FLOOD MANAGEMENT IN THE KAMRANGIRCHAR SLUM OF DHAKA, BANGLADESH

The impact of flooding events on slum residents, institutions, and the development of sustainable infrastructures in the Kamrangirchar slum area of Dhaka, Bangladesh.

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Abstract

A study on the Kamrangirchar slum of Dhaka, Bangladesh has been completed by analyzing literature involving qualitative data, as well as quantitative data using a mixed method research design. The quantitative data from the World Bank (2020) and the UNDP (2020) is provided as background for the research. A series of relevant case studies and state documents are analyzed by using a qualitative 'onion-peel' approach to gather data. The theoretical framework is guided by access, adaptation, and vulnerability theories, exploring the effect of flooding events on economies and livelihoods. The study examines the duty of the state to prevent damage from disasters, as well as in creating a plan for resiliency and future innovation. Projects to build the Kamrangirchar slum of Dhaka, Bangladesh sustainably to increase disaster resilience are analyzed, including the involvement of institutions in these development projects.

The lack of infrastructure in the Kamrangirchar slum area has been analyzed and connections are made between infrastructure and disaster response. The GIS mapping resource is utilized by seeing how sewage and water systems have been implemented in Dhaka, Bangladesh. The Kamrangirchar slum is in focus, specifically observing whether this area has been neglected by urban planning and infrastructural development. The analysis and discussion of this information could potentially give some indication that the slum area lacks the infrastructure needed to be better prepared for future flooding events.

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Abbreviations

CFE-DM	Center for Excellence in Disaster Management
DRR	Disaster Risk Reduction
DSIP	Dhaka Sanitation Improvement Project
DWASA	Dhaka Water Supply and Sewerage Authority
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographic Information System
HBRI	Housing and Building Research Institute
PAR	Disaster Pressure and Release
SDG	Sustainable Development Goals
UNDP	United Nations Development Program
UNISDR	United Nations International Strategy for Disaster Reduction
UPPR	Urban Partnerships for Poverty Reduction

Keywords

Flooding, flood management, disaster management, disaster risk reduction, disaster recovery, disaster resilience, disaster preparedness, climate change, livelihood, vulnerability, adaptation, assets, economic insecurity, infrastructure, slum, sewerage networks, sanitation, housing, sustainable development, onion-peel approach, mixed method design

I.   Introduction

The geographical location and unique climate of Bangladesh has captivated the audience of many politicians, environmentalists, and economists over the years. Bangladesh is a low-lying country situated in the Ganges Delta with several distributaries flowing into the Bay of Bengal (Ali et al., 2012). Combined with the country's tropical monsoon climate, Bangladesh has been especially affected by flooding. This has caused a specific threat to several urban areas of Bangladesh, disturbing infrastructure, and livelihoods. As you can see in Figure 1a (Bairagi, 2018), a map of the flood-prone areas of Bangladesh, the capital city of Dhaka is significantly impacted by flooding.

The densely populated city of Dhaka, located on the banks of the Buriganga river, has historically faced disastrous flooding events due to heavy rainfall overwhelming sewage and drainage systems. The slum area of Kamrangirchar, southeast of Old Dhaka along the Buriganga river, has been disproportionately devastated by these flooding events. The increasing threat of climate change will generate several problems, especially for the urban poor residing in Dhaka's slums. Improvements to infrastructure and the flood management strategies in the Kamrangirchar slum are necessary to minimize the risks of future disasters.

A. Relevance of the research

Sustainable development and disaster management have become heavily contested issues throughout history and concerns all parts of both the developing and developed world. The intensification of natural disasters caused by our quickly changing environment has caused a dialogue on how to reduce the risks of disaster, as well as improving the ability to recover from disasters. It is widely known that a changing climate could increase the frequency of natural disasters, including, to name a few, flooding, land erosion, and cyclones, making this topic increasingly relevant in the future. It is the interest of society to take measures that minimize climate change or slow it as much as possible to reduce the risks of disaster and allow for a swift recovery from disasters.

The integration of these two subjects of disaster management and development of infrastructures is extremely important for an economically sustainable future, as well as in the context of development studies. Performing a micro-level case study on the Kamrangirchar slum of Dhaka, Bangladesh, which attempts to integrate these two topics could highlight issues and provide answers for how to improve methods of disaster risk reduction to create a

sustainable future. In doing so, macro-level disaster management must also be discussed to fully understand the scope of disaster management in the Kamrangirchar slum.

At an international level, many lawmakers and environmentalists have pushed to make disaster risk reduction a centralized issue of sustainable development. In the Sustainable Development Goals set in 2015 by the United Nations General Assembly, disaster risk reduction and resiliency are mentioned (Bogati et al., 2020). In SDG 1.5 it states that

> *"By 2030 build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters"* (UNDP, 2015).

Another example is in SDG 9, involving industry, innovation, and infrastructure.

> *The goal is to "build resilient infrastructure, promote sustainable industrialization and foster innovation" (UNDP, 2015).*

This gives merit to the importance and relevance of the topic of integrating disaster recovery and sustainable infrastructures to achieve these goals in the Kamrangirchar slum of Dhaka, Bangladesh.

B. Purpose of the research

The aim of this study is to assess how Dhaka, Bangladesh has integrated disaster risk reduction and recovery with developing sustainable infrastructures to respond to flooding events in the Kamrangirchar slum. Specifically, assessing how policies and actions have been formed by an environmental cost-benefit analysis of disaster management in response to flooding events. This study will be delimited to the Kamrangirchar slum which is the largest slum area of Dhaka, Bangladesh. This slum area was chosen due to their exposure to flooding events, as well as because of the effect on livelihoods of residents in this slum area caused by past floods.

1.   The research questions

To reach that aim, an attempt will be made to answer the following research questions and sub-questions throughout this study.

> *How has the integration of disaster management and the development of sustainable infrastructures to withstand flooding been implemented in the Kamrangirchar slum of Dhaka, Bangladesh?*

Sub-questions:

1. *What is the role of institutions in flood management for the Kamrangirchar slum? Specifically, how have policies and actions been formed by environmental cost-benefit analysis of flooding management?*
2. *How has the development of sustainable infrastructures and sewage networks been affected by flooding in the Kamrangirchar slum of Dhaka, Bangladesh?*
3. *How has flooding impacted the livelihoods of the urban poor residing in the Kamrangirchar slum area?*

2.   Why the research questions should be answered

This research question needs to be answered to shed light on the issue concerning flood management in the Kamrangirchar slum of Dhaka, Bangladesh. The research contributes to the advancement of knowledge about vulnerability, access and institutional involvement in disaster risk reduction efforts. Through improvements in disaster response methods, the livelihoods of people living in the slum area would potentially be improved.

Disasters cause severe economic loss as well for people living in the slums. It is important to find strategies to improve disaster management and resilience methods to lessen the impact of flooding events on people living in the slum. This theme of disaster risk reduction and the integration of sustainable infrastructures will be further explored in this paper. It is the aim of this study to gather information on the topic and present the issue affecting millions of people in Dhaka, Bangladesh today.

C. Thesis outline

To deliver a comprehensive answer to the research question, the thesis has been outlined as follows: I will begin by providing background to understand why the study has been delimited to the Kamrangirchar slum area of Dhaka, Bangladesh. I will then review the literature by categorizing it to understand keywords in the text. Next, I will discuss the theoretical framework and connect theories to the research question. In the following section, I will describe the methods of the research and data collection and coding process. The data will then be critically analyzed to answer the sub-questions in the analysis section. The discussion will include a reflection on the overarching research question, as well as interlinking with previous studies and discussing the limitations. The thesis will end with the conclusion section to provide final remarks on the overall results and recommendations for further study areas.

II.   Background

A. Bangladesh climate issues

First and foremost, the geography and location of Bangladesh in the Ganges Delta with several distributaries flowing into the Bay of Bengal cause the country to be especially prone to flooding. It is often mentioned that climate change is the biggest threat to low-lying countries like Bangladesh (Ahmed, 2014). Climate change has caused erratic weather patterns, with increased intensity and frequency of monsoonal rainstorms causing flooding to be a major issue for the urban areas of Bangladesh. Therefore, improved disaster management strategies are necessary, especially in urban cities, to be able to better withstand future flooding events. Urban areas in Bangladesh often struggle with overwhelmed drainage systems, leading to detrimental effects on infrastructure in cities. It is evident that improvements to these sewage and drainage systems need to be made to minimize the threat of climate change.

In addition, the urban population in Bangladesh is high and has been increasing rapidly, as you can see in Figure 6a and 7a (see appendix) (World Bank, 2020). Therefore, more people can be affected by improvements made in urban development policies concerning disaster management. The effect on the urban population will likely be magnified in the future due to climate change and flooding. The urban poor in Bangladesh tend to live in marginal areas that are especially prone to flooding due to their location as well as the lack in adequate infrastructure. Sewage and drainage systems are typically not sufficient in urban slum areas of Bangladesh. A prime example of this is the Kamrangirchar slum of Dhaka, Bangladesh which is the focus of this study.

B. Why Kamrangirchar slum?

The study has been delimited to the slum area of Kamrangirchar because it is the largest, most densely populated slum area of Dhaka, Bangladesh, with over one million residents. GIS mapping has been used to put this into perspective, with Figure 3a (see appendix) portraying the slum areas of Dhaka. The tight living quarters in the slum has created several water and sanitation issues as well, making health and disease a major concern for the region.

The Kamrangirchar slum is surrounded almost entirely by water, situated along the banks of the Buriganga river, as you can see in Figure 2a (see appendix). During monsoonal rain periods, the water level of the Buriganga river is often overflowing to neighboring regions, posing a particular threat to Kamrangirchar. The lack of infrastructure to manage these major rain events

has negatively impacted the livelihoods of the population residing in Kamrangirchar. As you can see in Figure 4a and 5a (see appendix), the sewage networks of Dhaka have largely neglected Kamrangirchar, leaving the region exposed to flooding events. Reasons for this will be further explored throughout this study.

Economic insecurity in this region could be one explanation for why the slum area has been widely neglected. The heavily populated slum is characterized by a high degree of economic insecurity. The Kamrangirchar slum is comprised of a large percentage of Bangladesh's population living in multidimensional poverty, which was recorded at 24,6% in 2019 by the UNDP (2020). Kamrangirchar also has limited infrastructure in place to protect the slum from disastrous flooding events, despite being one of the most vulnerable areas of Dhaka. There are some examples of developing infrastructure in the slum that would be able to withstand flooding events, although it seems these efforts have not been particularly extensive. The extent of these projects will be further discussed in the following literature review section. The following section will also give further background on the stakeholders and projects involved with disaster management both on a macro-level, concerning the government of Bangladesh, then on a micro-level with the local government of Dhaka in focus.

III.   Literature Review

This section is comprised of reviewing previous studies to provide background and historical significance to put this study into an academic context. The methodology of my research regarding disaster management in Bangladesh, with a focus on flooding in the Kamrangirchar slum, will also be justified by previous literature. I will also give perspective on contributions of this study to the literature.

A. Key concepts within the literature

Several concepts were observed when reviewing previous literature. The main, overarching concept is disaster management, thereby including the terms disaster risk reduction, resilience, and recovery. How these themes were discussed in the literature will be further explored in the following section, as well as three topics that also connect to the theme and sub-questions of this research. The way the role of institutions, infrastructures and the effect on livelihoods was portrayed by the literature will be examined.

1.   Disaster management

The issues with disasters and flood management have persisted for many years in Kamrangirchar and neighboring areas of Dhaka, Bangladesh. The term disaster management has generally been described by relevant literature as reducing vulnerability to disasters. In the paper by Abedien (2010), the approach to disaster management is emphasized as the following:

> *"Two key strategies are generally considered to reduce vulnerability to disaster: 1) decreasing the impacts of hazards on lives and resources through prevention, protection, and preparedness; and 2) increasing resilience by strengthening and diversifying livelihood options"* (p.1).

