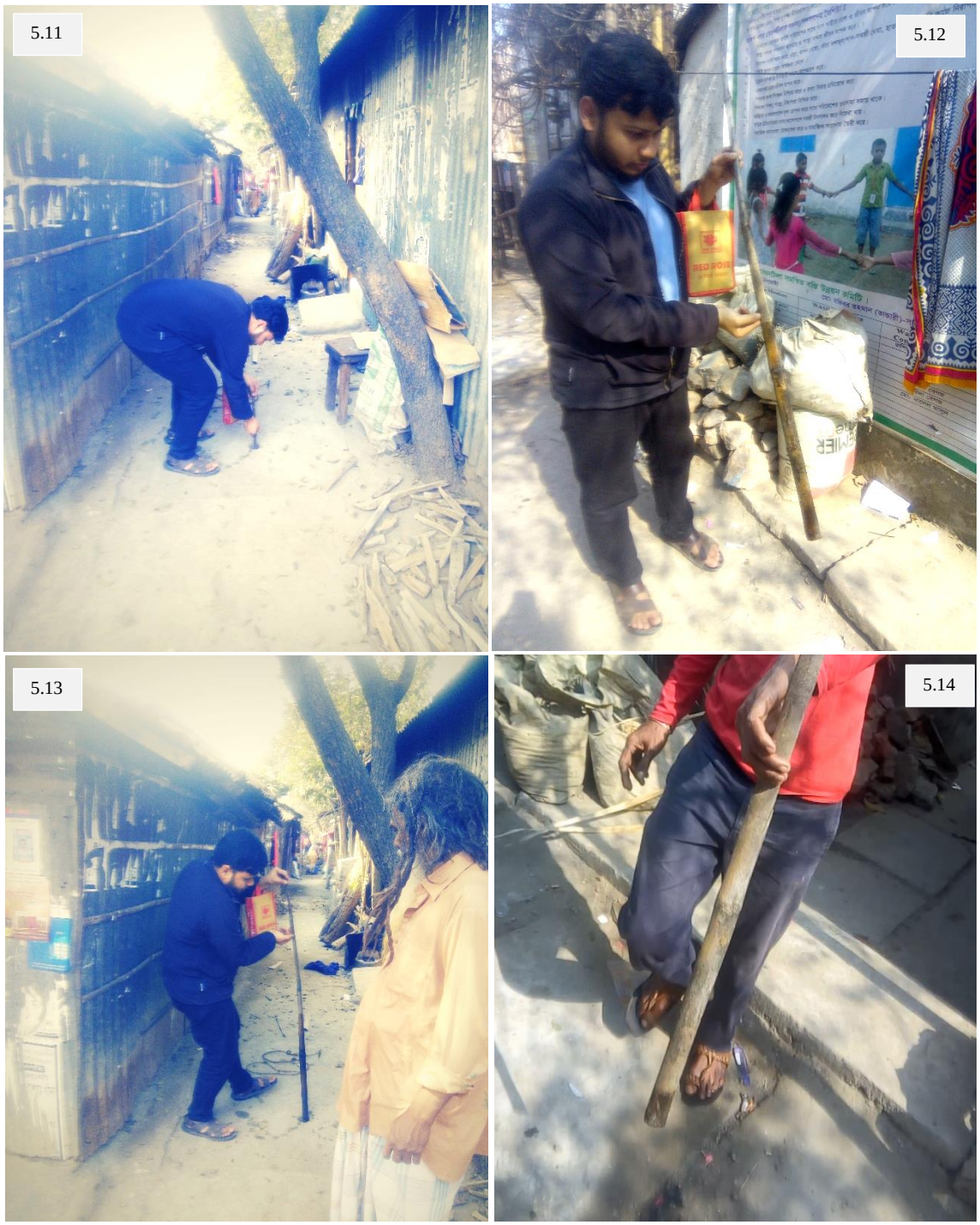


Figure 5.11, 5.12, 5.13 and 5.14: Drain height measurement with stick shows different height for different drains

Source: Field survey (2018)

During the field investigation, it was found that there is no sewerage system in Beguntila slum. Although the toilets and tube-wells were found to be well above the ground level, the septic tanks become filled by water during inundation. Therefore, the water from the septic tank overflow inside the toilet. It hampers the hygienic condition of toilet. The leakage of sanitary pipes cause pollution sometimes. The community people reported that the leakage of sanitary pipes cause skin diseases. The children are mostly vulnerable to skin disease. Since the toilets are not equally distributed throughout the slum, some people need to walk far to have access to sanitation facilities. These families face difficulties to access toilets during the time of inundation. In such a situation, some people defecate in open spaces. Particularly, the women suffer a lot to have access to sanitation facilities at night during inundation.

The tin-shed houses made by corrugated iron sheet supported by bamboo and metal sheet are unable to withstand strong wind during the time of storm. During the field investigation, it was noticed that few houses were bent. The dwellers reported that the houses were bent due to the impact of a storm. The community stated that these houses are vulnerable to hailstorm and strong wind. Some of the community participants reported that hailstorm caused holes in their tin-roof.

Although the roads of Beguntila are concreted, the lanes in the northern part of the slum are not concreted. In the northern part, the clay soil lanes become muddy during rainy season. Hence, people often slide or become stuck in the lanes. The community stated that children often fall in these muddy lanes and suffer injury. Some people stated that cutting the concrete roads damaged the durability of the roads. According to them, the concreted roads are sometimes dug to install utility lines.

The community stated their concern regarding the electric poles. According to them, the bamboo poles supporting the electric wires possess a threat during the time of storm. The community reported frequent electric failure during the rainy season as the electric poles or the wires sometimes cause electric failure during and after storm. The community people reported collapses of electric poles on tin shed houses and roads.

The following table highlights these underlying causes and corresponding consequences on infrastructure with frequency of occurrences.

Table 5.1: Underlying causes for vulnerabilities and consequences on infrastructure in Beguntila

Type of Infrastructure	Underlying Causes	Consequences	Frequency of Occurrences
Drainage	Drain height too low	- Overflow of water in little rain during rainy season	Often
		- Roads and houses are inundated	Sometimes
		- Free movement and livelihood are interrupted	Sometimes
		- Disable and children are effected	Sometimes
		- Outbreak of skin diseases and communicable diseases	Sometimes
	No Screener or slab	- Congestion of water by waste	Often
		- Odour pollution surrounding drain during inundation	Often
		- Mosquito and fly menace	Sometimes
		- Water spills from the drain	Sometimes
	Narrow width	- Overflow of water in little rain	Often
		- Takes long time to drain out rain water	Often
		- Causes inundation in the nearby area	Sometimes
House	Tin-shed houses are very light	- Tin roof gets blown away during storm	Rarely
	Hole in tin (caused by hailstorm)	- Rain water enters into house through hole	Rarely
	Road level higher than ground level of house	- Rain water or flood water enters into house	Sometimes

Road	Road surface is made by clay soil in the northern part	- The road surface gets muddy and walking becomes difficult as the feet slides on the surface or plunge	Often
	Cutting road for installing water pipe	- The soil dug washes away by rain and blocks the drain	Rarely
Sanitation	Unsewered septic tank gets filled during inundation in the eastern part	- Overflow of excreta inside the toilet	Sometimes
		- Creates foul odour and unhygienic condition	Sometimes
Electric poles	Electric wires are hanged haphazardly over light bamboo poles	- Frequent failure of electricity during storm	Often
		- Electric poles tilt during storm	Rarely

5.4.3 Key Institutions and their Roles in Beguntila

The community participants of Beguntila stated that most of the contributions of infrastructural development are done by the NGOs. The community leaders act between the NGOs and the community. Before taking any kind of development activities, the NGOs require permission from the government. The community leaders and NGO work together to obtain permission from the City Corporation. According to the community participants, this process gives some kind of security of the investment made for infrastructural development. According to the community, most of the infrastructural development support, such as roads, toilets, drainages and house repairs are provided by Habitat for Humanity Bangladesh at present. However, there are other organizations playing an important role for infrastructure development in the slum community. The following table contains the key organisations working in the slum community and their contribution in brief.

Table 5.2: Key Institution and their roles in infrastructure development in Beguntila

Name of Organization	Key Roles in Beguntila Slum
World Vision	- Construction of several toilets - Construction of water Reservoirs
Plan International Bangladesh	- Disaster training workshop - Provided meeting room for developing community engagement - Construction of toilet
Habitat for Humanity Bangladesh	- Construction of toilet - Construction of 300 feet road - Construction of drains - Repairing of the vulnerable houses - Construction of water reservoirs - Community risk assessment - Capacity building training to community
Dushtha Shasthaya Kendra (DSK)	- Construction of water reservoirs -Construction and repair of toilets
NGO Forum	- Construction and repair of toilet - Construction of water reservoir
WSUP Bangladesh	- Construction of toilets
BRAC University	- Water quality testing
Dhaka City Corporation	- Construction of drains - Construction of toilets
Nagar Seba	- Conducted survey for providing water connection

According to the community, the NGOs have started considering climate resilience issue before building infrastructures. For example, the new toilets by Habitat for Humanity Bangladesh are set up well above the ground level. Hence, these toilets do not go under water during inundation. The NGO is currently working on building climate resilience in the study area. For that purpose, the NGO conducted community risk assessment before development of new infrastructure. They improved a few lanes and the drains as well. The drains are constructed with increased width and height than previously. Concrete slabs were provided to drain out water from the

lanes. Plan International Bangladesh is encouraging community participation in disaster issues, the NGO is providing disaster training workshops to the community.

5.5 Climate Change Vulnerability of New Purba Kurmitola Camp Community

During field observation on different slums of Dhaka, it was found that the New Purba is one of the most vulnerable slums to impacts of climatic hazards in Dhaka. The geographical location and the surrounding features of the slum makes it highly vulnerable to climatic hazards. The southern boundary in the backside of the slum is covered by a large floodplain. Since the space is fully open, the storms hit this part of the slum every year. During the rainy season the slum gets inundated by the water from the floodplain. The vulnerability due to location is illustrated in the Map 4.2 in previous chapter. During a reconnaissance survey, many broken tin-shed houses were found in the backside of the slum near the floodplain. These structures were blown away during storm. The slum is also vulnerable to inundation because of a poor drainage system. While discussing about the climate change and its impacts, one of the community respondent expressed helplessness to climatic hazards in following words.

"The poor people suffer the most, for they tackle the most (climatic hazards). Poverty made us defenceless".

This statement makes it clear how the poor economic condition led them to live in a vulnerable condition. Due to their poor economic conditions, the community are unable to invest in infrastructural development. The community people have no legal status in the land. Therefore, they live in the area with constant fear of eviction. This fear discourages the community people to make collective effort to address these vulnerabilities. The following section outlines the impacts climatic hazards on infrastructure of New Purba Kurmitola Camp community in brief.

5.5.1 Impacts of Climatic hazard on the infrastructure of New Purba Kurmitola Camp

a) Impacts on Water, Sanitation and Drainage

The slum dwellers of New Purba Kurmitola Camp stated that the water, sanitation and drainage system of the slum is hampered during heavy rainfall and storm. According to them, there is no proper drainage system available in the area. Only one lane has a drain under it. Since the area is situated in a low-lying land beside the floodplain and no proper drainage is available, the slum becomes submerged under water in the rainy season. During the time of inundation, the community, especially women and children, find it very difficult to access water and

sanitation facilities. The toilets are located in the backside of the area near the floodplain. The toilet is set up well above the ground level. However, the existing number of toilet is very inadequate considering the number of population living in the slum. Therefore, too many people share one toilet. The condition of the pans inside the toilet are not good as well. The participants of the FGDs reported that the pans are unsteady. During inundation, the scenario becomes even more difficult. The community participants stated that the output pipe of the toilet is connected to the floodplain. So during inundation, the pipe gets blocked and the waste water overflows in the toilet. The sanitary pipes leak sometimes, water spills out from septic tanks when these are filled up by rainwater. It causes major problems to people and hampers hygienic sanitation process. This situation also causes the spread of communicable diseases. The community also reported snake attacks during rainy season. The unhygienic condition of drains cause odour pollution and mosquito menace.

During flood, the community faces crisis of safe water as the tube-wells are inundated and the water is contaminated by flood water. According to the community, the community faced crisis of safe water during flood of 1999 and 2009. In absence of a sewerage system, it takes a long time to drain out water naturally.

b) Impacts on Housing

"*The storm came in such a way that the tin of our house was flown to the lake. My daughter's hand was cut by the tin*."