This approach has caused several stakeholders to become involved, starting projects aimed at solving issues with disaster preparedness and recovery. The main contributor to literature associated with flood management has been the World Bank which has funded several projects in Dhaka and in the Kamrangirchar slum. The World Bank has worked together with local organizations in Dhaka to solve sewage issues for example (Alam et al., 2020). The UNDP has been another contributor to disaster efforts in Dhaka, partnering with municipal government to provide relief (Ahmed, 2014). The GFDRR has worked with the UNDP on several urban development projects (Ahmed, 2014). The major stakeholders and past projects have been briefly outlined in Figure 1 below to present a description of flood management efforts in Dhaka, Bangladesh thus far.

The World Bank	DWASA	UNDP	GFDRR

• **The Dhaka Sanitation Improvement Project (DSIP)**
  ▪ Reduce inland flooding and water pollution through the Pagla Sewage Treatment Plant
  ▪ Improve sanitation services in the city to increase quality of life particularly in slums in the southern region.
  ▪ The project will upgrade sewage and septage by upgrading toilets and installing communal septic tanks (World Bank, 2020).
	• **The Sewerage Master Plan**
	  • Improve water and sewage in Dhaka, Bangladesh with a loan from the World Bank of an estimated $900 million USD (2020).
	  • DWASA, a Bangladesh government agency under the municipal government of Dhaka responsible for water and sewage, has planned to implement the Sewerage Master Plan with the loan (World Bank, 2020).
		• **Urban Partnerships for Poverty Reduction (UPPR) project**
		  • Improve the living conditions and livelihoods of 3 million urban poor people (UNDP, 2020)
		  • The largest initiative in Bangladesh that has specifically targeted the urban poor in Dhaka, for example those living in the Kamrangirchar slum (UNDP, 2020).
			• **Urban Resilience Project**
			  • Incorporating municipal government with improving developmental planning and urban projects
			  • The vulnerability of infrastructure, public facilities and lifelines has been assessed to integrate disaster risk in development planning.
			  • Equipped agencies with disaster response resources and training (GFDRR, 2020).

Figure 1: Stakeholders and projects involved in disaster management

2.   Disaster risk reduction

Certain literature focused solely on disaster risk reduction through increasing government involvement, infrastructure development, and improving livelihoods in Bangladesh. The main idea of DRR that needs emphasis to separate the term from other ideas is the disaster timeline. DRR refers to efforts made *prior* to disasters to minimize risks and vulnerability. The terminology used by the UNISDR (2009) to define DRR is the following:

> *"The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events"* (p.10).

In the Disaster Management Reference Handbook developed by the CFE-DM (2020), DRR is used as a concept to describe adaptability to climate change. The handbook describes that Bangladesh has made many strides to improve DRR strategies to minimize the likelihood of flooding. The term DRR has also been described as disaster preparedness and mitigation by the handbook and several other sources. In this context, it can also be referred to as flood risk reduction, for example in the text by Shi (2020). In this paper, infrastructure is discussed to go beyond DRR, exploring adaptation efforts in Bangladesh. Shi (2020) assesses projects associated with coastal afforestation, to understand ways in which these projects have learned from previous knowledge to make strides toward successful adaptation efforts.

The study on Dhaka, Bangladesh put forth by Hossain and Rahmen (2017) also presents DRR in a light of increasing disaster preparedness and adaptation. The paper presents the idea of developing a drainage system in Dhaka that reduces the risks of flooding (Hossain & Rahmen, 2017, p.391). Improving livelihoods for the urban extreme poor is also considered, specifically through promoting long-term resilience to flooding in Dhaka. Their use of the third concept of disaster recovery will be further explored in the section below.

3.   Disaster response and recovery

The concept of disaster recovery encompasses management efforts done in direct response to disasters. Beck (2005) uses Bangladesh to explain lessons learned from disaster recovery, specifically concerning recovery efforts affecting those in poverty. The paper presents an interesting case on the recovery of poorer households following disasters and how extra support is needed. In this paper, as well as in others, the term resilience is often used to define the work

that is done directly after a disastrous event to minimize damage or risks from future events. However, the phrase can also be used when referring to development efforts prior to disasters in terms of building resilient infrastructure (Moles et al., 2013).

In this study, the efforts of response and recovery from specifically flooding events are the focus. The literature from Hossain and Rahmen (2017) discusses possibilities of building resilience to climate events such as flooding. The paper discusses increasing community involvement and refining the role of local and national governments to provide more aid to disaster-hit areas. A similar discussion is seen in the paper from Ahmed (2014), addressing significant actors involved with urban poor issues. The paper examines projects involved with building resilience in Dhaka's slum communities. The projects discussed in this paper mostly center on water and sanitation improvements in slum areas, which is a major concern specifically for the Kamrangirchar slum. This was important to review to gain understanding on disaster management efforts in the Kamrangirchar slum.

B. Contributions to the literature

This study contributes to the advancement of knowledge about disaster management efforts specifically in the Kamrangirchar slum of Dhaka, Bangladesh. There are currently gaps in literature pertaining to the disaster efforts in the Kamrangirchar slum. Very few studies have been done on flooding in this slum area, likely due to lack of funding and access to resources. As discussed previously, economic insecurity in the region could be to blame for the lack in literature on this specific slum of Dhaka.

This study also contributes to the discussion of integrating topics of sustainable development and disaster management. My study provides a perspective on the effect of flooding events on the urban poor living in slum areas. While many studies have been done previously on this topic, this study could provide insight on the effect on livelihoods, infrastructure and political structures and policies that flooding causes. There is currently a discourse in combining these topics in a way that is unique to my study.

IV.   Theoretical Framework

In this section, I describe the theoretical framework that upholds my research. I will start by evaluating the relevant theories and then apply each theoretical concept to the context of my research question. The theoretical framework is predominately supported by the concept of vulnerability, outlined in Wisner et al.'s *At Risk: Natural Hazards, People's Vulnerability and*

Disasters (2003). This paper describes the vulnerability theory in detail, as well as the disaster pressure and release model and the access model. Lastly, Moser's (2011) asset adaptation framework, which is also discussed in Hossain and Rahmen's (2017) paper, will be applied to the context of my research.

A. Evaluation of theories

1.   Theory of vulnerability

The concept of vulnerability, which has been touched on previously, has a strong connection with disaster management, risk reduction and recovery. The vulnerability theory that is presented by Wisner et al. (2003) is initially generated by economic, social, and political processes. This theory can be applied to flood management in Kamrangirchar in several ways. The application of the theory to Kamrangirchar's flood management has been further detailed in Figure 2 below.
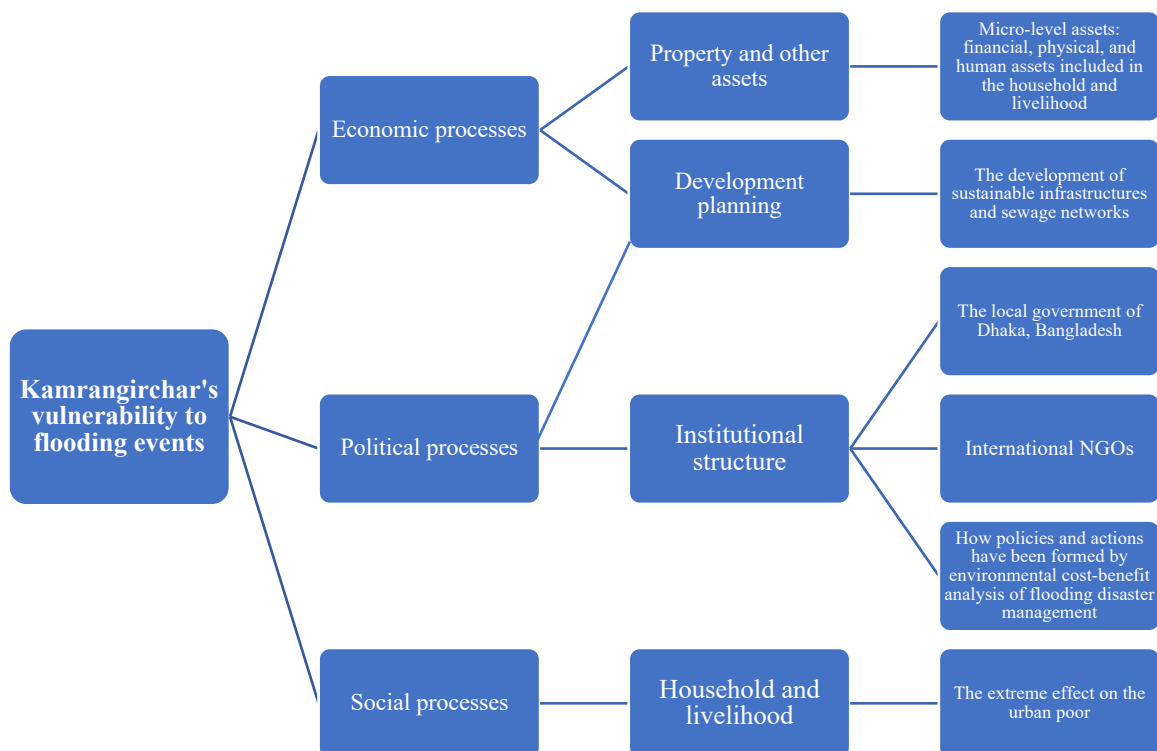
Figure 2: Applying vulnerability theory to the Kamrangirchar slum

As stated by Wisner et al. (2003), vulnerability includes "the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" (p.11). In the case of Kamrangirchar, the impact of flooding on livelihoods and assets was in focus. Vulnerability involves a combination of these

complex factors that are threatened by disaster risks. The theory of vulnerability relates to the livelihood aspect of the research question and the concepts of disaster risk reduction and flood management. The theory encompasses why management strategies are needed in the first place – to minimize vulnerability to disasters, and in this context, specifically through developing sustainable infrastructures.

a)   Disaster pressure and release model

The PAR model describes the nature and progression of vulnerability, dividing the concept into three categories: root causes, dynamic pressures, and unsafe conditions. The model shows how disasters or risks occur when hazards, in this case flooding, affect vulnerable people. It identifies the progression of vulnerability, in which "root causes are formed by a series of dynamic pressures and give rise to the unsafe conditions" (Wisner et al., 2003, p.50). The vulnerability of the people residing in the Kamrangirchar slum, according to this model, is rooted in social processes and underlying issues which may be separate from the specific disaster event (Wisner et al., 2003, p.50). The PAR model has been outlined in detail in Figure 3 below.
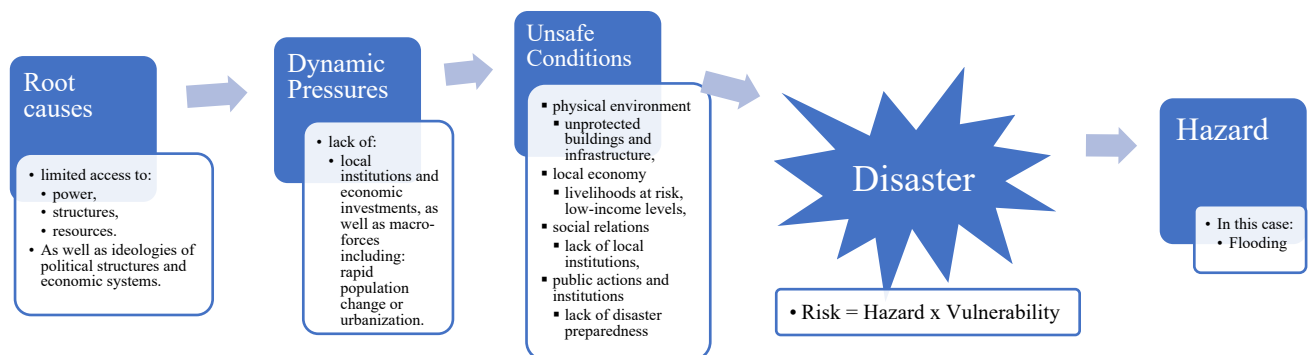
Figure 3: Wisner et al.'s (2003) Disaster Pressure and Release Model

The application of the vulnerability theory and the PAR model to the research is similar. The PAR model relates to the general sense of the importance of flood management and minimizing vulnerability. It also goes deeper into why certain groups of society are disproportionately affected by disasters, in this case the urban poor residing in slum areas. The PAR model also relates to the first sub-question of the role of institutions and how political and economic systems affect flood management in the Kamrangirchar slum.