The above statement from a community participant of New Purba Kurmitola Camp reflects the current vulnerabilities of the tin-shed houses near the lake. These tin-shed houses of New Purba Kurmitola Camp are impacted by storm and heavy rainfall every year. According to the community, the houses are inundated almost every year in rainy season. Lack of drainage is the main reason according to them. When the water enters inside house, they set bricks under their bed to elevate the level. The household goods are sometimes damaged by the rainwater. There is also risk of snake attacks during this period. According to them, the tin-shed house is highly vulnerable to storm. It was found that many houses were blown away or distorted by storm. The hailstorm caused holes in tin. The community people reported that one old women died some years ago due to lightning hitting the house. The female participants reported that the water entered into kitchen and they could not cook food. During severe inundation, the

families affected leave their houses and take shelter in relatives' house temporarily. One community participant expressed his never-ending sufferings in following words.

"Our salary ranges from 5000 to 6000 taka every month. When the rainwater becomes dry, the frame of our houses collapse since the soil washes away [by rain]. We repair our houses again. Again, houses are inundated in rain and again we repair it. That means we cannot save money from our earning to be in a better position. We are in such a difficult situation."

The above statement depicts the continuous struggle of repairing the floor of the house each time the house faces inundation in the rainy season. Since this slum receives little attention or support from the NGOs, the dwellers need to borrow from micro-credit providers to repair their houses. Hence, it puts economic stress to such a low-income disadvantaged community.

Figure 5.15 and Figure 5.16: Tin-shed houses were blown away by storm near the Lake.
Source: Field survey (2018)

c) Impacts on Road and Electricity

The New Purba Kurmitola Camp community reported that the road and the lanes are under water after torrential rain or during flood. During a field visit, it was found that a little rain caused the lanes become muddy and difficult for walking. The community people reported that the reason for this inundation is filling of nearby wetlands. The female FGD participants reported that it becomes difficult for them to move in the muddy lanes to collect water or to

access to toilets. The children and disabled people are vulnerable to injuries in these muddy lanes. At night, it becomes difficult for the people to walk.

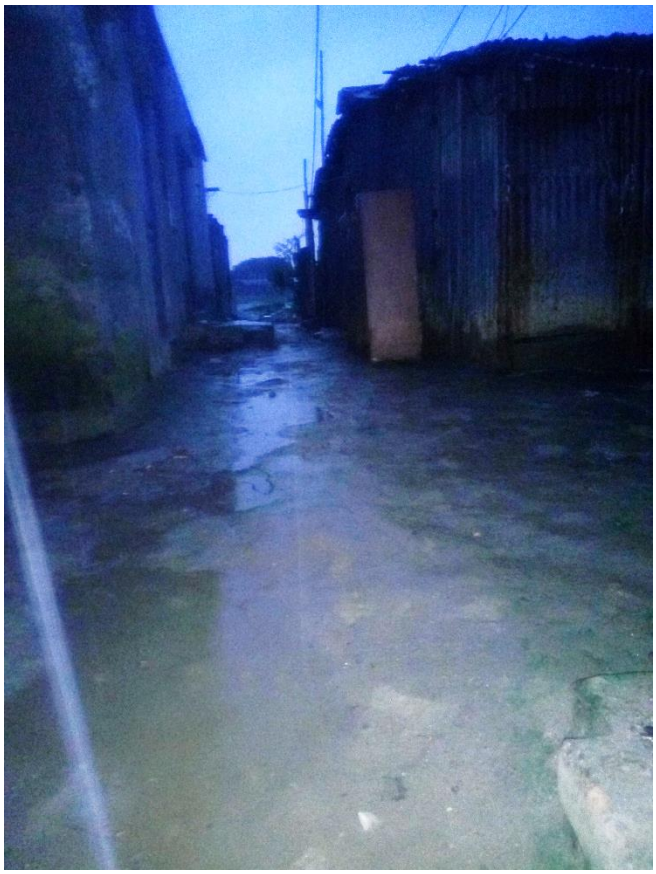



Figure 5.17 and 5.18: The lanes of New Kurmitola Camp became inundate and muddy inundated in little rain
Source: Field survey (2018)

The above figure illustrates the impact of little rain for few hours in the New Purba Kurmitola Camp. Figure 5.17 was captured during the time of rain and figure 5.18 was captured the next day. In absence of drainage system, it takes a long time for the road to become dry. During the time of severe inundation, it becomes even more severe.

The electricity distribution system and vulnerability of new Purba Kurmitola Camp is found to be almost same as Beguntila slum. The light bamboo poles are vulnerable to storm. The electricity is frequently interrupted during storm. The FGD participants of New Kurmitola

Camp community reported injuries due to electric shock. The electric wires were seen hanging in the poles haphazardly making them highly vulnerable to storm.

5.5.2 Underlying Causes for the Vulnerabilities and Consequences on Infrastructure

During focus group discussion with the community and interviews with experts, the participants of New Purba Kurmitola Camp were asked to explain the root causes that aggravates the climatic impacts on infrastructure. The community participant helped to identify a number of root causes and their consequences on infrastructure.

According to them, the prime reason for these vulnerabilities is that there is no wall or embankment to protect the slum from the water of floodplain. In absence of such protection, the whole area is under water in the rainy season every year. Another key reason the community highlighted is the lack of drainage system. In absence of which, the situation becomes worse after heavy rainfall for few days or during flood and the slum remains under water for long time. Filling up nearby wetlands added more pressure to the existing situation. The water level in the floodplain becomes higher as it cannot distribute the water to nearby waterbodies properly.

There are other reasons for the vulnerabilities on infrastructure. The materials used for the house structures are very weak. Due to their poor economic condition, most of the houses are built from low cost materials. Most commonly used materials for building houses are corrugated iron sheet, bamboo, wood and iron plate. The floor is constructed by clay soil. These houses are very weak to withstand strong wind during storm.

The walking lanes are not concreted. These clay soil lanes become muddy during rainy season. According to the community, the roads cannot pass water in absence of drainage system. Therefore people often slide or become stuck in the mud. Children often fall in these muddy lanes and suffer injury. The community uses sand bags or bricks to walk during inundation. However, it does not help when the water level is too high due to torrential rain.

The main distribution pole for electric supply is wooden. However, the electric poles connecting the houses in the slum are set by bamboo stands. According to the community, some of the bamboo poles have become old. These poles often sway or even collapse during storm. These weak poles often possess threat to injure people staying in the tin-shed houses.

The following table outlines these underlying causes and their consequences on infrastructure system.

Table 5.3: Underlying causes for vulnerabilities and consequences on infrastructure in New Purba Kurmitola Camp

Type of Infrastructure	Underlying Causes	Consequences	Frequency of Occurrences
Drainage	No drainage system in the slum apart from a new drain constructed in one lane	- Roads and houses are inundated in rainy season	Very often
		- Free movement and livelihood are interrupted during inundation	Very often
		- Disable , children, pregnant women and old people are affected	Sometimes
		- Outbreak of skin diseases and communicable diseases	Sometimes
		- Mosquito and snake menace during inundation	Sometimes
		- Takes long time to pass rain water	Often
	Filling up of nearby wetlands in south	- The water level of the floodplain rises higher than before, water enters the slum area and causes inundation	Often
House	Tin-shed houses are very light	- Tin roof gets blown away during storm	Rarely
		- The houses are damaged and distorted by storm	Rarely
	Hole in tin (caused by hailstorm)	- Rain water enters into house through hole	Rarely
	Road level higher than ground level of house	- Rain water or flood water enters into house	Sometimes

Road	Road surface is made by clay soil	- The road surface gets muddy and walking becomes difficult as the feet slides on the surface or plunge	Often
		- Disable , children, pregnant women and old people are affected	Sometimes
Sanitation	Unsewered septic tank gets filled during inundation	- Overflow of excreta inside the toilet during inundation	Often
		- Creates foul odour and unhygienic condition	Often
	The toilet pipe is connected to adjacent waterbody in the south	- The toilet pipes are blocked during inundation and waste water backflows inside toilet	Often
	Hanging latrines	- The hanging latrines cause unhygienic condition in its surroundings during inundation	Very often
		- Creates nuisance of mosquito, fly and Insects	Very often
	Tin-roof on toilet	- The roof of the toilet are blown away by storm	Sometimes
Water	Tube wells are not installed high above the ground level	- Tube-wells sink under water during inundation	Sometimes
		- The dirty water of tube-well spread diarrhoea, fever and skin disease	Sometimes
Electric poles	Electric wires are hanged haphazardly over light bamboo poles	- Frequent failure of electricity during storm	Often
		- Electric poles collapse during storm	Rarely
		- Causes injury to people	Rarely
Waste	No proper waste management system and only few waste	- Creates nuisance of mosquito, fly and Insects	Very often
		- Causes odour pollution	Very often

	bins are available as many of them are stolen	- Mixes with water, and causes pollution and skin disease during inundation	Often
Embankment	No embankment in the south to prevent lake water entering the slum	- The water from floodplain in the south rise up during rainy season and enter in the slum area in absence of barrier	Often
		- Inundates the roads, houses and tube-wells	Often

5.5.3 Key Institutions and their Roles in New Purba Kurmitola Camp

"Often they come for a visit. However, nobody keep up later. An NGO once concreted one lane and then they did not come again. [They] said [that] project fund is unavailable"

While discussing about the key institutions and their roles, a participant from New Purba Kurmitola Camp expressed disappointment by above statement. During field exploration, it was found that only two NGOs are working in the slum area. According to community people, World Vision and WSUP Bangladesh are currently working in this slum. World Vision constructed one 120 feet long drain in a single lane. However, due to lack of fund, the construction work could not extend. World Vision also works for child protection, health and nutrition. WSUP Bangladesh constructed one tank to supply water in the toilet. The community people stated that long ago Nagar Daridra Basteebashir Unnayan Sangstha (NDBUS), an NGO, constructed one water point in the slum. Since then only a limited number of NGOs are working in this slum, so the community make their own collective effort to address the impacts of climate change.

5.6 Comparison of strategies in dealing with climatic hazards – Difference between Beguntila and Purba Kurmitola Camp

After investigating the two slums, it is evident that Beguntila slum follows a different strategy to deal with climate change vulnerabilities and impacts than the New Purba Kurmitola camp slum. The role of community leader is bigger and significant in Beguntila slum compared to New Purba Kurmitola Camp. The community leaders divide the roles among themselves to deal with climate change vulnerabilities and impacts. The slum also receives assistance from NGOs to build and repair water, sanitation, drainage, housing and road infrastructure. The community leaders act as a bridge among NGOs and community people. In New Purba Kurmitola Camp, there is a lack of organisation among community members to deal with community vulnerabilities. Since there is no drainage system in the New Purba Kurmitola Camp, the slum is more vulnerable to inundation during the rainy season than Beguntila slum. The walking lanes are not concreted in New Purba Kurmitola camp like Beguntila. Hence, the lanes become muddy and daily movement is interrupted during rainy season. The field investigation result shows that water and sanitation infrastructure in New Purba Kurmitola Camp is more vulnerable to climate change impacts than Beguntila slum. Unlike the Beguntila community, there is no NGO currently present in the New Purba Kurmitola Camp community to guide or train them to deal with the climate change impacts. Hence, whenever the community faces a severe impact, people who are affected collect the funds and address the issue themselves. Whenever the impact effects a large portion or the whole area, the community leader contacts mechanics, technicians or construction workers to repair or address the infrastructural problems. However, in cases such as severe inundation, the communities have no instant solution to address the problem or even require leaving their houses to stay in a safe place. For all of these reasons, New Purba Kurmitola Camp is more vulnerable to climate change impacts than Beguntila slum.

5.7 Progression of Vulnerability to Disaster

Analysing the vulnerabilities of two different type of slum areas in Dhaka makes it evident that there are a number of underlying causes (as mentioned in section 5.4.2 and section 5.5.2) triggered by dynamic pressures and unsafe conditions lead to progression of vulnerability as defined by Blaikie et al. (1994). The dynamic pressures in terms of low-income settlements in Dhaka are poverty, lack of investment, lack of institutional support and training, rapid urbanization and infilling of floodplains and wetlands, and lack of social insurance among the

notable ones experienced through field study. The unsafe conditions arise due to vulnerable geographic location (as illustrated in map 4.1 and map 4.2 in previous chapter) and fragile local economy. When the slums are hit by climatic hazards, these increased level of vulnerabilities turn into disaster situation as per the PAR Model of Blaikie et al. (1994). The following diagram illustrates in light of progression of vulnerability by Blaikie et al. (1994) on how the progression of vulnerability in the low-income settlements of Dhaka leads to disaster conditions due to climatic hazards.

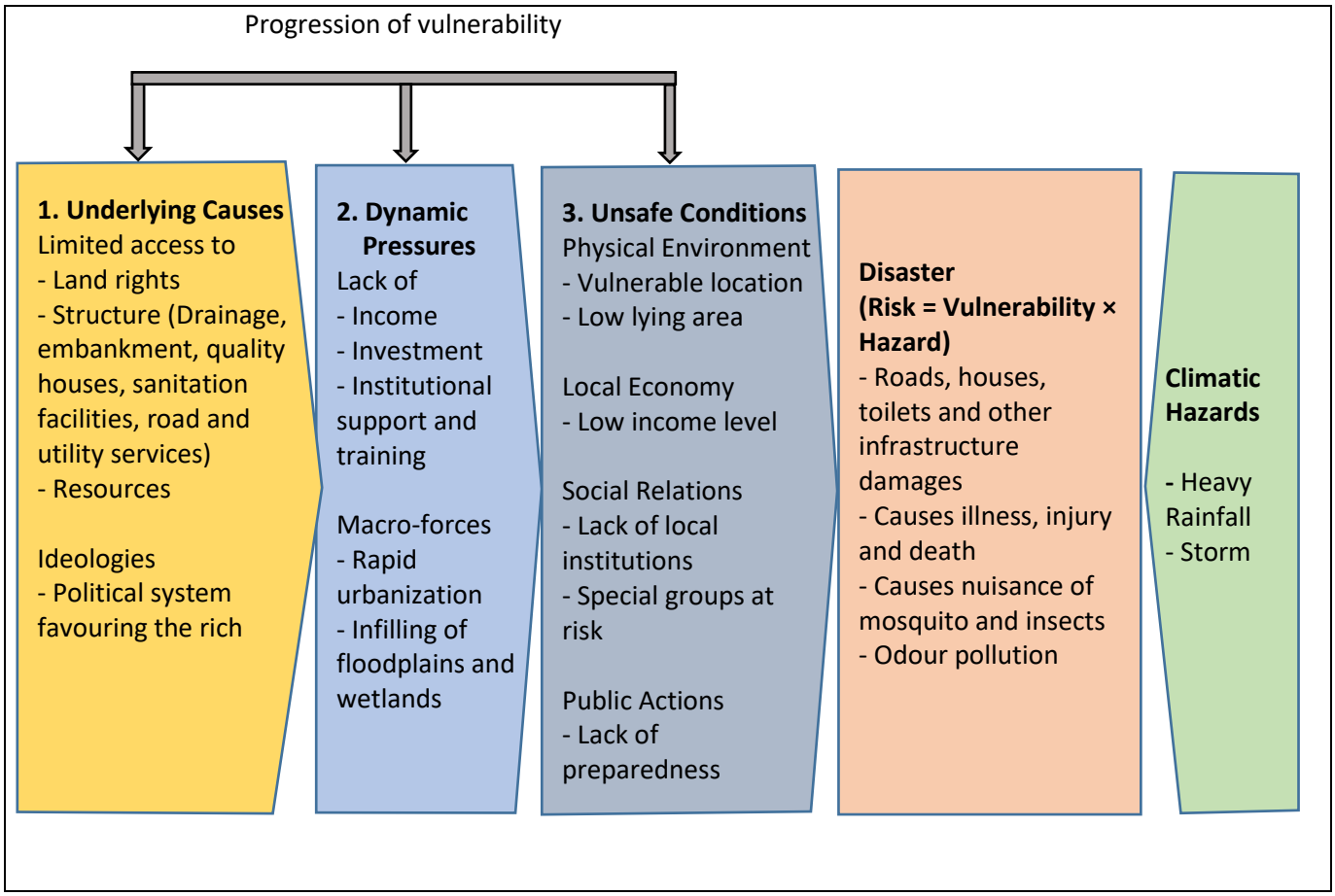


Figure 5.19: Progression of vulnerability to disaster in the low-income settlements of Dhaka
Source: Adapted from Blaikie et al. (1994)

5.8 Climate Change Vulnerabilities and Gender

The analysis of male and female focus group discussion outcomes and the opinions of experts makes it evident that the women are more vulnerable to climatic hazards than men in many ways. According to most of the community participants of both slums, the vulnerable groups to climatic hazards are women, children, disable and old people. Women are responsible for most of the household activities such as cooking, cleaning, collecting water and look after children. Men are responsible for earning livelihood and mostly stay outside of house during

the day. The household activities become more difficult during the time of inundation. When the houses become inundated, the women work hard to clean the houses and cook food. Collecting water from water points become difficult. When the children become ill during inundation caused by heavy rainfall or flood, the mother needs to take care of the children besides the daily household activities. Women with maternal conditions face more difficulties to deal with impacts of climatic hazards due to poor road, drainage and sanitation system in the slums. The male participants stated their difficulties in movement and access to water and sanitation facilities. At times, they need to repair the house affected by storm, clear the wastes inside drain and clear the rainwater from house. Children and disabled people are vulnerable to injuries due to torrential rain or flood as the roads become inundated and muddy. The children suffer from skin disease, diarrhoea, cholera other diseases during that period.

5.9 Conclusion

This chapter reflects the overall condition of the infrastructure in the low-income informal settlements of Dhaka. After analysing the infrastructural vulnerabilities and impacts of Beguntila and New Purba Kurmitola Camp, it has become evident that the slums in the low-lying lands are extremely vulnerable to climatic hazards like heavy rainfall and storm. The root causes (as mentioned in section 5.4.2 and 5.5.2 in this chapter) are triggered by their poor socio-economic condition which results in multiple consequences that leads to vulnerability. When the slums are hit by climatic hazards, these vulnerabilities turn into a disaster situation. The current drainage system in the slum areas are not efficient to address the impacts of torrential rain. The tin-shed houses built from low cost materials are very weak to withstand heavy storm. The slum which receive assistance for infrastructural development from the NGOs are more resilient to climatic hazards than the one which receive no or less support from the NGOs. The outcome of this shows that women are more vulnerable to climatic hazards then men in the slum areas. Women with maternal conditions, disabled people and children suffer the most from the impacts of climatic hazards. Every year the low-income settlements in Dhaka city face damages due to storm and heavy rainfall. In absence of infrastructural resilience, the communities repair the damages and prepare for repairing it again in the upcoming year. The little amount of savings they are able to make from limited income are spent on the repairing their houses and infrastructure. Hence, they are not able to save up for their own development. This situation urges the need for building climate resilience in the infrastructure of low-income communities. The following chapter reflects community opinion of Beguntila and New Purba

Kurmitola Camp slum on the possible climate resilient measures that can be taken to address the climate change vulnerabilities mentioned in this chapter.

Chapter Six: Enhancing climate resilience on infrastructure – required improvements for addressing the impacts of climate change in Beguntila and New Purba Kurmitola Camp

6.1 Introduction

This chapter outlines the possible measures required to address the vulnerabilities and improve resilience to the impacts of climate change on infrastructure of Beguntila and New Kurmitola Camp community. To identify the climate resilient solutions to the vulnerabilities mentioned in previous chapter, this chapter reflects on the opinions of community participants and experts on how to enhance resilience to these vulnerabilities caused by heavy rainfall and storm. These opinions were collected through applying two qualitative data collection tools i.e. focus group discussions and key informant interviews. The tools were developed through reviewing literatures around the idea of progressing towards climate resilient infrastructure through adaptation strategies. The framework for adaptation and resilience is outlined in chapter three under the section 3.3 to section 3.8. To delineate the process of climate resilient infrastructure in the low-income settlements, this research focused on affordability, safety, security and sustainability issues of the possible solutions.

The community participants of focus group discussions and key informants addressed each of the vulnerable infrastructures separately to provide essential information on "what can be done", "how to do it" and "who can do it". The participants also applied their own ideas, which they developed from their previous experience in the study areas. They identified the required constructions or improvements for individual infrastructures, key actors, adaptation strategies, and financing options. The participants also helped to identify the areas where immediate intervention is required. Individual interviews with the key informants were helpful in gaining expert opinion on possible alternatives to develop climate resilient infrastructure. The focus group discussions allowed the collection of opinion in a more interactive environment than the individual interviews, as community engagement is a key characteristics of a resilient system and it helps to build sense of belonging (Bahadur et al., 2010). The options of engaging communities in these infrastructure development activities were also discussed along with the key challenges in implementing these projects. The community participants provided their opinion on how social technology e.g. mobile SMS alerts, weather updates, and wireless communication technologies can be applied to keep community updated about climatic hazards.

All this information was compiled in this chapter to depict the process of building climate resilient infrastructure in the Beguntila and New Purba Kurmitola Camp slum communities.

6.2 Enhancing climate resilience on infrastructure in Beguntila Slum

To address the climatic vulnerabilities on infrastructure in Beguntila, this study worked with the Beguntila community to identify the improvements required to build climate resilient infrastructure. At the beginning of group discussions, the participants of Beguntila community were given a brief idea about climate resilience. The characteristics of a resilient system elaborated by Bahadur et al. (2010), and safe and resilient community by IFRC (2012) were discussed with the participants. The role of infrastructure in building climate resilience was explained so that they could visualize how resilient infrastructure works to address vulnerabilities. During key informant interviews, the participants who were not familiar with climate resilience were given a general idea prior to raising questions regarding climate resilient infrastructure development. Providing this primary information helped the community participants of Beguntila to answer the requirements for building climate resilience on infrastructure. Since the victim of climatic hazards should be the main driver for attaining climate resilience, the probable role of urban poor in building climate resilient infrastructure was discussed with participants. The participants also identified the challenges that need to be overcome to implement the required infrastructural developments.

The following table reflects the community opinion on the measures to be taken to build infrastructural resilience against climatic hazards, such as heavy rainfall and storms. It highlights the required activities, key actors that can perform the role, and the process that can be followed to fulfill the activities.

Table 6.1: Required measures for building infrastructural resilience against climatic hazards in Beguntila slum

Type of Infrastructure	Required improvements	Required strategies	Key actors to play role
Drain	- Reconstruction and repair of the old drains - Construction of slab or screener over drain to protect the wastes clogging the drains	- The height and width of the drain needs to be readjusted so that there is no interruption in drain water flow - The height of the drain can be selected as 3.5 feet and width can be selected as 2.5 feet - The broken drains need to repaired - The sand and cement ratio should be 3:1 to ensure durability - The drains constructed in the middle of narrow lanes and beside the road need to be covered by concrete slab and screener on top of it to prevent wastes getting inside the drain - The flow of the drain water needs to be designed by an expert civil engineer - The plan needs to be shared with Dhaka City Corporation to obtain No Objection Certificate from the Ward Commissioner	- The NGOs working for water, sanitation and hygiene can play a major role with the assistance of slum development committee members from community - The NGOs can collaborate by dividing the work within themselves as well - The community can monitor the work and help with the construction work - A portion of development cost can be shared with the community - The ward commissioner (Ward no. 2, Dhaka City Corporation) needs to grant permission to allow such development on Government land
House	- Construction of brick wall - Replacement of old tin - Repairing and binding the structure - Elevation of ground level	- As the corrugated iron sheet houses are too light to withstand strong wind during storm, the wall needs to be reconstructed with brick and cement - The old rusted tin roofs need to be replaced with new tin	- The NGOs working in the field of housing in the slum areas (e.g. Habitat for Humanity Bangladesh) can take the responsibility - The community can monitor the work and help with the construction work

	- Cementing the floor of house	- The tin roofs affected by hailstorms need to be replaced as well - The tin roofs need to be bound properly with wooden frames and metal joins - The ground level of the houses need to be elevated from the road level with soil - The floor of the houses need to cemented to prevent it from getting muddy	- The community can share the cost of construction - The ward commissioner needs to grant permission to allow such development on Government land - The local government can take initiative to build structures for permanent rehabilitation
Road and lanes	- Elevation of road level in the east - Construction of concrete road in the north	- The ground level of the roads in the east side near the lake needs to be elevated - The road surface made by clay soil in the northern part of the slum needs to be concreted to prevent it from getting muddy - The road should be properly connected with the drainage system - The plan needs to be shared with Dhaka City Corporation to obtain No Objection Certificate from the Ward Commissioner	- The NGOs working in the field of infrastructure and settlement development in the slum areas (e.g. Habitat for Humanity Bangladesh) can take the responsibility - The NGOs can collaborate by dividing the work within themselves - The community can monitor the work and help with the construction work - The community can share the cost of development - The ward commissioner needs to grant permission to allow such development on Government land
Sanitation	- Construction of sewerage system	- The septic tanks need to be connected with sewerage system using pipe network	- The NGOs working for water, sanitation and hygiene can play a major role with the assistance of slum development committee

			members from community - The community can monitor the work and help with the construction work - The cost of constructing sewerage system can be shared with the community - The ward commissioner needs to grant permission to allow such development on Government land
Embankment	- Construction of boundary wall near lake	- A boundary wall can be constructed in the eastern side to prevent the lake water entering the slum area	- The NGOs working in the field of infrastructure and settlement development in the slum areas (e.g. Habitat for Humanity Bangladesh) can take the responsibility - The community can monitor the work and help with the construction work - The community can share the cost of development - The ward commissioner needs to grant permission to allow such development on Government land
Electric poles	- Replacement of bamboo poles - Hanging the electric wires properly on poles	- The bamboo poles need to be replaced by the wooden poles - The electric wired need to hanged in a more organized way to prevent accident during storm	- The private electricity provider company can take the responsibility to replace the bamboo poles - The city corporation can use authority to control the providers to make such changes

According to male focus group participants, the quality of the infrastructure development work lies on availability of fund and supervision by a skilled engineer. They stated that the current infrastructure could be more resilient if it is developed in light of community experience and information.