2.   Theory of access to resources

Resource accessibility is essential in disaster management and determining the severity of disaster events. The theory of access connects to livelihoods and households in a particular way of assessing the ability of an individual, family, or community to secure resources in disasters (Wisner et al., 2003, p.94). The variations in level of vulnerability due to access for certain groups in society are important to consider in flood management efforts. Especially, when an individual or institution is determining strategies of risk reduction and preparedness. Analyzing at a micro-level how a person is vulnerable to disasters is a fundamental aspect of the theory of access. Essentially, the theory and model of the theory is an expanded analysis of the PAR model, focusing more specifically on how disasters impact people and their responses. The access model is designed to understand complex disaster events and long-term processes which will be further discussed below.

a)   Access model

The establishment and trajectory of vulnerability is a fundamental feature of the access model. As Wisner et al. (2003) explains, it is essentially a magnifying glass on the PAR model to explain disaster effects. The authors go on to say that "it deals with the impact of the disaster as it unfolds, the role and agency of the people involved, what the impacts are on them, how they cope, develop strategies and interact with other actors" (Wisner et al., 2003, p.88). It is a dynamic, economistic model that is based on both social and economic impacts of disaster. The access model also involves a livelihood analysis to explain how a person gains capital through increased access to assets and resources. The five types of capital are outlined in Figure 4 below.
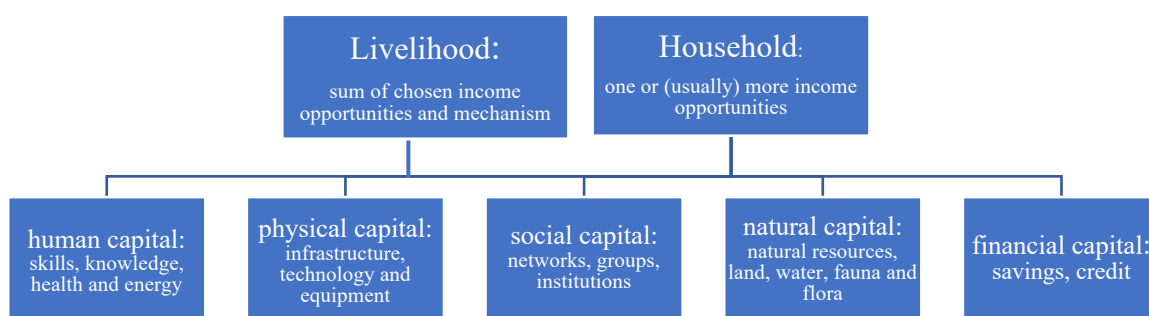

Figure 4: Simplifying Wisner et al.'s (2003, p.87) livelihood aspect of the access model

Through this livelihood analysis of the theory of access, the model connects to the sub-questions of the research including both the role of institutions and the impact on livelihoods. The access model includes an assessment of how institutions provide access to resources and

their trajectory through a disaster event. It simultaneously provides context on a micro-level for the impact of disasters on livelihoods and individuals in a seamless way to put this research into an academic context.

3.   Theory of assets and adaptation

Similarly, Moser's (2011) theory of assets and adaptation provides context to the sub-questions of the research including the role of institutions and impact on livelihoods. This theory however is very broad and has therefore been narrowed down to the context of climate change. It focuses on the role of assets in providing low-income individuals the capacity to adapt to disaster events (Moser, 2011, p.232). In other words, it is the capacity to reduce risk and adapt to increased risk from disaster events, as well as the ability to function with local governments.

The theory includes financial, physical, and human assets, including general household assets and contributions to livelihoods (Hossain & Rahmen, 2017). These are included in micro-level asset adaptation involving the individual which is the focus of this study. The theory however also includes meso- and macro-level asset adaptation that is shaped by entire community and municipal government adaptive responses. Returning to Moser's (2011) perception of the theory, asset adaptation connects to the "identification and analysis of the connection between vulnerability and the erosion of assets" (p.233). The framework of asset-based adaptation is outlined further in the following section.

a)   Asset-based adaptation framework

The framework from Moser's (2011) perspective on asset-based adaptation can be narrowed down to three main principles. It seeks to identify resiliency strategies in a context of increased effects of climate change on society. It includes the exploitation of opportunities and assets to adapt or recover from the effects of climate change or more specifically in this case flooding events. The three principles of Moser's (2011) asset-based adaptation framework are described in further detail in Figure 5 below.

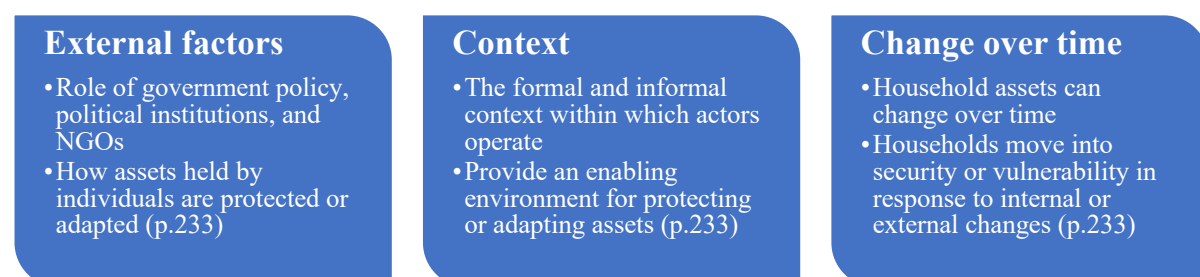| **External factors**	**Context**	**Change over time**
• Role of government policy, political institutions, and NGOs • How assets held by individuals are protected or adapted (p.233)	• The formal and informal context within which actors operate • Provide an enabling environment for protecting or adapting assets (p.233)	• Household assets can change over time • Households move into security or vulnerability in response to internal or external changes (p.233)

Figure 5: Moser's (2011) principles of the asset-based adaptation strategy

As stated, this connects to the research question aspect of focusing on the impacts of flooding on individuals residing in the Kamrangirchar slum. The general sense of the question is how the individual is impacted by institutional, infrastructural and livelihood changes caused by flooding events. The asset-based adaptation framework encompasses those concepts to give validity to why this research question needs to be answered.

V.   Methods and Data

My methodology is guided by the grounded theory of vulnerability, utilizing a qualitative form of content analysis to explore this theme. For background and additional context of the case, quantitative data from the World Bank (2020) and UNDP (2020) was also collected. Therefore, a mixed method approach was used in this study including both qualitative and quantitative data. Since this method can often be quite broad, it has been narrowed down and limited to analyzing using a specific approach to view the case of Kamrangirchar. To provide validity to the case and find the root causes of the issue, the overall research design made use of Wamsler's (2007) interpretation of the 'onion-peel approach' to the multi-level system. This approach was used to manage and analyze sources holistically on a global, national, municipal, and household level. I will end each section by discussing the limitations and delimitations to my methodology. The data section, following the methodology, includes the collection and coding of data. The process of coding the data was guided by inductive coding to find themes in the text to then create a hierarchal coding frame. First, however, the overall research design will be discussed.

A. Methodology and research design

The complexity of the unit of analysis as the Kamrangirchar case made finding the type of research design that was most appropriate to use a difficult process. However, a similar approach to Wamsler's (2007) 'onion-peel' strategy was applied, combining quantitative and qualitative data for a mixed method research design.

The 'onion-peel approach' was used to analyze the multi-level system in a holistic manner to get to the root of the flood management issues in Kamrangirchar. The approach, which is outlined in Figure 6 below, is ideal for exploring the themes within the literature to connect and analyze within the different sources. The selection of case studies also made the 'onion-peel approach' ideal for providing context to the micro-level qualitative and quantitative research.
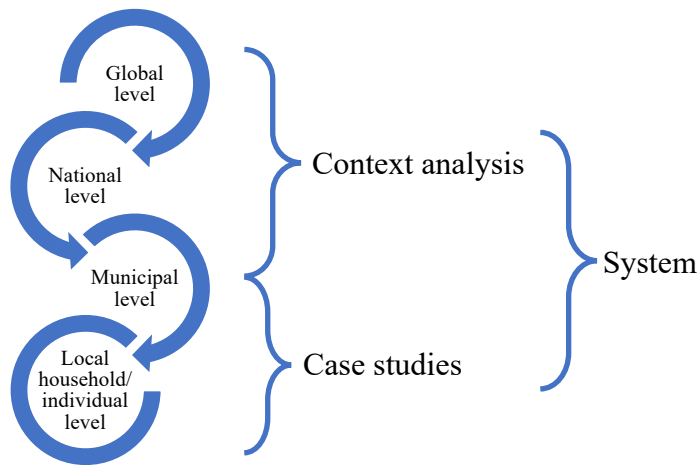
Figure 6: Wamsler's (2007) onion-peel approach

1.   Quantitative research methodology

The methodology of the quantitative research approach was done mostly from a global level and then restricting the data to a national and municipal level. Therefore, the 'onion-peel approach' is applied to the quantitative data to organize and manage the sources in the multi-level system. The World Bank and the UNDP were the main quantitative data source to provide context for flood management in Bangladesh. Economic activity in Bangladesh was reviewed before and after major disaster events in Dhaka, Bangladesh for possible indication of the extensiveness of each flooding event (Figure 15a, see appendix). The 20th century floods of 1987, 1988, and 1998 are analyzed, as well as the more recent floods of 2004 and 2010. The GDP and HDP are chosen as indicators to understand the economic effects of flooding on Bangladesh, and on Dhaka more specifically. The trajectory of these indicators before and after flooding events are analyzed to provide comprehensive context to the analysis.

Additional indicators of poverty in Bangladesh's urban slums are collected as quantitative data for the context analysis. The urban population curve has been included, as well as population density to understand the extensiveness of urban development issues in Bangladesh. The GINI index, which analyzes income, is used as another indicator of poverty in Bangladesh. Disaster-related statistics in Bangladesh have also been included but are limited to data on the number of people displaced by disaster events (Figure 11a, see appendix). The collection of these statistics is used to provide context to the case of Kamrangirchar and understand the economic effect of flooding in slum areas.

The quantitative research methodology is however limited to providing context only from the national and global level. Quantitative data on the municipal level is minimal and the data from

a local household level is extremely limited. Therefore, the quantitative data has been supplemented by qualitative research to provide sufficient context analysis.

2.   Qualitative research methodology

The qualitative data, on the other hand, was able to provide more comprehensive context to the case at a municipal and local household level. The qualitative data guided the overall research design process and allowed for better understanding of the case of Kamrangirchar. The nature and topic of the case study is exploratory, explanatory, and descriptive which is why the qualitative methodology is appropriate. The qualitative method includes a holistic approach to the data, interpreting the complex data according to the 'onion-peel approach'. This is done in a methodical way to analyze, manage, and code the data in an appropriate manner. Much of the qualitative data is collected from secondary sources, including academic journal articles, newspapers, books, and papers. Official state documents and government reports are also included in the qualitative data for context analysis to the study. These secondary sources provide non-nominal data on the impacts of flooding events on municipal and local household levels to review in this study.