The community participants of focus group discussions and key informant interviews were asked if any of the infrastructure services needs immediate improvement. Most of the participants stated that the drain in the east side meeting the Balughat-Mastertek road needs to be reconstructed as earliest possible. The current height and width are narrow as displayed in figure 5.12 in previous chapter. This narrow drain is interrupting the flow of the current drainage system. Consequently, the surrounding area beside the drain becomes inundated after heavy rainfall. Some of the community participants of both focus group discussions and key informant interviews suggested that there should be a barrier to prevent the lake water inundating the eastern part of the slum. They recommended constructing a boundary wall beside the lake to protect the area. The male focus group participants suggested making an embankment of sandbags beside the lake.

The community participants expressed their opinion on how they are willing to contribute in the infrastructure development activities. The committee members for slum development are currently providing awareness activities on water, sanitation and hygiene. As a part of the training, they ask the community to dump their wastes in the proper place, so that it does not block the drain. All the participants from the community stated that they are willing to provide assistance in construction and monitoring activities. Some of the participants are interested in funding collection and sharing the cost of development.

6.3 Challenges in building climate resilient infrastructure in Beguntila slum

The community members reported some probable challenges in implementing the activities mentioned above. Most of the community participants highlighted a lack of funds to take such infrastructural development activities. They stated their earlier experiences in this matter. According to them, many infrastructural development activities could not be fully finished because of funding problems. A small number of participants reported that the water and sanitation facilities are mostly distributed nearby the houses of community leaders. The participants of a male focus group reported that construction of new drains under the lanes that have increased height and width were done in only few lanes. Since the unfinished work

resulted in different height in different drains (as shown in figure 5.11 to figure 5.14 in previous chapter), the flow of the system is interrupted and causes overflows after heavy rainfall or storm. Hence, their earlier experience suggests that funding is a major challenge in development of climate resilient infrastructure.

Another challenge the community highlighted is the lack of legal right to the land where they are living. Since the community have constant fear of eviction on their mind, many people are not willing to spend their hard-earned money in these large projects. Their previous experience of facing eviction makes the scenario more difficult to address. Therefore, this challenge needs to provide security of investment for specific period. The government should make the eviction plan clear, i.e. in what way they will be rehabilitated after eviction.

One of the NGO professionals among the key informants stated a matter of concern on the development of house structures. As many slum dwellers of Beguntila are living on rental basis, the benefit of reconstruction supported by NGOs go to the owner of the house. There are chances that the owners would increase the rent of houses. Therefore, it requires advocacy with the house owners on how they should deal with the community before undertaking such development by NGOs.

One of the community experts indicated the challenge of organizing the committee to make it more capable for building climate resilient infrastructure in Beguntila. It needs to consider the power structure, threats and knowledge of committee members on NGOs. The study analysis shows that the women are more vulnerable than men. According to the statement of a key informant for this study, there are challenges on how to raise the voices of women in the committee.

These are the possible challenges that may appear while undertaking the required activities for development of climate resilient infrastructure in Beguntila according to community participants and experts. These challenges need to be considered in the planning stage before commencing the development process. The community and key informants emphasized on the need for a good plan and collaboration among multiple stakeholders, including the community, to address these challenges beforehand to help avoid future crises.

6.4 Enhancing climate resilience on infrastructure in New Purba Kurmitola Camp

The participants of male and female focus group discussions and community experts from New Purba Kurmitola Camp identified the required activities and their strategies for enhancing climate resilience on current infrastructure. Before that, a brief idea about climate resilience, characteristics of a resilient system as described by Bahadur et al. (2010), and features of safe and resilient community illustrated by IFRC (2012) were given to the participants. The community participants were also provided the understanding on how to progress towards climate resilience through adaptation strategies as illustrated by Binder and Snover (2011) as the 4-As (i.e. awareness, analysis, action and assessment) of adaptation planning. The participants were briefed about the role of infrastructure in strengthening climate resilience. This information helped them to visualize how resilient infrastructure works to address climatic vulnerabilities. The participants were asked about engaging the community in building climate resilient infrastructure. After that, the participants identified the challenges that need to be addressed for implementing the required infrastructural developments.

The following table depicts the community opinion on the measures need to be taken in New Purba Kurmitola Camp to build infrastructural resilience against climatic hazards. The required infrastructural improvements, strategies and key actors as identified by the community participants and experts to achieve climate resilient infrastructure are outlined in this table.

Table 6.2: Required activities for building infrastructural resilience against climatic hazards in New Purba Kurmitola Camp

Type of Infrastructure	Required improvements	Required strategies	Key actors to play role
Drain	- Construction of drainage system - Construction of slab or screener over drain to prevent wastes blocking the drains	- Drain needs to be constructed in each lane of the slum - The depth and width of the drain need to be fixed by a skilled construction engineer so that the water flow is not interrupted - The drain needs to be concreted by appropriate mixture of sand and cement	- The NGOs working for slum infrastructure development in Dhaka (e.g. Habitat for Humanity Bangladesh, World Vision etc.) can take the lead responsibility - The NGOs can also collaborate and divide the work within themselves - The community can monitor the work and help in construction work

		- There should be slab constructed on top of the drain so that the slab works as walking lanes - There should be screener or holes in drains to prevent waste getting into the drains	- The ward commissioner (Ward no. 2, Dhaka City Corporation) needs to grant permission to allow such development on Government land
House	- Elevation of floor level -Construction of brick wall - Alteration of tin-roof - Binding and repairing the structure - Cementing the floor	- The floor level of the houses need to be elevated from the road level with soil to avoid water entering the house - Since corrugated iron sheet found to be vulnerable to strong wind of storm, the wall needs to be reconstructed with brick and cement - The old, deformed and rusted tin roofs need to be altered with new tin - The tin roofs affected by hailstorms need to be altered - The tin roofs need to be bound properly with wooden frames and metal joins - The floor of the houses need to be cemented to prevent it from getting muddy	- The NGOs working in the field of housing in the slum areas (e.g. Habitat for Humanity Bangladesh) can take the responsibility - The community can monitor the work and help with the construction work - The community can share a portion of construction cost given their poor socio-economic condition - The ward commissioner needs to grant permission to allow such development on Government land - The local government can take initiative to build structures for permanent rehabilitation - The Local Government Engineering Department (LGED) can take responsibility slum improvement project
Lanes	- Construction of concrete lanes	- 15 lanes out of 16 lanes in the slum need not be concreted to prevent these from getting muddy - The drains need to be constructed under the lanes to support the rain water flow	- The NGOs working for slum infrastructure development in Dhaka (e.g. Habitat for Humanity Bangladesh, World Vision etc.) can take the lead responsibility - The NGOs can collaborate by dividing

		- The lane which is already concreted need to be reconstructed after adjusting the depth and width of drain underneath it with other drains - The plan needs to be shared with Dhaka City Corporation to obtain No Objection Certificate from the Ward Commissioner	the work within themselves as well - The community can monitor the work and help in construction work - Community can share a portion of development cost if needed - The ward commissioner (Ward no. 2, Dhaka City Corporation) needs to grant permission to allow such development on Government land - The Local Government Engineering Department (LGED) can take responsibility slum improvement project
Water and Sanitation	- Construction of hygienic latrines - Repairing septic tanks - Construction of sewerage system - Setting up tube-well higher from ground level	- The unstable pits in the latrines need to be repaired - The hanging latrines need to be changed with safe and hygienic latrines - The leaked pipes in toilets need to be changed - The tube-wells are needed to be set up in a higher platform to avoid inundation during flash floods	- The NGOs working for water, sanitation and hygiene can play the vital part here - The community can monitor the work and help with the construction work - The community is willing to share a portion of cost - The ward commissioner needs to grant permission to allow such development on Government land
Embankment	- Construction of boundary wall near lake	- A boundary wall can be constructed in the backside of the slum to prevent water from floodplain entering the slum area during rainy seasons	- The NGOs working in the field of infrastructure and settlement development in the slum areas (e.g. Habitat for Humanity Bangladesh, World Vision etc.) can take the responsibility

			- The community can monitor the work and help with the construction work - The community can share a portion of cost of development - The ward commissioner needs to grant permission to allow such development on Government land
Waste Disposal	- Setting waste bins	- Setting permanent waste bins in different locations so that these are not stolen	- The NGOs working for water, sanitation and hygiene (e.g. World Vision) can assist to set-up permanent waste bins - The community can monitor regular waste management
Electric poles	- Alteration of bamboo poles - Hanging the electric wires properly on poles	- The bamboo poles need to be replaced by the wooden poles - The electric wired need to hanged in a more organized way to prevent accident during storm	- The private electricity provider company can take the responsibility to replace the bamboo poles - The city corporation can use authority to control the providers to make such changes

Since the construction requirements are numerous, it will result in hefty cost, which the community deems to be unbearable. The participants stated that they could provide information on vulnerable spots from their experiences which could help to improve the infrastructural development process.

Among the required improvements, the participants of focus group discussions and community experts particularly emphasized an immediate construction of a boundary wall in the backside of the slum near the floodplain. According to them, the community incurs a huge loss of property damage every year in absence of such barrier against water raising from the floodplain during rainy seasons. The situation becomes even worse in absence of drainage system. The

participants stated the urgent need of drains in each lane of the slum. According to them, if the drains are constructed with slab on top of it, then it will become walkable during rainy seasons. The community feel that boundary wall and drainage system together will help to reduce the losses caused by climatic impacts in the future.

The participants stated their opinion on how they are willing to contribute in the infrastructure development activities. All the participants from the community expressed their interest to provide assistance in construction and monitoring activities. The focus group participants stated their inability to arrange a big fund for cost sharing of the development activities due to their poor economic background. However, they are willing to form a committee. They would like to open a bank account where they can save their small fund collections. The participants are more interested in micro-credit loans to pay their share of infrastructure development costs.

6.5 Challenges in building climate resilient infrastructure in New Purba Kurmitola Camp

The community participants of New Purba Kurmitola Camp outlined the likely challenges in implementing the required activities mentioned in section 6.4. The community participants are particularly concerned about funding such infrastructural development. According to them, the drainage system could not take place due to lack of funds for the project taken by an NGO. Due to poor their socio-economic status, the community is not in a position to share large amount of the construction cost. This is particularly challenging because sometimes the NGO requires the community to share the project cost so that the community earns the sense of belonging to the development.

The community expressed their concern on making investment in a land where there is no security of tenure. Since the community have constant fear of eviction on their mind like the people of Beguntila slum, many people are not willing to spend their hard-earned money in these large projects. As the community was evicted by the army from their previous location, this experience makes the scenario more difficult to address. Hence, the community needs security of investment for a specific period.

The participants reported their concern about the rapid infilling of floodplains in the nearby area as a major threat for the community. According to them, the consequence of flash floods

has become more severe due to this reason. Since the floodplain area is reduced, the water level is raising up and causing inundation in New Kurmitola Camp.

As New Purba Kurmitola Camp received limited assistance from NGOs in terms of training and capacity building to deal with the climatic hazards like Beguntila slum, there is a gap of knowledge and coordination. Hence, there is a need for undertaking non-structural measures to fill up these gaps through awareness, training, workshop, capacity building, organization of committee, etc.

These are the possible challenges that may appear while undertaking the required infrastructural development for strengthening climate resilience in New Kurmitola Camp as per statement of community participants of FGD and key informants. The community feel that these challenges can be addressed if the government and NGOs work together for strengthening resilience in New Purba Kurmitola Camp.

6.6 Informing Community about Upcoming Climatic Hazards

Informing the community about upcoming climatic hazards can help to save a huge amount of loss. Therefore, the participants of focus group discussions and key informant interviews of both Beguntila Slum and New Purba Kurmitola Camp were requested to give their opinion on how they would like to get information about upcoming climatic hazards. They were also invited to give an opinion on how to use social technology in this cause. The participants from Beguntila slum is interested to form a new committee on disaster management in their existing board of committees. The committee members could be trained up to help communities to deal with different kind of disaster events including climatic hazards. According to them, the concerned authorities regarding disaster management may send their team to inform the committee and give directions before major disasters. The participants stated that the committee members could also be informed via phone calls or text messages in Bengali language. The participants of New Purba Kurmitola Camp would like to receive the information about upcoming climatic hazards from a key person from the community. The key person could be a member of community based organization. The member can announce important messages through a mic within the area. According to them, the disaster management authority can collect the important numbers from different slums in Dhaka and inform all the slums together about upcoming climatic events or disaster.

6.7 Progression of Safety towards Resilient Community

Analyzing the required improvements for two different slums in Dhaka reflects that there are a number of non-structural and structural adaptation strategies required in the form of awareness, analysis, actions and assessments as illustrated by Binder and Snover (2011) in their 4-As of adaptation planning towards climate resilience. The climate change vulnerability in the low-income settlements of Dhaka could be reduced by enhancing resilience through addressing the underlying causes, reducing pressures, ensuring safe conditions, and taking a range of hazard prevention and mitigation measures according to progression of safety of PAR model developed by Blaikie et al. (1994). The underlying causes could be reduced by ensuring equitable access to land rights, structures and resources. However, the political system favouring the rich remains a challenge that needs to be addressed. The dynamic pressures could be reduced by developing the income level, investment and providing institutional support and training. The unsafe conditions need to be addressed by achieving better physical environment, sufficient income level, access to micro-credit, social inclusion and preparedness to climatic hazards. A range of large-scale prevention measures could be taken to reduce impacts of climatic hazards in Dhaka such as construction of embankment, controlling the floodplains and wetlands, hazard mapping, improving drainage, setting up monitoring and early warning system etc. According to this model, the progression of safety will result in a more controlled situation by ensuring limited damage of wealth and property, less injuries and limited disease or pollution.

The following diagram illustrates in light of progression of safety by Blaikie et al. (1994) on how to achieve climate resilience in low-income settlements of Dhaka City.

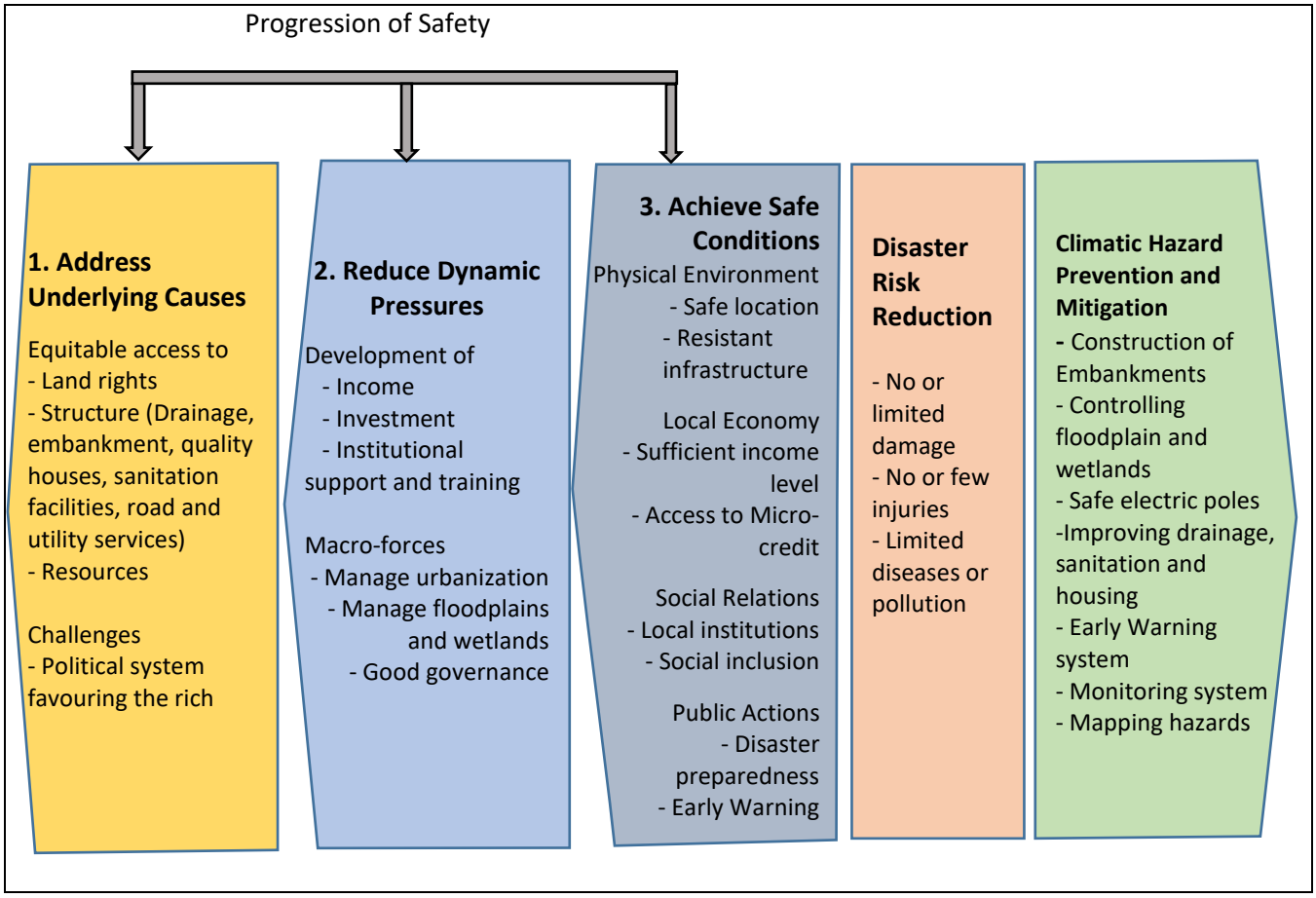


Figure 6.1: Progression of safety towards climate resilience in the low-income settlements of Dhaka

Source: Adapted from Blaikie et al. (1994)

6.8 Conclusion

This chapter reflects the voices of the low-income community in Dhaka to delineate the essential infrastructural improvements required to enhance climate resilience in these settlements. The analysis shows that the low-income informal settlements in Dhaka are in dire need of efficient drainage system to cope with the impacts of heavy rainfall and storm. This was found to be the immediate requirement from the statements of both Beguntila and New Purba Kurmitola Camp community. It is evident from the analysis that the most impeding factor for the advancement of the slum infrastructure is poverty. The statements from all participants of this research reflect that the main challenge for undertaking the required infrastructure development project is the crisis of funding. It is noticeable from the outcome of this analysis that these poor and vulnerable communities rely more on international NGOs than government for their infrastructural development. Since Beguntila community is well trained due to multiple NGO involvement and increased community participation in the area, hence

they could provide more specific information on required activities to enhance resilience than the New Purba Kurmitola camp. It emphasizes the need for NGO involvement to increase community participation in the decision-making process. It helps the community to provide specific information on the required improvements and prioritize goals.

The predicted impacts of climate change such as an increase in torrential rain and storms are damaging the slum infrastructure almost every year and will increase in future. Hence, the community and NGOs are spending money to repair or rebuild it every year. Therefore, a planned and durable climate resilient development may cost a lot of money; however, it will save money in the long run as the infrastructure becomes more resilient to climatic hazards after the development.

Chapter Seven: Summary, Recommendation and Conclusion

7.1 Introduction

This chapter summarizes the outcomes achieved through researching the prospects and challenges of building climate resilient infrastructure in the low-income settlements of Dhaka city. To do so, this chapter evaluates the key findings of this research against research questions to show how the questions are addressed. Further, it has covered a number of suggestions for enhancing climate resilience in the infrastructure of Beguntila slum and New Purba Kurmitola Camp. Finally, it provides guideline on the opportunities and implications for further research on improving climate resilience in the low-income settlements of Dhaka.

7.2 Overview of Key Outcomes

This study has taken a qualitative approach to meet the aim of this research: **to delineate the impacts of climate change on infrastructure and work with community to design a climate resilient infrastructure solution in the low-income settlements of Dhaka City**. In this regard, this research studied the background of climate change vulnerability and vulnerable low-income groups in Dhaka from the available literature. To understand the factors that contribute to enhance climate resilience of infrastructure, a number of theories and models were reviewed. To identify the root causes for the vulnerabilities and consequences on infrastructure, this study selected two slums using purposing sampling and conducted reconnaissance survey, focus group discussion and key informant interviews in these slums. To identify the required measures for building climate resilience in these slums, this study collected community opinions from participants to help design a climate resilient infrastructural solution by addressing the vulnerabilities. The key outcomes of this study according to the research questions are outlined below.

Research Question: What are the existing vulnerabilities and problems of climate change in the low-income settlements of Dhaka?

Outcomes: The environmental profile of Bangladesh reveals that the country is highly vulnerable since it is situated in the confluence of three major rivers. Every year floods and cyclones strike the country. Surrounded by rivers and canals, Dhaka city, the capital of Bangladesh, receives huge influxes of migrants contributing to an alarming growth of the slum population. These slums are typically located in the low-lying lands or near the floodplains. More than half of these slums become fully or partially inundated by water during general flood

conditions. The low-income vulnerable group live in low-quality houses with poor drainage and sanitation systems. Many shelters are below the ground level and remain inundated after heavy rainfall or flood during the rainy season. The tin-shed corrugated iron sheet houses are the common structures found in the slum that are highly vulnerable to storms. Hailstorms cause holes in the tin while strong winds can blow away roofs. In the absence of climate resilient infrastructure, the slum communities experience severe consequences such as sanitary leakage, faecal contamination, overflow of sanitary wastes, scarcity of fresh water, drainage congestion, inundation of houses and roads, outbreak of vector borne and water borne diseases etc. Bamboo poles supporting the electric wires possess a threat during storm as electric poles or wires may fall on tin-shed houses and roads. Climate change vulnerability differs according to gender and age. The vulnerable groups to climatic hazards are women, children, disable and old people. Due to a lack of tenure security, the constant fear of eviction discourages community people to make a collective effort to address these vulnerabilities.

Research Question: What are the factors contribute to enhance climate resilience to infrastructural vulnerabilities in the low-income settlements?

Outcomes: Resilience is the ability of a system to withstand external influences, shocks and stresses. Improving climate resilience requires identifying and assessing risks of hazard, addressing vulnerability, increasing resistance and adaptation planning. The literature shows that the safe and resilient communities are knowledgeable and have ability to assess, manage and monitor its risk. These communities are organized and connected. Resilient communities have strong infrastructure and utility services, diverse range of economic opportunities and have the ability to protect natural resources. Infrastructure can play a vital role to minimize the impacts of climatic hazards. Flood defence and improved drainage can minimize the risk of flooding. Communication infrastructures can help with early warning of upcoming threats. Application of land use regulations can help to prevent building in vulnerable areas. Existing infrastructures also need regular maintenance to function during a disaster event.

Research Question: What are the underlying causes and consequences for these vulnerabilities in the low-income settlements in terms of infrastructure services and management system?

Outcomes: The study outcome shows that a number of factors worsen the impacts of the climatic hazards in the low-income settlements of Dhaka. These are due to infrastructural deficits and man-made vulnerabilities. The major reason for these vulnerabilities on

infrastructure due to heavy rainfall is inefficiency of current drainage system in the slum areas. Either there is no drainage system or the drains are too narrow to pass storm water and do not have slab or screener on it. The movement of rainwater through the drains is often interrupted by wastes. The clogged drain overflows and the surrounding area becomes inundated by rainwater. In absence of sewerage system, septic tanks become filled by water during times of inundation. The leakage of sanitary pipes cause skin diseases. The tin-shed houses made by corrugated iron sheet supported by bamboo and metal sheets are weak and unable to withstand strong winds during storms. These houses are often affected by hailstorm and strong wind. The clay lanes become muddy during rainy season. Hence, people often slide or become stuck. Children often fall in these muddy lanes and suffer injury. The bamboo poles supporting the electric wires are commonly found in the slum areas of Dhaka. These possess threat during the time of storm. Collapse of electric poles on tin-shed houses and roads can cause injuries to slum dwellers.