The geographic composition of Dhaka, Bangladesh is a main component of the qualitative research methodology. The GIS systems have been used as elements of analysis to situate the reader geographically. Images of the GIS mapping of slum areas in Dhaka, Bangladesh is included in the annex to understand the geographical composition of the Kamrangirchar slum. The GIS mapping of sewage and drainage systems are reviewed to understand the situation of infrastructure in the urban slum area of Kamrangirchar (Figure 3a, 4a, see appendix). This is reviewed to understand whether the slum area has been neglected from city development planning in the past. The qualitative data from maps also paints a picture of the disaster plan in Dhaka, providing indication of efforts of disaster risk reduction. There are however practical limitations to using GIS mapping. The information provided is minimal since GIS software is expensive. Information on slum areas is limited and few indicators on flood management can be analyzed through GIS mapping.

The general qualitative research methodology is limited as well in several aspects. The complexity and nature of the Kamrangirchar case generates a methodology that exceeds the scope of this study. Additional context analysis and case studies is needed to understand complex issues involved with disaster management in Kamrangirchar. This methodology is

therefore limited to providing a concise representation of flood management in the slum of Kamrangirchar.

3.   Limitations to the 'onion-peel approach'

Throughout the qualitative and quantitative research methodology, the 'onion-peel approach' is used to characterize the root causes of flood management issues in the Kamrangirchar slum. There are methodological limitations however that are worth mentioning. There is a lack in previous research on this topic which limits the study. This specific approach is also limited to qualitative data and therefore was not followed in its entirety. The 'onion-peel approach' is naturally limited to the selection of case studies. My personal interpretations and representations of data created researcher limitations as well, restricting the methodology to the collection of data that I deemed to be relevant. Themes and ideas were derived according to my interpretation of the data sources to bound the methodology approach. The data and collection process are further discussed in the remainder of this section.

B. Data

1.   Data collection process

The data collection process was guided by reviewing texts to collect relevant content on the case of the Kamrangirchar slum. At the global research level of the 'onion-peel approach', data from the World Bank (2020) and UNDP (2020) was collected to provide background for the micro-level case study of the Kamrangirchar slum. Data from the national government of Bangladesh was collected as well to give context to case studies done at a national level.

Much of the research was done on a municipal level regarding the government of Dhaka, Bangladesh by analyzing case studies. A lack in data at the local household level made the municipal research more significant in providing context to the urban slum of Kamrangirchar. The collection of this data supported the theoretical level to extract common themes from the text, as well as contributing to the overall understanding of the system.

2.   Source criticism and addressing biases

Throughout the collection process, criticism of sources was carefully reflected upon. The emphasis of biases of the author present in the literature is important when conducting research. Biases fueled by political motivations, along with other social and financial biases of the author are important to mention to mitigate certain falsehoods and inaccuracies present in sources. This study makes use of state documents which can inherently present an image of a situation that is inaccurate. Government reports oftentimes withhold certain information to paint the

country in a positive light. I recognize this bias as a minor issue for my research study to be able to present an accurate representation of flood management in the Kamrangirchar slum.

Although, the collection of various sources from different research levels mitigates this issue to a certain extent. The aim of this study is to generate an objective account of history centered on accurate and authentic historical facts, as Graebner et al. (2012) stresses in their paper. Providing representativeness through the proper management of sources is displayed in the following analysis section. Representativeness of sources is highlighted in the coding process of data as well.

3.   Data coding

The process of thematic coding, also known as thematic analysis, was used to code the qualitative and quantitative research for this study. Coding aided in organizing the data to interpret common themes and concepts in the literature. Exploring these themes that arise from coding was useful in connecting and analyzing content within the different data sources. Content analysis was selected as the preferred method of qualitative data analysis to categorize and tag certain themes in the data. This was done in an inductive manner, meaning by creating codes that arise from the qualitative data itself. Inductive data coding made finding themes in the text therefore manageable.
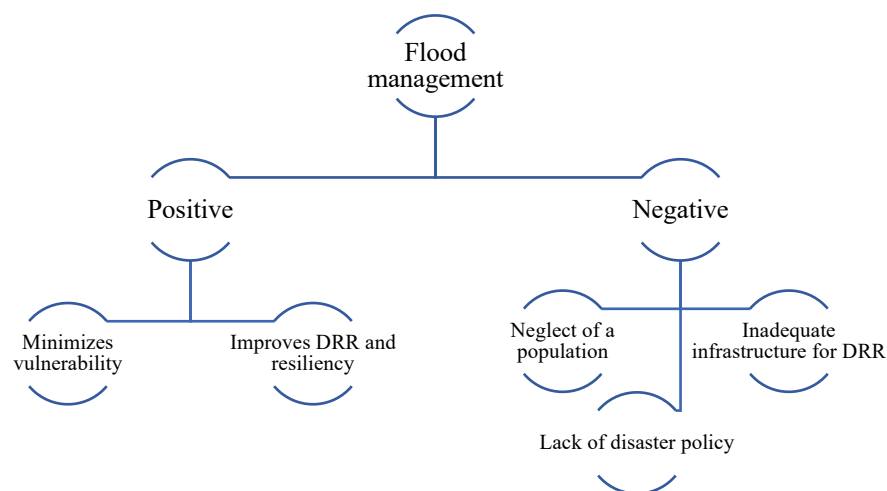

Figure 7: Hierarchal coding frame

This technique of coding aided in constructing a hierarchal coding frame, as seen in Figure 7 above, to organize and manage the data. The management of flooding in the Kamrangirchar slum is the main topic of this study and is therefore placed at the top level of the hierarchal coding frame. The mid-level is comprised of dividing the topic in positive and negative aspects.

The positive aspects are the benefits in the environmental cost-benefit analysis that increase human well-being. The negative aspects are thereby the costs in the analysis that contribute to reductions in human well-being. The themes that have been extracted from the literature are then comprised in the third level of the hierarchal coding frame. Figure 7 has been included to paint a clear representation of the coding frame that has been used to organize themes from the literature and will also be discussed further in the following analysis section.

VI. Analysis

In this section, I inductively analyze the research findings to answer the overarching research question by dividing it into three parts: institutions, infrastructure, and livelihoods. These three themes have been included in my sub-questions to then be able to answer the main research question.

A. Thematic analysis

1. Role of institutions and policies

Relevant literature on the role of institutions and policies in flood management in the slum of Kamrangirchar will be analyzed to answer the first research sub-question:

> *What is the role of institutions in flood management for the Kamrangirchar slum? Specifically, how have policies and actions been formed by environmental cost-benefit analysis of flooding management?*

To answer this question, I will follow Wamsler's (2007) 'onion-peel approach' to analyze the multi-level system. Beginning at the global level of the approach, according to the literature, it seems that global institutions have a significant role in flood management in the Kamrangirchar slum. The World Bank is the main institution involved in efforts to minimize vulnerability and improve DRR and resiliency efforts. Partnering with local institutions, the World Bank has provided much of the funding for improving flood management in slum areas of Dhaka. They have also provided funding for projects and reports on the subject matter to increase awareness of the issues the Kamrangirchar slum is facing.

The quantitative data collected from the global research level gives indication that the role of institutions needs to be strengthened as well. Bangladesh has seen stable, rising GDP growth rates in the past decade as you can see in Figure 12a (see appendix) (World Bank, 2020). On the other hand, the quality of life and human development indexes have been low in Bangladesh, making an improved development strategy necessary.

On the national level, the government of Bangladesh has taken measures to improve flood management in Dhaka, although much of the focus has been on the wealthy areas of the city. In the rationale for the HBRI (2018) guideline for housing in disaster prone areas of Bangladesh, it states the following:

> *"Although Bangladesh has shown responsive approaches to disaster risk reduction and management, lack of an inclusive policy and guideline at a national level is obstructing the successful outcome of the overall process in most of the cases." (HBRI, 2018)*

The municipal level has been similar in this sense, with the government of Dhaka largely neglecting the Kamrangirchar slum area in flood management efforts. This is shown through GIS mapping of the Dhaka sewerage network displayed in Figure 4a (see appendix). The maps show that Kamrangirchar lacks the sewerage network needed to reduce risks of flooding. An environmental cost-benefit analysis, shown in Figure 8 below, has likely been completed on a national and municipal level when developing policies and actions. According to literature, it can be assumed that agencies have determined to not include the slum of Kamrangirchar in their government policies associated with flood management after conducting the cost-benefit analysis described below.
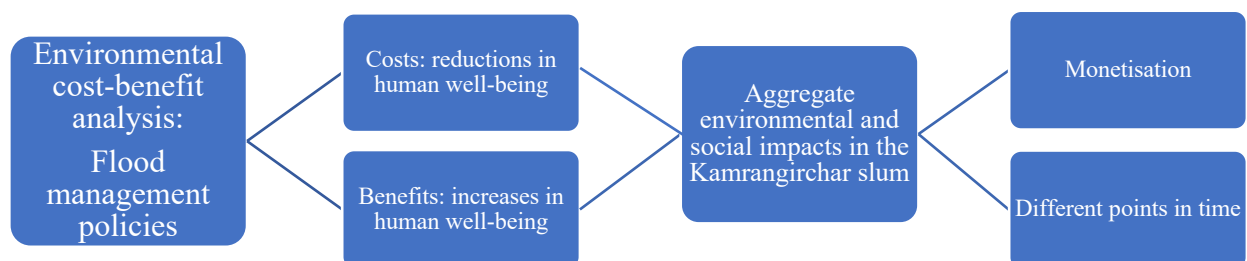

Figure 8: Analysis of environmental cost-benefit analysis

Therefore, the local household level has been negatively impacted by this neglect, lacking the infrastructure needed to withstand major disaster events. It can be asserted that institutional involvement from each research level of the 'onion-peel approach' have negatively impacted the system in its entirety to not provide adequate flood management strategies in the Kamrangirchar slum. The impact of infrastructures, closely linked with institutional involvement, is further discussed in the following section.

2. Development of infrastructures

To answer the second research sub-question:

How has the development of sustainable infrastructures and sewage networks been affected by flooding in the Kamrangirchar slum of Dhaka, Bangladesh?

A series of literature sources concerning infrastructure have been reviewed to answer this question. Housing and sewerage systems were among the main concern discussed in selected literature. For example, Ali et al. (2012) state "that in the past 20 years, 135 million people in Bangladesh have been affected by natural disasters" (p.1). The paper continues, stating that "while many have lost their lives or been injured, millions of others have also lost their homes, land, and livelihoods" (Ali et al., 2012, p.1).

This opens the discussion of why housing is a vital aspect of flood management on a national level. The HBRI (2018) guideline states that housing is the most affected by flooding, making a national guideline for housing development necessary. Moles et al. (2013) discussed the issue of housing in disaster-prone areas of Bangladesh. It was concluded in this paper that housing provided by government and NGOs to disaster affected people have in part been very costly and robust, but also that some are unable to withstand flooding events. The article by Ahmad (2018) points out that "sustainable housing has a key role in the quality of human life". He continues, stating that the poor and vulnerable population are especially affected by this, lacking adequate housing due to discrimination and exclusion from public policies (Ahmad, 2018). An analysis of these texts displays that housing is an important element impacted by flooding, as well as proper water and sanitation services for the households.

The second element of infrastructure impacted by flooding, is the sewerage networks of Dhaka. According to Alam et al. (2020), "the existing sewerage network serves only 20% of the total urban population, mostly concentrated in wealthier areas" (p.2). This is displayed in the GIS mapping images included in the appendix (Figure 4a, 5a). Another relevant statistic that was found in the study from Alam et al. (2020) is that approximately 31% of Bengali urban residents lack proper sanitation. Many of these residents that are neglected from sewerage networks are those living in slums like Kamrangirchar. There are currently projects in place to address these concerns but more needs to be done on the national and municipal level to solve these issues that impact livelihoods of slum residents. Housing and sanitation improvements would likely have a significant impact on livelihoods of Kamrangirchar residents. The impact of flooding on households and livelihoods will be further examined in the following section.

3.   Impact on households and livelihoods

The third and final sub-question, which ties everything together well to then address the overarching research question, concerns the livelihoods of slum residents. The question is presented as follows:

How has flooding impacted the livelihoods of the urban poor residing in the Kamrangirchar slum area?

This is a loaded question that connects to the previous sub-questions in several ways. A person's livelihood and household are affected by institutions and infrastructure development in a direct way. As mentioned, policies created concerning flood management have an impact on housing and sanitation services for slum residents that directly impacts their livelihoods. As the HBRI (2018) guideline states, Bangladesh is exposed to flooding which significantly affects the overall livelihood of those residing in disaster prone areas, such as the Kamrangirchar slum. Floods impact housing and household assets that get damaged, as well as water supply and sanitation that get disrupted and thereby affects livelihoods (Ahmed, 2014, p.748). Jobs are affected by flooding, along with schools and religious centers which all disrupt livelihoods. As Ahmed (2014) states, floods are disproportionately affecting the urban poor living in vulnerable areas because of severe secondary effects on their livelihoods (p.749).

Livelihood-centered approaches to disaster management are important in reducing vulnerability, according to Abedien (2010). The DRR project discussed in this paper has "used a sustainable livelihoods approach to demonstrate positive development impacts that increase resilience and the ability to adapt to climate change" (p.1). The further development of this project, along with those discussed in detail in the literature review, are important for the improvement of livelihoods of Kamrangirchar slum residents. The extensiveness and scope of the disaster relief projects also need to be expanded to be more inclusive to helping Dhaka's slums. As Ahmed (2014) mentions, floods impact the urban poor in several ways and the adverse effects of flooding influence livelihoods as well (p.748). It is clear from the analysis of the literature that livelihoods are impacted by efforts from every research level of the 'onion-peel approach', including on a global, national, municipal, and local household level.

B. Delimitations of the analysis

Using this 'onion-peel' approach, the main research question can then be methodically and deliberately answered. These three themes of institutions, infrastructure, and livelihoods that have been discussed, in turn, delimits the research to not exceed the scope of the study. The topic of flood management is a complex issue that includes economic, political, and social

systems that need delimitations. The study has been delimited to the slum of Kamrangirchar as well and flooding issues concerning slum residents in general has been included to provide better understanding for their situations.

The delimitations also generate possibilities for further study or action on this topic that could be explored in the future. This research would in that case be useful for studies concerning this topic. Having said that, after analyzing the literature, certain assumptions can be drawn on the root causes of the issue concerning flood management. This will be deliberated in the following discussion section of this paper.

VII. Discussion

In this section, the discussion of the overall results of the study will occur. This will be done first by answering the overarching research question:

> *How has the integration of disaster management and the development of sustainable infrastructures to withstand flooding been implemented in the Kamrangirchar slum of Dhaka, Bangladesh?*

This research question is in part answered by the three sub-questions that have been carefully answered in the analysis. These answers will be integrated concisely to provide better understanding for the overall results.

A. The overall research findings

After careful analysis of the research sub-questions, the following assumption can be made: the integration of disaster management and the development of sustainable infrastructures to withstand flooding has *not* been implemented properly in the Kamrangirchar slum of Dhaka, Bangladesh. However, efforts have been made on a global, national, municipal, and local level to improve flood management in the slum.

Global level efforts have been the main contributors to funding improvements to flood management in the slum. Although, more funding is needed for infrastructural change to increase resilience to flooding. Housing development and initiating a sewage network in the slum could be two elements to direct funding to. The World Bank and international NGOs are however limited in their funding and efforts to improve micro-level Kamrangirchar flood management. More needs to be done in collaboration with national efforts from the government of Bangladesh.

Regarding national level disaster relief efforts, previous studies and government documents discuss that Bangladesh has made great strides in managing flooding. For example, the CFE-DM (2020) states that the country has created a system to send out early warnings to the public when flooding may occur (p.24). The handbook continues, stating that Bangladesh has also improved DRR by developing around 2,500 concrete storm shelters which have resulted in a massive decline in storm-related deaths (CFE-DM, 2020, p.24). This concern for livelihoods needs to come from a national level to make an impact for the Kamrangirchar slum. According to Hossain and Rahmen (2017), "the national government should give power and resources to local governments so they can help poor household and communities obtain safe, legal land sites for housing" (p.392). The possibilities are much greater when partnerships are made between national and local governments and organizations to help the urban poor.

The municipal level efforts to implement sustainable infrastructure to improve flood management has been minimal in slum areas like Kamrangirchar. The local government of Dhaka, as mentioned previously, has failed to prioritize areas with high levels of economic insecurity. Instead, wealthy areas of Dhaka have received improved DRR infrastructure, such as flood-resistant housing and better sewerage and drainage systems. This is usually beyond the means of community-based organizations, according to Hossain and Rahmen (2017). Micro-level projects are constrained to needing funding from municipal, national, and global organizations to implement drainage infrastructure in communities like Kamrangirchar (Hossain & Rahmen, 2017, p.391).

The local household level efforts are entirely different from those from the global, national, and municipal level. Since they are the ones directly affected by flooding events, the focus is their efforts in improving adaptability and minimizing vulnerability in the community. Returning to the theories mentioned in the theoretical framework, vulnerability and asset adaptability is important on a local household level for DRR efforts. Making plans and guidelines to move to safe places in the event of a disaster to prevent storm-related deaths is essential (Hossain & Rahmen, 2017, p.396). These strategies need to be clearly outlined well in advance to keep the public informed in where the nearest safe place is to escape flooding. To protect communities from large-scale asset erosion, collaborations are necessary from all levels of the 'onion-peel'.

1.   Substantiating findings

Going deeper, the implementation of flooding management strategies has not been sufficient in minimizing disaster-related deaths in the Kamrangirchar slum. Livelihoods, HDI and GDP have been negatively affected by flooding events. Figure 15a (see appendix) displays the effects to HDI and GDP after major flooding events in the past few decades in Dhaka, Bangladesh (World Bank, 2020, UNDP, 2020). This data shows that strategies to curtail effects to the economy and the well-being of the population could be improved to lessen this impact. Improving DRR methods is a necessity in minimizing effects to the HDI and GDP of a country.

To diminish the vulnerability of slum residents, measures need to be taken to improve government policies and develop sustainable infrastructure to protect the population of Kamrangirchar. The area cannot be neglected as it has been previously. Funding from all levels of the 'onion-peel' is needed to solve the humanitarian issue in the Dhaka slums. Upon review of results from previous studies, it can be shown that there is room for improvement to decrease vulnerability and asset-erosion. More on this will be touched upon in the following section.

2.   Interlinking with previous research

The result of this study relates to previous studies in certain ways that are worth exploring. While this study is unique in its presentation of research questions and topic, there are similarities with previous research findings. First, since much of this study was done based on thorough investigation of secondary data, the research relied on studies that had collected primary data from interviews and surveys. This information was useful in giving substance and accuracy to this study. It was also helpful in providing a localized perspective on the situation in the slums of Dhaka. Reviewing an abundance of literature that all had similar conclusions provided certainty to the results of this study.

While few texts discussed the situation in Kamrangirchar specifically, the mixed method design allowed for an abundance of data to be reviewed. The collection of quantitative data for the background and overview of the status of the developing country was useful in substantiating findings. It was also useful in making connections between various studies and with my own. In all the studies that were observed, it was concluded that Kamrangirchar's flooding management is not adequate. This validates the findings of this study and allows for accurate assumptions to be made.

3.   Identifying overall areas of improvement

Although thorough investigation of secondary data was sufficient in bringing forth results, there are some areas of the study that could be improved. The ineffective implementation of flood management strategies in Kamrangirchar can be seen through secondary and tertiary data, however supplementary primary data collection would have been useful in this study. For example, conducting interviews and surveys with slum residents could have been helpful in providing a more local perspective to the Kamrangirchar slum. The lack in data on this slum area also makes this element significant to the study.

In addition, a field work-based approach to the study would have improved the research and data collection process considerably. This could be taken into consideration however in a future research project on this topic. Visiting the slum area and conducting interviews with residents as well as government-based organizations and NGOs associated with flood management would be extremely beneficial. In this study however, this could not be conducted due to the present situation of travel restrictions and additional limitations. More on these limitations will be deliberated in the final section of the conclusion.

VIII. Conclusion

From the analysis and discussion, it can be concluded that there are major economic benefits of making disaster risk reduction central to development, contributing to the relevancy of this topic in a development context as well as in economic history. Disaster risk reduction efforts save money and lives if the efforts are successful in lessening the impact of natural disasters on societies (Kellet, 2014, p.5). Investments in infrastructure is necessary prior to disasters to reduce the effect on livelihoods and the economy, rather than as a direct response to disasters.

Despite the economic growth Bangladesh has been experiencing in the past few years, the country is facing several challenges concerning the environment. The number of people displaced by disasters has been rising for several years, as you can see in Figure 11a (see appendix) and will likely continue to rise due to climate change (World Bank, 2020). The percentage of the urban population living in areas below five meters elevation is also rising as you can see in Figure 9a (see appendix) (World Bank, 2020). Progress towards decreasing these numbers can be further supported and enhanced by improved development policies concerning disaster management and sustainable infrastructure.

Historically, disasters tend to trap people in poverty. The social impact of disasters in the past have exposed inequities in communities and disproportionately affect lower class people in society, keeping the poorest poor (Kellet, 2014, p.3). Therefore, poor communities will benefit from disaster risk reduction efforts, allowing them to escape poverty by minimizing the economic impact disasters have on their livelihood and future. The livelihoods of the urban poor have been disproportionately affected by disastrous flooding events, taking years to fully recover (Hossain & Rahmen, 2017).

Due to lack of funding from local municipal government and organizations, economic insecurity in the region persists long after flooding events in Kamrangirchar occur. In the past, the slum area has relied mostly on international investors, such as NGOs and the World Bank. Payment systems and loans have been made accessible to slum residents to relieve some hardships caused by disastrous events, although more needs to be done for significant change. As mentioned, improvements in infrastructure in the slum could have a major effect on disaster response and the time it takes to recover from disasters.

I found that it is clear from literature that Kamrangirchar has limited infrastructure in place to protect the slum from disastrous flooding events, despite being one of the most vulnerable areas of Dhaka. There are some examples of developing infrastructure in the slum that would be able to withstand flooding events, although these efforts have not been particularly extensive. An effort was made to develop two-story housing in the slum to minimize the effect of flooding, although this has not led to the necessary widespread infrastructural change to minimize vulnerability in the slum area (Hossain & Rahmen, 2017).

As GIS mapping and various sources show, the slum area has also been largely neglected from sewage treatment plans, leaving the region exposed to flooding. Drainage systems have instead been built in affluent areas of Dhaka to minimize disaster risks affecting the wealthy population. This has created a further gap between groups in society in terms of vulnerability to flooding and access to resources. These theories of vulnerability and access in terms of disasters are important to centralize in proposed development policies. Further studies on this topic would shed light on issues concerning the slum and create a pathway for increased discussion on the topic.