Research Question: What measures should be taken in order to establish climate resilient infrastructure for the urban poor based on existing situation and past experiences?
Outcomes: The outcome shows that the low-income informal settlements in Dhaka immediately require efficient drainage system to cope with the impacts of heavy rainfall and storm. To build efficient drainage system, the drains need to be durable having adequate height and width to support the flow of rainwater. Concrete slabs and screeners need to be constructed on top of it to prevent waste blocking the drains. Since the unsewered latrines are causing problems in the slum areas, there should be sewerage system to prevent overflow of water in the septic tanks or wastewater inside the toilets. Leaking sanitary pipes need to be repaired to prevent water borne or vector borne diseases. The tube-wells need to be constructed well above the ground level. The tin-shed structures requires reinforcement by building walls around it. The ground level of the houses need to be elevated from the road level. The old, deformed and rusted tin roofs need to be altered with new tin. The floor of the houses need to cemented to prevent it from getting muddy. The walking lanes are often found to be muddy during the rainy season. These need to be concreted to prevent injuries during inundation. The government authorities need to take action to change the life threating electric poles in the slum and replace these with wooden poles.

The study outcome shows that poverty is the most impeding factor for the advancement of the slum infrastructure. The main challenge for undertaking the required infrastructure

development project is the crisis of fund in the projects taken by NGOs. Results show that poor and vulnerable communities rely more on international NGOs than government for their infrastructural development. It emphasizes the need for NGO involvement to increase community participation in decision-making process. Since the impacts of climate change are damaging the slum infrastructure almost every year, this research emphasizes on planned and durable climate resilient development rather than low cost development for short-term benefits.

7.3 Recommendations

After studying climate change vulnerability and impacts, vulnerable groups, root causes, and prospects challenges and challenges of climate resilient infrastructure in the low-income settlements in Dhaka, this section suggests some recommendations that could be helpful in achieving climate resilience in the infrastructures of these vulnerable settlements. To achieve climate resilient infrastructure status in the low-income settlement, the following suggestions need to be considered for further attention.

- The research outcome shows that lack of security of tenure is a key concern that is impeding the infrastructural development and increasing vulnerabilities in the low-income informal settlements in Dhaka. The government should focus on this issue and take action to address this situation in light of National Housing Policy 2016. In particular, the government should provide make it clear to the slum dwellers in what way they will be rehabilitated after eviction. The concerned authorities should also inform the slum dwellers regarding how long they can stay in their temporary shelters.

- It was noticeable that poverty is the main reason for slum communities to live in vulnerable locations. The slum communities are unable to develop their current infrastructure due to lack of access to capital. Therefore, the government should develop strategies to generate income for these low-income peoples. The NGOs should develop initiatives to help slum communities by building skills so that these populations can be turned into a skilled workforce. The NGOs should also allow communities to have access to micro-credits for building infrastructure.

- The local government should come forward to help low-income communities in developing infrastructure, providing training for capacity building and addressing the disaster risks by constructing dams, flood wall and drainage system.

- The study findings show that the initiatives taken by the government to address the infrastructural vulnerabilities of low-income community in Dhaka is insignificant compared to the development initiatives taken by the NGOs. Although the Local Government Engineering Department has taken on slum improvement projects in some areas, more projects required to ensure safe conditions for massive number of slum population. After visiting Housing and Building Research Institute (HBRI), the government owned research institute for housing, it was noticed that this institute has good examples of low-cost housing, shelter for disaster, brickless buildings, earthquake resistant buildings etc. However, the institute is yet to construct a model for low-income houses in the slum areas located in the urban centers. The HBRI should make more effort to develop models for building climate resilient low-cost slum houses.

- The government should take action to control macro-forces contributing to infrastructural vulnerabilities in the low-income communities. Among the macro-forces, rapid urbanization and infilling of floodplains and wetlands are among the significant ones need to be controlled by the government to reduce vulnerabilities in low-income settlements.

- The contribution of slum communities in the city is undeniable; hence, the slum settlements need to be considered as an integral part of the city rather than considering it as an informal part of the city. The government should protect the slum communities by taking both structural and non-structural measures to address the vulnerabilities. The study findings show that resilient communities are knowledgeable and healthy. Hence, the government should ensure proper education and healthcare facilities in these slum areas of Dhaka.

- It is evident from the results that social relations and connectedness contribute to increased resilience against climatic hazards. Lack of local institutes increase the community vulnerabilities. Therefore, the formation of committees in slum areas is highly recommended.

- The study findings show that there is a lack of collaboration among the NGOs working for slum development. If the NGOs work together in a coordinated way, this would result in development that is more resilient by synergic effects.

7.4 Areas for further research

This study examines the prospects and challenges of climate resilient infrastructure in the low-income settlements of Dhaka by investigating two slum communities as case study. However, the results could be more accurate and improved if further research is conducted by selecting more slums from different parts of including government owned slums and those which are developed by the side of rail tracks. Further research could include multiple researchers having diverse academic backgrounds such as political science, the built environment, civil engineering, disaster management and public health experts. This would allow to come up with more specific outcomes on how to address each vulnerabilities and what measures need to be taken to build climate resilience.

This research focused on impacts of heavy rainfall and storm as impacts of climate change. However, there are other impacts of climate change such as heat waves. Further research could be conducted incorporating wider impacts.

The infrastructural vulnerabilities of the low-income communities due to storm and heavy rainfall urge the need for more research on how to achieve social inclusion in climate resilient settlements. The role of good governance for ensuring social inclusion could be investigated in this regard.

From the outcome of this study, it is evident that there is a scope for micro-credit loans for developing climate resilient infrastructure in the low-income settlements. The role of micro-credit loans for enhancing climate resilience in the slum areas could be further examined.

The research findings also show that security of tenure is a major challenge for developing climate resilient infrastructure in the low-income settlements. It accentuates the need for further investigation on how this problem could be addressed through policy initiative or actions.

7.5 Conclusion

Bangladesh is one of the most vulnerable nations to climate change impacts due to its geographically disadvantaged location. As such, the country should take climate resilient measures to reduce vulnerabilities and losses. With the increasing number of climatic events, it is becoming more crucial to build climate resilience in the infrastructure system. As the studies show that, the vulnerable groups are located in the hazard prone areas have poor quality of housing, sanitation and drainage as they are least able to afford better housing conditions; efforts should be taken to address their vulnerabilities and ensure affordable and climate resilient housing. The outcomes of this research reflect that slums in Dhaka are extremely vulnerable to climatic hazards. Lack of access to land rights, infrastructure services, and resources triggered by poor socio-economic conditions lead the low-income communities to live in vulnerable conditions. These vulnerabilities turn into a disaster situation when the communities are exposed to climatic hazards. The outcome of this research shows that the communities need to repair the damages caused by climatic hazards almost every year. The little savings of such poverty-stricken communities are not sufficient for repairing their houses and infrastructures. This situation urges the need a planned and durable climate resilient development in low-income communities. As these communities are not financially solvent and well educated, these communities need financial and technical support from both government and NGOs. As the research outcomes reflect that the initiatives taken by the government to address the infrastructural vulnerabilities of low-income community in Dhaka is insignificant compared to the development initiatives taken by the NGOs, both government bodies and NGOs should work together to enhance climate resilience in these settlements.

References

Abuodha, P.A. & Woodroffe, C.D. (2006). *International Assessments of the Vulnerability of the Coastal Zone to Climate Change, Including an Australian Perspective*. University of Wollongong Australia: Wollongong.

Ahasan, M. N., Chowdhury, M. A. M., & Quadir, D. A. (2011). Simulation of a heavy rainfall event on 14 September 2004 over Dhaka, Bangladesh using MM5 model. *J. Sci. Res*, *3*(2), 261-270.

Ahmed, I. (2014). Factors in building resilience in urban slums of Dhaka, Bangladesh. *Procedia Economics and Finance, 18*, 745-753.

Alam, M., & Rabbani, M. G. (2007). Vulnerabilities and responses to climate change for Dhaka. *Environment and urbanization*, *19*(1), 81-97.

Alam, S. S., Alam, A. J., & Rahman, S. (2015). Urban climate resilience, water and sanitation. Improving multistakeholder collaboration in Dhaka, Bangladesh. Asian Cities Climate Resilience Working Paper Series 25: 2015.

Anderson, B. J., & Theodori, G. L. (2009). LOCAL LEADERS' PERCEPTIONS OF ENERGY DEVELOPMENT IN THE BARNETT SHALE. *Southern Rural Sociology*, *24*(1), 113-129.

Asghar, S., Alahakoon, D., & Churilov, L. (2006). A comprehensive conceptual model for disaster management. *Journal of Humanitarian Assistance*, *1360*(0222), 1-15.

Australian Greenhouse Office. (2005). *Climate Change Risk and Vulnerability: Promoting an efficient adaptation response in Australia*. Department of the Environment and Heritage. Australia: Allen Consulting Group.

Awal, M. A. (2015). Vulnerability to disaster: Pressure and release model for climate change hazards in Bangladesh. *International Journal of Environmental Monitoring and Protection*, *2*(2), 15-21.

Bahadur, A. V., Ibrahim, M., & Tanner, T. (2010). *The resilience renaissance? Unpacking of resilience for tackling climate change and disasters*. Institute of Development Studies (for the Strengthening Climate Resilience (SCR) consortium): Brighton, UK.

Baker, J. L. (Ed.). (2012). *Climate change, disaster risk, and the urban poor: cities building resilience for a changing world*. The World Bank.

BBS. (2014). *BBS Slum Census*. Bangladesh Bureau of Statistics. Retrieved from http://www.bbs.gov.bd/WebTestApplication/userfiles/Image/Slum/Preli_Slum_Census.pdf

BBS. (2015). *Census of Slum Areas and Floating Population 2014*. Bangladesh Bureau of Statistics, Statistics and Information Division, Ministry of Planning. Retrieved from http://203.112.218.65:8008/WebTestApplication/userfiles/Image/Slum/FloatingPopulation2014.pdf

Bicknell, J., Dodman, D., & Satterthwaite, D. (eds.). (2009). *Adapting Cities to Climate Change: understanding and addressing the development challenges*. London, Earthscan.

Binder, L. W., Snover, A. (2011, June). *Adapting to Climate Change.* Climate Impacts Group University of Washington. Paper presented at the ITEP Tribal Air Quality Conference, Arizona. Retrieved from http://itepsrv1.itep.nau.edu/itep_course_downloads/NTF/2011_SpokaneWA/June15/1030a-12p/ClimateChg/WhitelyBinder_AdaptToClimateChg_w_notes.ppt

Blaikie, P., T. Cannon, I. Davis & B. Wisner. (1994). *At Risk: Natural hazards, People's vulnerability, and disasters. London*, Routledge.

Brand, F. S., & Jax, K. (2007). Focusing the meaning (s) of resilience: resilience as a descriptive concept and a boundary object. *Ecology and society*, *12*(1).

Brown, A., Dayal, A., & Rumbaitis Del Rio, C. (2012). From practice to theory: emerging lessons from Asia for building urban climate change resilience. *Environment and Urbanization*, *24*(2), 531-556.

Campbell, D. T. (1955). The informant in quantitative research. *American Journal of sociology*, *60*(4), 339-342.

Carroll, A. M., Perez, M., & Toy, P. (2004). Performing a community assessment curriculum. *UCLA Center for Health Policy Research*. Los Angeles, California.

Centre for Urban Studies, Dhaka. (2006). *Slums of Urban Bangladesh: Mapping and Census, 2006*. Dhaka, Bangladesh.

Centre for Urban Studies, Dhaka. (2017). *CUS Bulletin on Urbanization and Development, Number 72*. Dhaka, Bangladesh.

Chowdhury, F. J., & Amin, A. N. (2006). Environmental assessment in slum improvement programs: some evidence from a study on infrastructure projects in two Dhaka slums. *Environmental Impact Assessment Review*, *26*(6), 530-552.

Claude, L., Bridger, J. C., & Luloff, A. E. (2000). Community well-being and local activeness. *Small Town and Rural Economic Development*, 39-45.

Conway, G., Waage, J., & Delaney, S. (2010). *Science and innovation for development*. London: UK Collaborative on Development Sciences.

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. *Global environmental change*, *18*(4), 598-606.

Da Silva, J., Kernaghan, S., & Luque, A. (2012). A systems approach to meeting the challenges of urban climate change. *International Journal of Urban Sustainable Development*, *4*(2), 125-145.

Dodman, D., Ayers, J., & Huq, S. (2009). Building resilience. *Worldwatch Institute, State of the world*, 75-77.