Upon personal reflection of the research findings, I believe it would be interesting to expand the scope and limitations in a future study on the topic. Exploring the flood management issues in the Kamrangirchar slum area further and focusing more on the issues concerning

infrastructure, institutions and livelihoods in the slum would be fascinating. Specifically, conducting interviews with residents to gather information on their personal experiences with flooding would be valuable in future studies concerning this topic. Gathering more extensive data and statistics on relevant beneficiaries and institutions involved with flood management would be interesting as well. Distributing surveys and questionnaires, as well as interviewing actors that are concerned with flooding management efforts in Kamrangirchar would be beneficial in future studies. There are endless possibilities concerning the complex issue of flood management in the slum of Kamrangirchar in Dhaka, Bangladesh and I very much enjoyed researching this topic.

IX.   References

Abedien, Z., Ahmed, S. U., Haque, R., et al. (2010). *Elements of disaster resilience: lessons from Bangladesh: Mainstreaming Livelihood-Centered Approaches to Disaster Management Project.* Practical Action: Technology challenging poverty. https://www.recoveryplatform.org/assets/publication/cluster%20housing%20in%20bangladesh%20practical%20action.pdf

Ahmad, T. (2018). *Sustainable housing for sustainable cities and communities in Bangladesh.* The Financial Express, World Town Planning Day, 2018. 28 October 2018. https://www.thefinancialexpress.com.bd/views/sustainable-housing-for-sustainable-cities-and-communities-in-bangladesh-1540740307

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

Alam, M., Sharior, F., Ferdous, S. et al. (2020). *Strategies to Connect Low-Income Communities with the Proposed Sewerage Network of the Dhaka Sanitation Improvement Project, Bangladesh: A Qualitative Assessment of the Perspectives of Stakeholders.* International Journal of Environmental Research and Public Health. 1 October 2020.

Ali, S. S., Rahman, M. M., & Chowdhury, N. R. (2012) *Bangladesh: A Sustainable and Disaster Resilient Future.* Islamic Relief Worldwide-Bangladesh. June 2012. https://www.preventionweb.net/files/27650_bookletstoryteller.pdf

Asad, R. & Ahsan, R. (2012). *Structuring Urban Sustainability with Water: A Case of Kamrangir Chor, Dhaka, Bangladesh.* Journal of Social and Development Sciences. Vol. 3, No. 8, pp. 293-303, Aug 2012. Khulna University, Khulna, Bangladesh. https://core.ac.uk/download/pdf/288023479.pdf

Bairagi, S. (2018). *Image: Map of flood-affected areas in Bangladesh.* Retrieved from: https://www.researchgate.net/figure/Map-of-flood-affected-areas-in-Bangladesh_fig1_326263766

Banglapedia (2014). *Kamrangirchar Thana.* National Encyclopedia of Bangladesh. 30 June 2014. http://en.banglapedia.org/index.php?title=File:KamrangircharThana.jpg

Beck, T. (2005) *Learning Lessons from Disaster Recovery: The Case of Bangladesh.* The Hazard Management Unit of the World Bank. Disaster Risk Management Working

Paper Series No. 11.

    https://www.recoveryplatform.org/assets/publication/bangladesh.pdf

Bhattacharjee, S. & Mukherjee, N. (2017). *Floating Houses: A design for flood resilience innovations in Bangladesh.* PLEA 2017 Proceedings – Design to Thrive. Volume III. p. 5149-5156.

Braun, B. & Aßheue, T. (2011). *Floods in megacity environments: vulnerability and coping strategies of slum dwellers in Dhaka/Bangladesh.* Natural Hazards 58, p. 771-787. 25 February 2011. https://link-springer-com.ludwig.lub.lu.se/article/10.1007/s11069-011-9752-5#citeas

CFE-DM (2020) *Bangladesh: Disaster Management Reference Handbook.* Center for Excellence in Disaster Management & Humanitarian Assistance. May 2020. https://www.cfe-dmha.org/LinkClick.aspx?fileticket=OI7WaP1idxA%3d&portalid=0

Das, P. & Rahman, R. (2018) *Management of Unanticipated Extreme Flood: A Case Study on Flooding in NW Bangladesh during 2017.* International Journal of Disaster Response and Emergency Management. Vol. 1. Issue 1. January-March 2018.

Haque, A. N. (2018). *Adaptation to Flooding in Low-Income Urban Settlements of the Least Developed Countries: A Case of Dhaka East, Bangladesh.* February 2018.

HBRI (2018). *Standard Guideline for Rural Housing in Disaster Prone Areas of Bangladesh.* Housing and Building Research Institute, Ministry of Housing and Public Works, Government of the People's Republic of Bangladesh. February 2018, Dhaka, Bangladesh. https://www.sheltercluster.org/sites/default/files/docs/standard_guideline_for_rural_housing_in_disaster_prone_areas_bangladesh1.compressed_0.pdf

Hossain, Z. & Rahman, A. U. (2017). *Pro-poor adaptation for the urban extreme poor in the context of climate change: A study on Dhaka City, Bangladesh.* Urban and Rural Planning Discipline, Khulna University, Khulna, Bangladesh. 23 August 2017. https://www.emerald.com/insight/content/doi/10.1108/IJCCSM-08-2016-0117/full/pdf

Islam, M. S., Hossain, T., Podder, R., & Moles, O. (2016). *Environment-friendly Sustainable Rural House Designs for Different Geographic Regions of Bangladesh.* Seminar of Environment Friendly Housing and Construction Technology: Bangladesh Perspective

Housing and Building Research Institute (HBRI), May 2016, Dhaka, Bangladesh. https://hal.archives-ouvertes.fr/hal-02535620/document

Kellet, J. (2014). *Disaster risk reduction makes development sustainable*. United Nations Development Program. https://oxfamilibrary.openrepository.com/bitstream/handle/10546/311422/disaster-risk-reduction-development-sustainable-150114-en.pdf?sequence=1

Kohn, N. A. (2014). *Vulnerability Theory and the Role of Government.* Yale Journal of Law and Feminism. Vol. 26:1. https://digitalcommons.law.yale.edu/cgi/viewcontent.cgi?article=1345&context=yjlf

Moles, O., Islam, S., Hossain, T. R., & Podder, R. K. (2014). *Improvement of vernacular housing for disaster prone areas in Bangladesh: a six year experience.* Vernacular Heritage and Earthen Architecture, 2013, p. 683-688. 4 April 2014.

Molla, M. T. (2014) *Kamrangirchar Thana.* Banglapedia: National Encyclopedia of Bangladesh. 10 August 2014.

Neuman, W. L. (2009). *Social Research Methods: Qualitative and Quantitative Approaches.* 7th ed. New York: Pearson.

Sarwar, G. M. (2005). *Impacts of Sea Level Rise on the Coastal Zone of Bangladesh.* Lund University International Master's Program in Environmental Science. 21 November 2005. https://www.lumes.lu.se/sites/lumes.lu.se/files/golam_sarwar.pdf

Shi, L. (2020). *Beyond flood risk reduction: How can green infrastructure advance both social justice and regional impact?* Socio-Ecological Practice Research 2, p. 311-320. 5 September 2020. https://link.springer.com/article/10.1007/s42532-020-00065-0#citeas

United Nations (2009). *UNISDR Terminology on Disaster Risk Reduction*. United Nations International Strategy for Disaster Reduction. Geneva, Switzerland. May 2009. https://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf

United Nations Bangladesh (2020). *HCTT Contingency Plan 2020 for Climate-Related Disasters in the COVID-19 Pandemic Context.* Government of Bangladesh, UN Resident Coordinator for Bangladesh. 3 May 2020. https://reliefweb.int/report/bangladesh/hctt-contingency-plan-2020-climate-related-disasters-covid-19-pandemic-context

United Nations Development Program (2020) *Human Development Index (HDI) Ranking.* Human Development Data Center. From the 2020 Human Development Report. http://hdr.undp.org/en/data

UNDRR & ADPC (2020). *Disaster Risk Reduction in Bangladesh: Status Report 2020.* United Nations Office for Disaster Risk Reduction – Regional Office for Asia and Pacific Asian Disaster Preparedness Center. https://www.undrr.org/publication/disaster-risk-reduction-bangladesh-status-report-2020

Wamsler, C. (2007). *Managing Urban Disaster Risk: Analysis and Adaptation Frameworks for Integrated Settlement Development Programming for the Urban Poor.* Housing Development & Management (HDM), Lund University.

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2003). *At Risk: natural hazards, people's vulnerability, and disasters.* Second edition.

World Bank (2018). *Bangladesh Disaster Risk and Climate Resilience Program.* 25 July 2018. https://reliefweb.int/report/bangladesh/bangladesh-disaster-risk-and-climate-resilience-program

World Bank (2020). *Bangladesh: World Development Indicators.* The World Bank Group, 2020. https://data.worldbank.org/country/bangladesh. Accessed 25 April 2021.

Zhou, H., Wang, X., & Wang, J. (2016). *A Way to Sustainability: Perspective of Resilience and Adaptation to Disaster.* MDPI Journal: Sustainability, 8, 737.
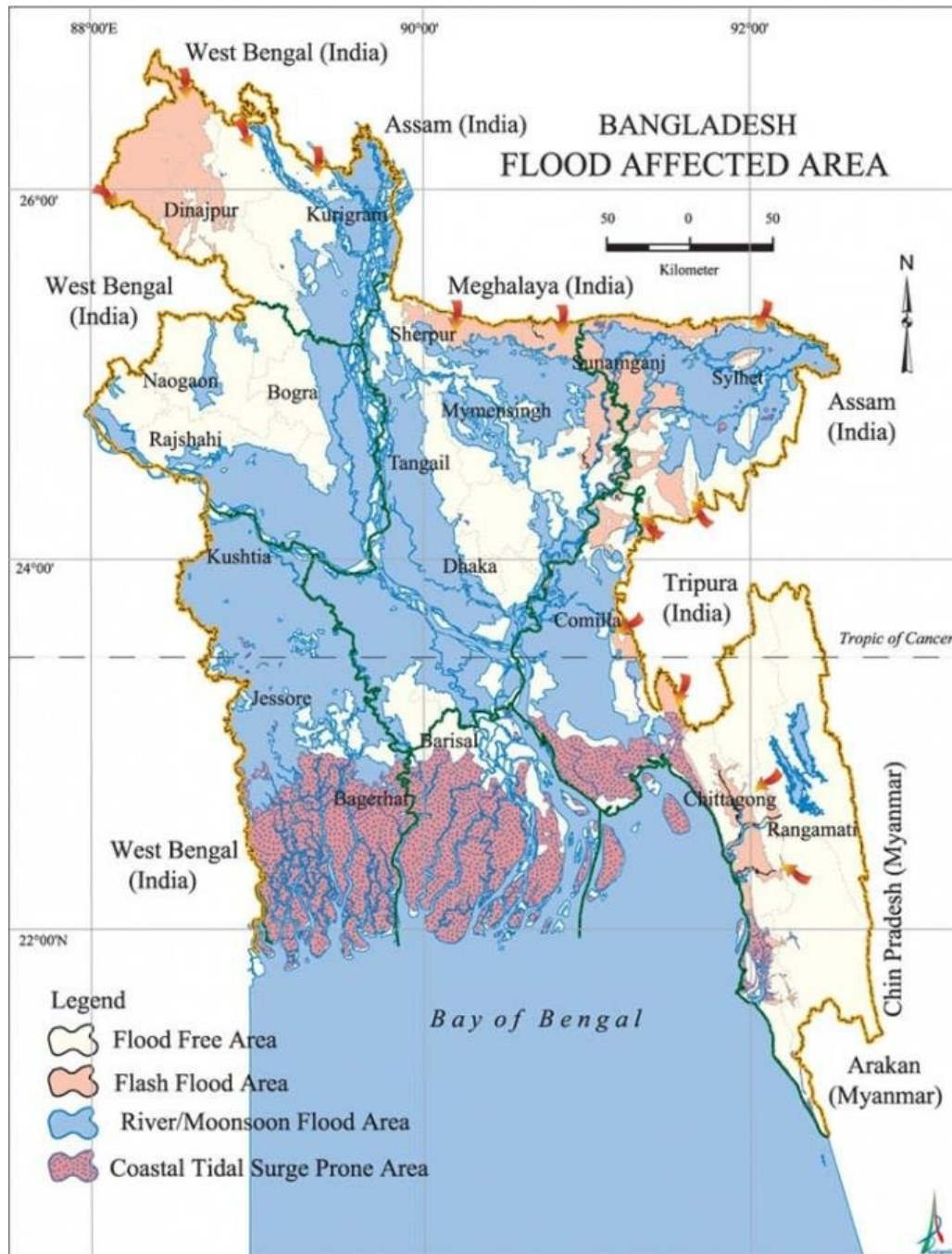
X.   Appendix

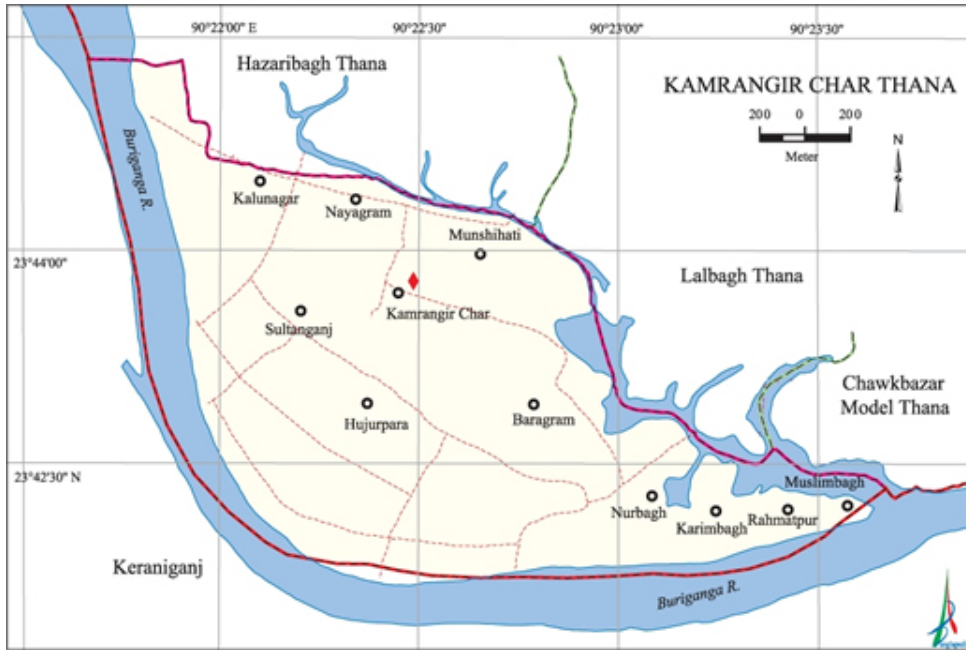*Figure 1a: Flood-affected areas in Bangladesh (Bairagi, 2018)*

Figure 2a: Map of Kamrangirchar slum (Banglapedia, 2020)

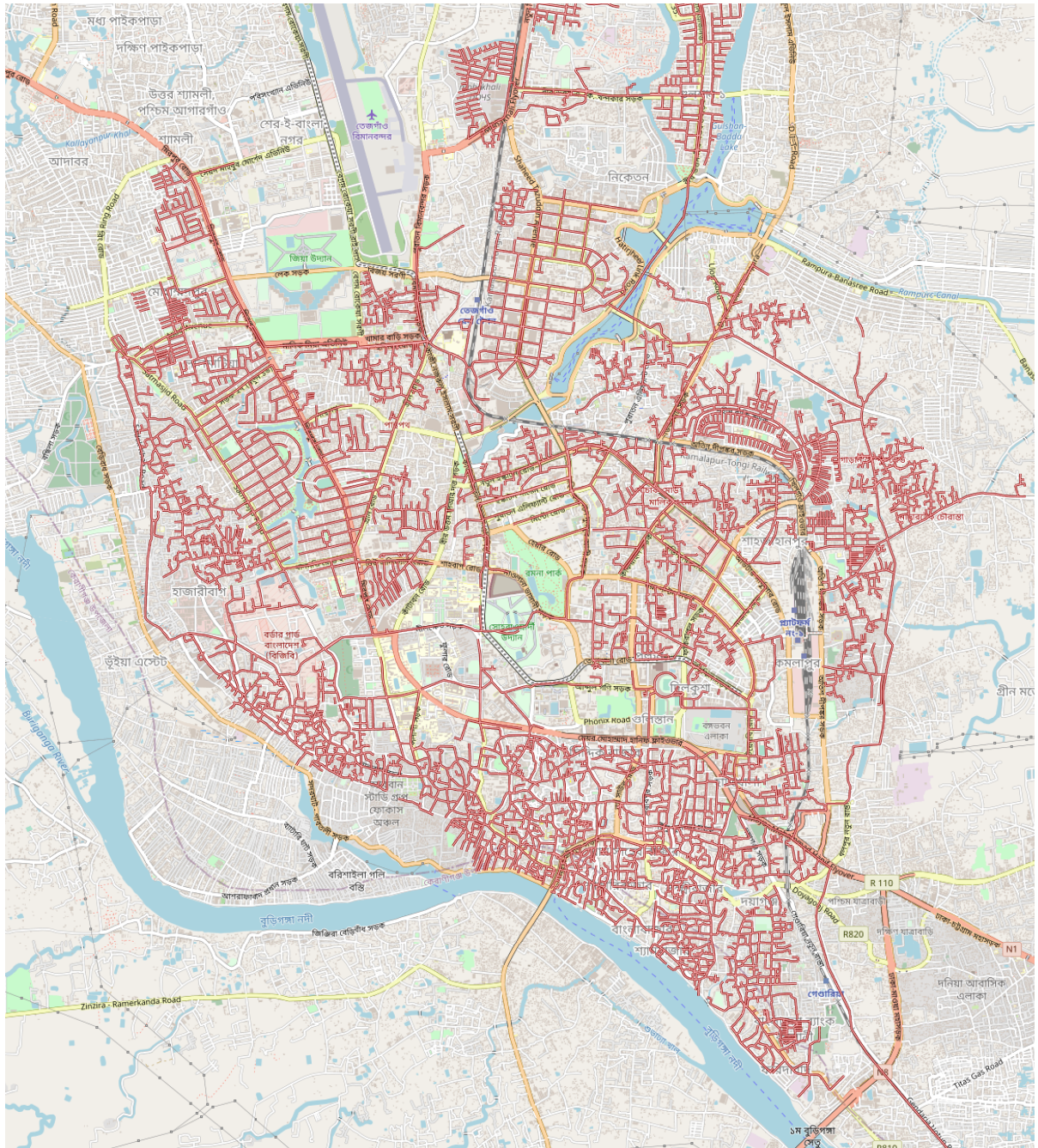

Figure 3a: Slum areas of Dhaka (GIS mapping, 2021)

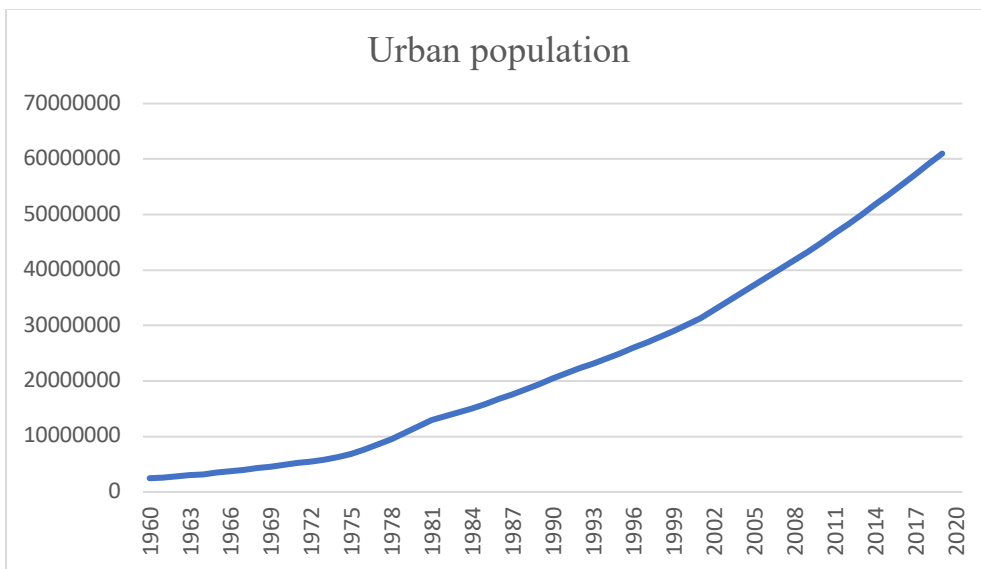*Figure 5a: Major Sewerage Lines in Dhaka (GIS mapping, 2021)*

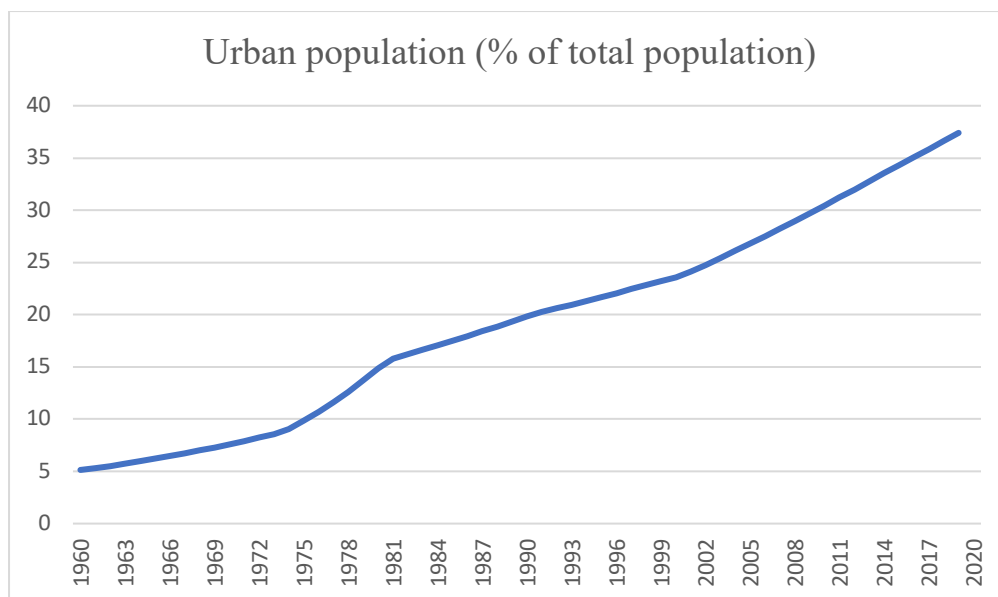*Figure 6a: Urban population in Bangladesh (World Bank, 2020)*