European Commission Humanitarian Aid Office (2010). *Urban Risk Assessment: A Facilitator's Guidebook*. Dhaka, Bangladesh.

Flick, U. 1998. An Introduction to Qualitative Research. SAGE Publications, London.

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change*, *16*(3), 253-267.

Food and Agriculture organization. (2015). *Climate change Challenge Badge, Second Edition.* Retrieved from: www.fao.org/3/a-i5216e.pdf

Given, L. M. (Ed.). (2008). *The Sage encyclopedia of qualitative research methods*. Sage Publications.

Gunderson, L. (2008). Comparing ecological and human community resilience. *White Paper to Community Resilience Initiative, Southeastern Regional Research Initiative, Oak Ridge National Lab, TN.*

Habitat for Humanity Bangladesh. (2018). *Urban Informal Settlement mapping.* Retrieved from http://www.dnccgismap.com/Dashboard

Hennink, M. M. (2013). *Focus group discussions*. Oxford University Press.

Herbst, F., & Coldwell, D. (2004). *Business research*. Juta and Company Ltd.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual review of ecology and systematics*, *4*(1), 1-23.

Hoque, S., Sarkertarna, T., Karim, F., & Khan, U. J. (2013). *Condition of basic services-water supply, sanitation and wastemanagement in slums of Dhaka City: An assessment*. (Thesis project), Ahsanullah University of Science and Technology, Retrieved from https://www.academia.edu/4974201/condition_of_basic_services-water_supply_sanitation_and_waste_management_in_slums_of_dhaka_city_an_assessment

Hossain, N. (2010). *Disaster Management Planning, Lecture Sheet – 4*, Department of Urban and Regional Planning, Jahangirnagar University, Savar. Dhaka.

Hossain, S. S., Habib, A. T., Islam, I., & Sharmin, N. (2013). Assessment of water supply, sanitation and drainage facilities of South Begunbari Slum, Dhaka, Bangladesh through Participatory Rural Appraisal (PRA) method and proposing upgrading schemes. doi:10.2139/ssrn.2344514

Huq, S., Kovats, S., Reid, H. and Satterthwaite, D. (2007). Editorial: reducing risks to cities from disasters and climate change. *Environment and Urbanization 19*(1), 3–15.

ICLEI – Local Government for Sustainability. (2011). *Resilient Cities 2011: Congress Report.* Bonn

ICLEI – Local Government for Sustainability. (2015). Resilient Cities Agenda. 2015. http://resilient-cities.iclei.org/fileadmin/sites/resilient-cities/files/Images_and_logos/Resilience_Resource_Point/ICLEI_Resilient_City_Agenda_Profile_Jan2016.pdf

International Federation of the Red Cross and Red Crescent Societies. (2012). *Community Based Disaster Risk Reduction Study - Characteristics of a Safe and Resilient Community*. London, UK. Retrieved from http://www.ifrc.org/PageFiles/96986/Final_Characteristics_Report.pdf

Jabeen, H., Johnson, C., & Allen, A. (2010). Built-in resilience: learning from grassroots coping strategies for climate variability. *Environment and Urbanization 22*(2), 415–431.

Joshi, D., Morgan, J., & Fawcett, B. (2005). *Sanitation for the urban poor: Whose choice, theirs or ours?* Research Report, Engineering for Development (IIDS), University of Southampton and Department for International Development (DFID).

Krannich, R. S., & Humphrey, C. R. (1986). Using key informant data in comparative community research: An empirical assessment. *Sociological methods & research*, *14*(4), 473-493.

Kreft, S., Eckstein, D., & Melchior, I. (2016). *Global Climate Risk Index 2017: Who suffers most from extreme weather events? Weather-related loss events in 2015 and 1996 to 2015*. Germanwatch Nord-Süd Initiative eV.

Kumar, K. (1989). *Conducting key informant interviews in developing countries*. Washington DC: Agency for International Development.

Lee, E. K. O., Shen, C., & Tran, T. V. (2009). Coping with Hurricane Katrina: Psychological distress and resilience among African American evacuees. *Journal of Black Psychology*, *35*(1), 5-23.

Leichenko, R. (2011). Climate change and urban resilience. *Current opinion in environmental sustainability*, *3*(3), 164-168.

Manoranjitham, S., & Jacob, K. S. (2007). Focus group discussion. *Nursing Journal of India*, *98*(6), 125.

McCarthy, J. J., Canziani, O. F., Leary, N. A., Dokken, D. J., & White, K. S. (Eds.). (2001). *Climate change 2001: impacts, adaptation, and vulnerability: contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change* (Vol. 2). Cambridge University Press.

Mitchell, T., & Harris, K. (2012). Resilience: A risk management approach. *ODI Background Note. Overseas Development Institute: London*.

MoEF. (2009). *The Bangladesh Climate Change Strategy and Action Plan 2009*. Ministry of the Environment and Forests, Government of Bangladesh. Retrieved from www.moef.gov.bd/climate_change_strategy2009.pdf

Moench, M., Tyler, S., & Lage, J. (Eds.). (2011). *Catalyzing urban climate resilience: Applying resilience concepts to planning practice in the ACCCRN Program (2009-2011)*. Institute for Social and Environmental Transition, International.

MoHW, GoB (2017). *National Housing Policy 2016*. Bangladesh Gazette, 26 July 2017, Ministry of Housing and Works, Dhaka, Government of Bangladesh.

Muller, M. (2007). Adapting to climate change: water management for urban resilience. *Environment and Urbanization 19*(1), 99–113.

Nelson, D. R., Adger, W. N., & Brown, K. (2007). Adaptation to environmental change: contributions of a resilience framework. *Annual review of Environment and Resources*, *32*.

Norris, F. H., Stevens, S. P., Pfefferbaum, B., Wyche, K. F., & Pfefferbaum, R. L. (2008). Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness. *American Journal of Community Psychology, 41*(1), 127-150. doi:10.1007/s10464-007-9156-6

Paton, D. (2007). Measuring and monitoring resilience in Auckland, *GNS Science Report 2007/18*.

Pelling, M. (2011). *Adaptation to climate change: from resilience to transformation*. Routledge.

Philander, S. G. (2008). *Encyclopedia of global warming and climate change: AE* (Vol. 1). Sage.

Poggie Jr, J. J. (1972). Toward quality control in key informant data. *Human organization*, 23-30.

Rahman, M. (2012). *Sanitation interventions in the urban informal settlements of Bangladesh: The role of government, NGOs and the grassroots* (Doctoral dissertation, Durham University).

Rahman, M. S. (2013). Climate change, disaster and gender vulnerability: A study on two divisions of Bangladesh. *American Journal of Human Ecology*, *2*(2), 72-82.

Rahman, M., Atkins, P.J., & McFarlane, C. (2014). Factors affecting slum sanitation projects in Dhaka City: learning from the dynamics of social-technological-governance systems. *Journal of Water, Sanitation and Hygiene for Development 4*(3), 346-58.

Rahman, S., & Rahman, M. A. (2015). Climate extremes and challenges to infrastructure development in coastal cities in Bangladesh. *Weather and Climate Extremes, 7*, 96-108.

Rashid, S. F. (2009). Strategies to Reduce Exclusion among Populations Living in Urban Slum Settlements in Bangladesh. *Journal of health, population, and nutrition, 27*(4), 574.

Reid, H., Simms, A., & Johnson, V. (2007). *Up in smoke? Asia and the Pacific: The threat from climate change to human development and the environment*. IIED.

Revi, A., Satterthwaite, D., Aragón-Durand, F., Corfee-Morlot, J., Kiunsi, R.B.R., Pelling, M., Roberts, D.C. & Solecki, W. (2014). *Urban areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability* (Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change). Cambridge University Press. Retrieved from http://www.ipcc.ch/report/ar5/wg2/

Schwartz, M. R., Bridger, J. C., & Hyman, D. (2001). A validity assessment of aggregation methods for multiple key informant survey data. *Community Development*, *32*(2), 226-237.

Sherbinin, A. D., Schiller, A., & Pulsipher, A. (2007). The vulnerability of global cities to climate hazards. *Environment and Urbanization*, *19*(1), 39-64.

Silverman, D. (2013). Doing qualitative research: A practical handbook. SAGE Publications Limited.

Singh, S. R., Eghdami, M. R., & Singh, S. (2014). The concept of social vulnerability: A review from disasters perspectives. *Int J Interdiscip Multidiscip Stud*, *1*(6), 71-82.

Smit, B., & Pilifosova, O. (2003). Adaptation to climate change in the context of sustainable development and equity. *Sustainable Development*, *8*(9), 9.

Smit, B., Burton, I., Klein, R. J., & Wandel, J. (2000). An anatomy of adaptation to climate change and variability. In *Societal adaptation to climate variability and change* (pp. 223-251). Springer, Dordrecht.

Stern, P. N. (1980). Grounded theory methodology: Its uses and processes. *Journal of Nursing Scholarship*, *12*(1), 20-23.

Strauss, A., & Corbin, J. M. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Sage Publications, Inc.

Streatfield, P. K., & Karar, Z. A. (2008). Population challenges for Bangladesh in the coming decades. *Journal of health, population, and nutrition*, *26*(3), 261.

The World Bank Group. (2011). Guide to Climate Change Adaptation in Cities. Retrieved from http://siteresources.worldbank.org/ INTURBANDEVELOPMENT/ Resources/336387-1318995974398/GuideClimChangeAdaptCities.pdf.

Tierney, K., & Bruneau, M. (2007). Conceptualizing and measuring resilience: A key to disaster loss reduction. *TR news*, (250).

Tremblay, M. A. (1957). The key informant technique: A nonethnographic application. *American Anthropologist*, *59*(4), 688-701.

Tyler, S., Reed, S.O., Macclune, K. & Chopde, S. (2010). Planning for urban climate resilience: framework and examples from the Asian Cities Climate Change Resilience Network (ACCCRN). *Climate Resilience in Concept and Practice: ISET Working Paper 3*, ISET. Retrieved from http://i-s-e-t.org/resources/working-papers/climate-resilience-paper-3.html

UNISDR. (2004). *What does vulnerability mean?* United Nations International Strategy for Disaster Reduction https://www.unisdr.org/2004/campaign/booklet-eng/Pagina8ing.pdf

UNISDR. (2015), *Global Assessment Report on Disaster Risk Reduction 2015*. United Nations International Strategy for Disaster Reduction. Retrieved from https://www.preventionweb.net/english/hyogo/gar/2015/en/gar-pdf/GAR2015_EN.pdf

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development.* Retrieved from https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

USAID Center for Development Information and Evaluation. (1996). *Performance Monitoring and Evaluation TIPS*. Number 2. Washington, DC. Retrieved from http://pdf.usaid.gov/pdf_docs/pnabs541.pdf.

Wong, L. P. (2008). Focus group discussion: a tool for health and medical research. *Singapore Med J*, *49*(3), 256-60.

Yahya, S. M., Shams, S., Islam, A. K. M. S., & Mahmud, K. (2010, September). Climate change impacts on flood vulnerability for Dhaka City. In *Proceedings of International Conference on Environmental Aspects of Bangladesh* (pp. 37-39).

Young, F. W., & Young, R. (1961). Key informant reliability in rural Mexican villages. *Human Organization*, *20*(3), 141-148.

Appendix One – Information Sheet – Key Informant Interviews

UNIVERSITY OF WAIKATO

FACULTY OF ARTS AND SOCIAL SCIENCES

Prospects of Climate Resilient Infrastructure in the Low-Income Informal Settlements of Dhaka – A Community Approach

Introduction

I am a graduate student doing Master of Environmental Planning at the University of Waikato. As a part of my Masters thesis I am undertaking research on climate resilient infrastructure in the low income settlements of Dhaka city. The purpose of this research is to understand the impacts of climate change on infrastructure giving special concentration on heavy rainfall and storm, and work with community to design a climate resilient infrastructure solution. Hence, I am interested in understanding the pattern and causes of vulnerabilities and problems on infrastructures due to climate change impacts in the low income settlements. I would like to hear from the community experts regarding the possible alternatives that can be helpful in building climate resilient infrastructure in the low income settlements.

Interviews

For this research I hope to conduct ten interviews with individuals that approximately last for 40 minutes to 1 hour in length. Your valuable experiences and opinions are very important for this research, so you are welcome to contribute by sharing these.

I would like to invite you to take part in an interview.