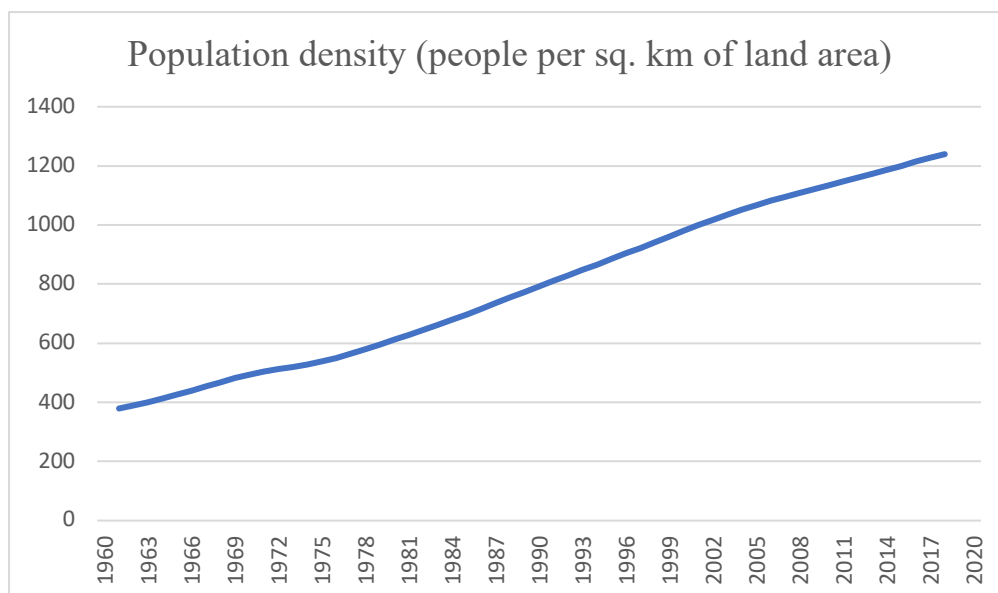*Figure 7a: Percent of total population living in urban areas (World Bank, 2020)*

Figure 8a: Population density in Bangladesh (World Bank, 2020)

Year	Urban population living in areas where elevation is below 5 meters (% of total population)
1990	1,60%
2000	1,73%
2010	1,79%

Figure 9a: Percent of total population living in urban areas where elevation is below 5 meters (World Bank, 2020)

Year	Population living in slums (% of urban population)
1990	87,3%
1995	84,7%
2000	77,8%
2005	70,8%
2010	61,6%
2014	55,1%
2016	49,4%
2018	47,2%

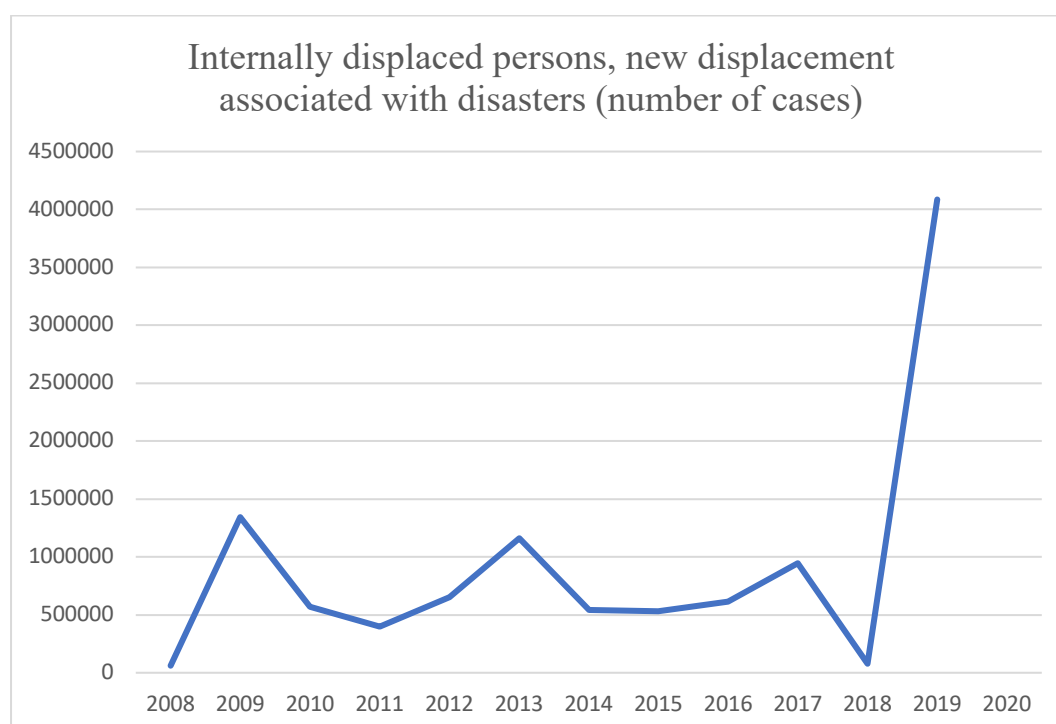*Figure 10a: Percent of urban population living in slums of Bangladesh (World Bank, 2020)*

Figure 11a: Number of displaced persons associated with disasters (World Bank, 2020)
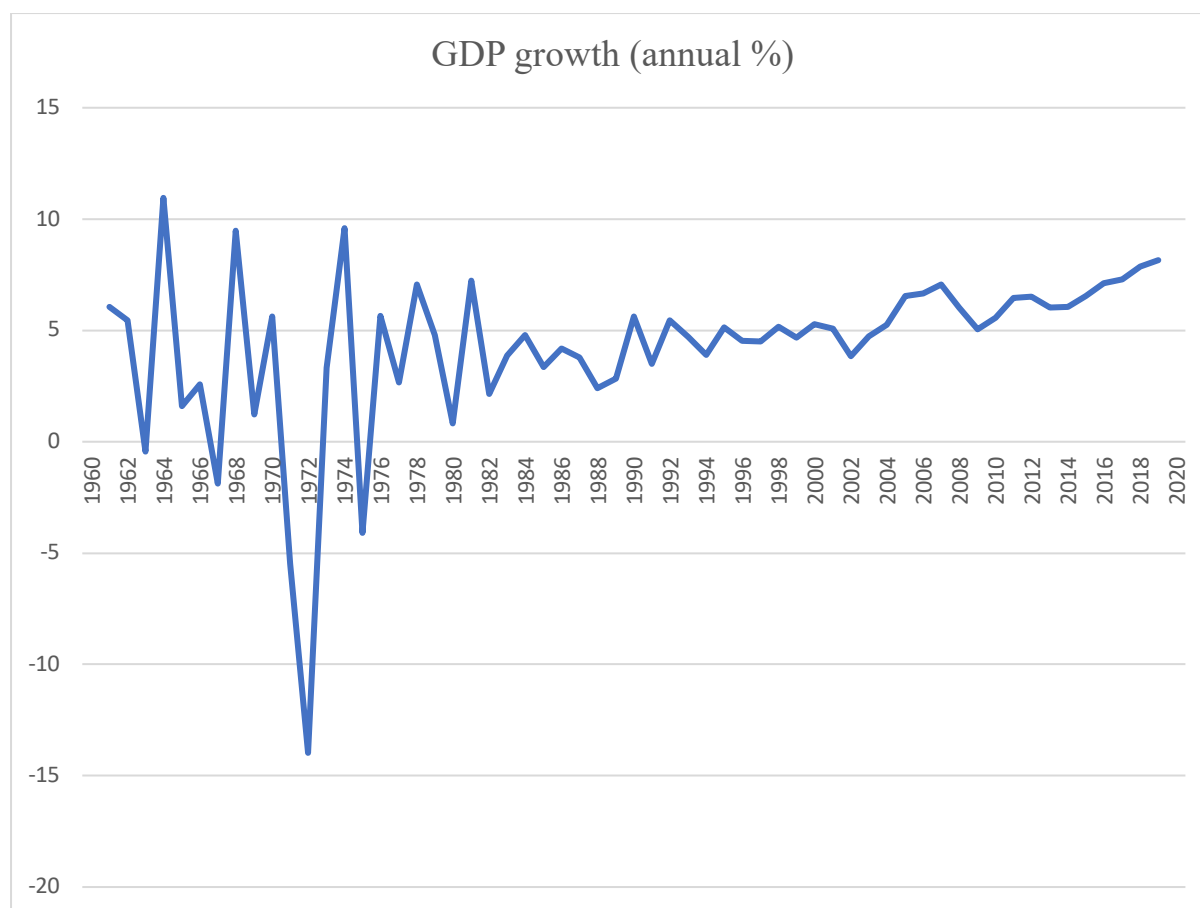
Figure 12a: Annual GDP growth in Bangladesh (World Bank, 2020)

Year	Gini index (*World Bank estimate)*
1983	25,9
1985	26,9
1988	28,8
1991	27,6
1995	32,9
2000	33,4
2005	33,2
2010	32,1
2016	32,4

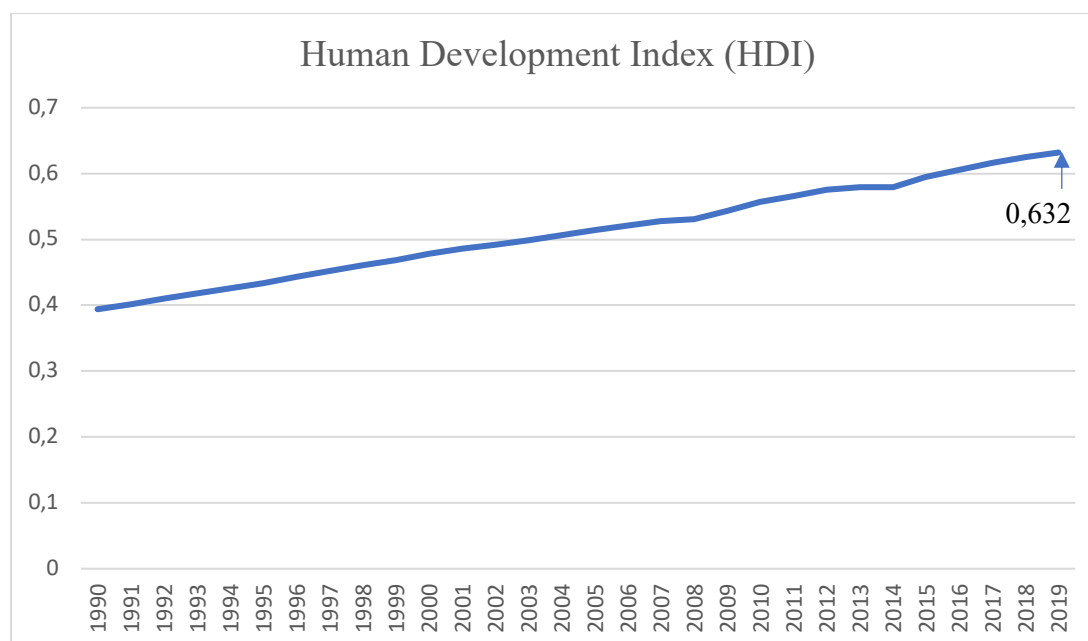*Figure 13a: Gini index in Bangladesh (World Bank, 2020)*

Figure 14a: Human Development Index (HDI) in Bangladesh (UNDP, 2020)

Flooding event in Dhaka	GDP growth (% annual)			Human Development Index (HDI)		
1987	**1986**	**1987**	**1988**	n/a		
	4,17%	3,77%	2,41%			
1988	**1988**	**1989**	**1990**	**1990**		
	2,41%	2,83%	5,62%	0,39		
1998	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
	4,48%	5,17%	4,67%	0,45	0,46	0,46
2004	**2003**	**2004**	**2005**	**2003**	**2004**	**2005**
	4,73%	5,23%	6,53%	0,49	0,50	0,51
2010	**2009**	**2010**	**2011**	**2009**	**2010**	**2011**
	5,04%	5,57%	6,46%	0,54	0,55	0,56

Figure 15a: GDP and HDI before and after flooding events (World Bank, 2020) (UNDP, 2020)