Your rights as a participant

You are not obliged to participate in this research, it is totally voluntary. If you choose to do so, you have the right to:

- Refuse to answer any particular question(s)
- Withdraw from the research
- Request that any material be erased
- Ask any questions about the research at any time during your participation

Confidentiality

All collected information will remain secure at all times. The Participants will retain the ownership of data. The interview schedules, written notes and other printed documents will be stored in a locked drawer. All recorded information will be stored for a duration of five years. I shall store these information in my laptop and the desktop provided by the University of Waikato with password protection. It is also expected that these information will be stored by my supervisor for 5 years using University of Waikato facilities.

The identity of the participants will remain anonymous unless otherwise requested by any participant during interviews in case the respondent is willing to include name for contribution in the research. The information will be used solely for academic purpose of completing the requirements of Master of Environmental Planning.

This research project has been approved by the Human Research Ethics Committee of the Faculty of Arts and Social Sciences. Any questions about the ethical conduct of this research may be sent to the Secretary of the Committee, email fass-ethics@waikato.ac.nz, postal address, Faculty of Arts and Social Sciences, Te Kura Kete Aronui, University of Waikato, Te Whare Wananga o Waikato, Private Bag 3105, Hamilton 3240.

Results

The results of this research will only be used as part of my Masters Thesis. A total of four copies of the thesis will be produced, of which three will be printed and one copy will be available online in the website of University of Waikato. It is expected that the outcome of the research will be presented in the conferences. Additionally one or more journal articles or conference proceedings may be produced from the result of the research.

What Next?

If you would like to participate in this research, I shall contact you so that we can schedule a meeting. You can contact me or my supervisor for further queries.

Sowmen Rahman

Masters Student, University of Waikato

+88001724178684, +64212388471

sowmenurp@gmail.com

Professor Iain White

Lecturer, Environmental Planning

07 838 4466 Ext. 9166

iainw@waikato.ac.nz

Appendix Two – Information Sheet – Focus Group Discussions

UNIVERSITY OF WAIKATO

FACULTY OF ARTS AND SOCIAL SCIENCES

Prospects of Climate Resilient Infrastructure in the Low-Income Informal Settlements of Dhaka – A Community Approach

Introduction

I am a graduate student doing Master of Environmental Planning at the University of Waikato. As a part of my Masters thesis I am undertaking research on climate resilient infrastructure in the low income settlements of Dhaka city. The purpose of this research is to understand the impacts of climate change on infrastructure giving special concentration on heavy rainfall and storm, and work with community to design a climate resilient infrastructure solution. Hence, I am interested in understanding the pattern and causes of vulnerabilities and problems on infrastructures due to climate change impacts in the low income settlements. I would like to hear from the community regarding the possible alternatives that can be helpful in building climate resilient infrastructure in the low income settlements.

Focus Groups

For this research I hope to conduct Focus Group Discussions with the community people. Your valuable experiences and opinions are very important for this research, so you are welcome to contribute by sharing these. Focus groups consists 10 participants each in an informal discussions where you can share your experiences, opinions and ideas as well as hear from others. To capture the gender dimension of the issues, two separate male and female Focus Group Discussions will be conducted. The discussion may continue one hour to one and half an hour.

I would like to invite you to take part in a focus group discussion. To have an accurate record of your given information, I would like to audio record the focus Group Discussions.

Your rights as a participant

You are not obliged to participate in this research, it is totally voluntary. If you choose to do so, you have the right to:

- Refuse to answer any particular question(s)
- Withdraw from the research
- Request that any material be erased
- Decline to be audio recorded and request the recorder to be turned off at any time
- Ask any questions about the research at any time during your participation

Confidentiality

All collected information will remain secure at all times. The Focus Group Discussions will be recorded using a device capable of storing good quality information. The Participants will retain the ownership of data. The written notes from Focus Group Discussions and other printed documents will be stored in a locked drawer. All recorded information will be stored for a duration of five years. I shall store these information in my laptop and the desktop provided by the University of Waikato with password protection. It is also expected that these information will be stored by my supervisor for 5 years using University of Waikato facilities. The identity of the participants will remain anonymous unless otherwise requested by any participants. The participants of the focus group discussions are requested to keep information confidential as well. The information will be used solely for academic purpose of completing the requirements of Master of Environmental Planning.

This research project has been approved by the Human Research Ethics Committee of the Faculty of Arts and Social Sciences. Any questions about the ethical conduct of this research may be sent to the Secretary of the Committee, email fass-ethics@waikato.ac.nz, postal address, Faculty of Arts and Social Sciences, Te Kura Kete Aronui, University of Waikato, Te Whare Wananga o Waikato, Private Bag 3105, Hamilton 3240.

Results

The results of this research will only be used as part of my Masters Thesis. A total of four copies of the thesis will be produced, of which three will be printed and one copy will be available online in the website of University of Waikato. It is expected that the outcome of the research will be presented in the conferences. Additionally one or more journal articles or conference proceedings may be produced from the result of the research.

What Next?

If you would like to participate in this research, I shall contact you so that we can schedule a meeting. You can contact me or my supervisor for further queries.

Sowmen Rahman

Masters Student, University of Waikato

+88001724178684, +64212388471

sowmenurp@gmail.com

Professor Iain White

Lecturer, Environmental Planning

07 838 4466 Ext. 9166

iainw@waikato.ac.nz

Appendix Three – Letter of Ethical Approval

Geography Programme
School of Social Sciences
Faculty of Arts and Social Sciences
Te Kura Kete Aronui
The University of Waikato
Private Bag 3105
Hamilton 3240
New Zealand

Phone +64 7 838 4466 ext 9174
E-mail colin.mcleay@waikato.ac.nz
www.waikato.ac.nz

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Sowmen Rahman
Iain White

Environmental Planning

24 November 2017

Dear Sowmen,

Re: **FS2017-50 Prospects of Climate Resilient Infrastructure in the Low Income Informal Settlements of Dhaka – A Community Approach**

Thank you for submitting your revised application to the FASS Human Research Ethics Committee. We have reviewed the final electronic version of your application and the Committee is now pleased to offer formal approval for your research activities, including the following:

- interviews with community leaders, representative of local government and Non-Government Offices (NGOs) and residents.
- focus groups with community members.

We would ask that you please provide Eileen Fenner, the FASS Ethics Committee Administrator, with a paper copy of your final application that has been signed by yourself and your supervisor.

We encourage you to contact the committee should issues arise during your data collection, or should you wish to add further research activities or make changes to your project as it unfolds. We wish you all the best with your research. Thank-you for engaging with the process of Ethical Review.

Regards,

Colin McLeay, Chair
Faculty of Arts and Social Sciences Human Research Ethics Committee.

Appendix Four – Consent form - Individual Interviews

UNIVERSITY OF WAIKATO

FACULTY OF ARTS AND SOCIAL SCIENCES

RESEARCH CONSENT FORM - INTERVIEWS

Name of person interviewed: _____

I have received a copy of the Information Sheet explaining the research project.

I read the information sheet and understand that

- I can refuse to answer any question, terminate the interview and can withdraw from the research.
- All information will remain confidential.
- My identity will remain anonymous unless I state otherwise
- All information collected will remain secure in a locked drawer or on a computer accessible by password only
- Information will be used for a Master's thesis, presentations, conference proceedings, conference presentations and journals.

I agree to participate in this interview and acknowledge receipt of a copy of this consent form and the research project information sheet.

_____ (to be signed and dated by participant)

_____ (to be signed and dated by Sowmen Rahman)

Appendix Five – Consent form – Focus Group Discussions

UNIVERSITY OF WAIKATO

FACULTY OF ARTS AND SOCIAL SCIENCES

RESEARCH CONSENT FORM – FOCUS GROUPS

Name of person interviewed: _____

I have received a copy of the Information Sheet explaining the research project.

I read the information sheet and understand that

- I can refuse to answer any question, terminate the focus group and can withdraw from the research.
- All information will remain confidential.
- My identity will remain anonymous unless I state otherwise
- All information collected will remain secure in a locked drawer or on a computer accessible by password only
- Information will be used for a Master's thesis, presentations, conference proceedings, conference presentations and journals.

I agree to participate in this Focus Group Discussion and acknowledge receipt of a copy of this consent form and the research project information sheet.

I am also giving the permission to audio-record the Focus Group Discussion - YES / NO

(Please Circle)

_____ (to be signed and dated by participant)

_____ (to be signed and dated by Sowmen Rahman)

Appendix Six – Key Informant Interview Schedule

Key Informant Interview Schedule

This schedule outlines some of the topics that will be during the interview. You are welcome to contribute in this research by sharing your experiences and ideas. I am interested in understanding the pattern and causes of vulnerabilities and problems on infrastructures due to climate change impacts in the low income settlements. I would like to hear from your opinion as well as ideas on the possible alternatives that can be helpful in building climate resilience infrastructure in the low income settlements. This interview will take about 45 minutes only. Your identity and responses to this interview will be kept anonymous and confidential unless you would like to include your name for your contribution in research. And your opinions will be used for research purpose only. Your spontaneous participation will be highly appreciated.

1. General Information of the respondent

1.1 Name of the Respondent: ……

1.2 Designation and Organization: ……
……

1.3 How long have you been living or working in this area (year/months)?

……
…….

For residents,

1.3.1 Where did you come from?

……

1.3.2 What is the reason behind choosing this area as a shelter?

……

2. Information on vulnerabilities and problems of climate change impacts i.e. heavy rainfall and storm on infrastructure

2.1. Do you think the area of the study is vulnerable to climate change impacts such as heavy rainfall and storm?

- ❒ Yes
- ❒ No

2.2. If yes, please describe the impacts of these climatic hazards on infrastructures from your recent experiences

Name of the climatic events	Impact on infrastructures	Frequency of Occurrence [Code: Rare = 1, Sometimes =2, Often = 3, Very Often = 4]	Severity of Occurrence [Code: Low = 1, Medium = 2 High = 3, Very High = 4]
Heavy rainfall			
Storm			

3. Information on causes of vulnerabilities and consequences on the infrastructure system and services

3.1. What are the causes for these vulnerabilities and consequences of these on the infrastructure system in the study area?

Causes	Consequences	Frequency of consequences [Code: Rare = 1, Sometimes =2, Often = 3, Very Often = 4]

4. Information on key actors and their roles

4.1 What are the key organizations working in the field of water, sanitation, shelter, road and drainage in this area and what are their roles?

Name of Organization	Field of interest (e.g. water, shelter, public health, drainage etc.)	Major Activities

5. Information on measures need to be taken to make infrastructure capable to withstand heavy rainfall and storm in the low income settlements

5.1 Based on your past experiences, what measures can be taken to improve infrastructure services than can tolerate heavy rainfall and storm considering affordability, security, safety and sustainability issues?

Infrastructure name	What can be done?	How to do (financing, strategy etc.)?	Key actors to play role

5.2 Any of the infrastructure services need immediate attention for improvement? If yes, what can be done to improve the situation?

……
…….

5.3 In your opinion, how community people can be engaged in these development activities?

……
……
……
……
……

5.4 Do you foresee any challenge in this task? If yes, please explain.

……
…….

5.5 Do you think social technology for example Mobile SMS alert, Wireless communication with community leaders, weather updates on FM radio can be applied for benefits? If yes, describe your opinion.

……
……
……
……
……

Appendix Seven – Checklist for Focus Group Discussion

Focus Group Discussion Checklist

This checklist outlies some of the topics that will be covered during the Focus Group Discussions. You are welcome to contribute in this research by sharing your experiences and ideas. I am interested in understanding the pattern and causes of vulnerabilities and problems on infrastructures due to climate change impacts in the low income settlements. I would like to hear from your opinion as well as ideas on the possible alternatives that can be helpful in building climate resilience infrastructure in the low-income settlements. Your spontaneous participation will be highly appreciated. If you are already interviewed, then we may have covered some of these questions before.

1. General understanding on the terms "Climate Change Impacts", "Climate Resilience" and "Climate Resilient Infrastructure".
2. Briefly mention the existing problems and vulnerabilities in infrastructure system and services in your area due to climate change impact.
3. Explain the underlying causes for these problems and vulnerabilities and consequences on infrastructure system.
4. Name key organizations working in the field of water, sanitation, shelter, road and drainage in this area and describe their roles in brief.
5. Identify the measures that can be taken to improve climate resilience to the infrastructure services considering affordability, security, safety and sustainability issues and describe the procedure in brief.
6. Explain how community people can be engaged in these development activities.
7. Identify the challenges in building climate resilience in the infrastructure system in your area.
8. Give your opinion on way of integrating social technology to minimize the impacts of climate change on infrastructure – for example, weather forecast on radio, SMS alert in mobile, keeping community leaders updated about possible heavy rainfall and storm to through wireless communication etc.