EVALUATION OF ULLAPARA POURASHAVA MASTER PLAN CONSIDERING CLIMATE CHANGE INDUCED FLOOD

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The thesis titled "**EVALUATION OF ULLAPARA POURASHAVA MASTER PLAN CONSIDERING CLIMATE CHANGE INDUCED FLOOD**" submitted by **Md. Mostafizur Rahman**, Roll No: **1009152008P**, Session: **October, 2009**, has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Urban and Regional Planning (MURP) on 17th January 2015.

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CANDIDATE'S DECLARATION

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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List of Abbreviations

ACAL	AQUA Consultant and Associates Ltd
ADB	Asian Development Bank
ADPC	Asian Disaster Preparedness Center
BARC	Bangladesh Agricultural Research Council
BBS	Bangladesh Bureau of Statistics
BCAS	Bangladesh Centre for Advanced Studies
BMD	Bangladesh Meteorological Department
BWDB	Bangladesh Water Development Board
^{o}C	Celsius Degree
CDWR	California Department of Water Resources
CIRIA	Construction Industry Research & Information Association
CIRM	Centre for Insurance and Risk Management
DDC	Development Design Consultants Ltd
DEM	Digital Elevation Modell
DIT	Dhaka Improvement Trust
DMB	Disaster Management Bureau
DoE	Department of Environment
FEMA	Federal Emergency Management Agency
GBM	Ganges-Brahmaputra-Meghna
GIS	Geographic Information System
GWP	Global Water Partnership
ICLEI	International Council for Local Environmental Initiatives
ICSU	International Council for Scientific Union
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
IWM	Institute of Water Modelling
LGED	Local Government Engineering Department
MoFA	Ministry of Foreign Affairs
MoHA	Ministry of Home Affairs
NDP	National Development Programme
NIPSOM	National Institute of Preventive and Social Medicine
OECD	Organisation for Economic Co-operation and Development
PAHO	Pan American Health Organization
PC	Planning Commission

PDC	Pacific Disaster Center
QDCS	Queensland Department of Community Safety
RHD	Roads and Highway Department
UDD	Urban Development Directorate
UNESCO	United Nations Educational, Scientific and Cultural Organization
UN-HABITAT	United Nations Human Settlements Programme
UNISIDR	International Strategy for Disaster Reduction
UTIDP	Upazila Towns Infrastructure Development Project
WB	World Bank
WHO	World Health Organization
WMO	World Meteorological Organization

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Abstract

Bangladesh is one of the most flood prone countries in the world. A number of research works have identified that the monsoon flood scenario will be aggravated with climate change context in Bangladesh. In 2008, Local Government Engineering Department (LGED) has started to prepare master plan (2011-2031) for 223 Pourashavas in Bangladesh. It is evident from the Terms of Reference (ToR) of the project that it did not consider future climate induced flood scenario which poses a question towards the sustainability of the plan in a flood prone country like Bangladesh. Ullapara Pourashava of Sirajganj district has been selected as a study area to conduct the research. Due to its geo-physical settings this area is most vulnerable to flood and future climate change induced flood will worsen the scenario. The study aims to evaluate the Pourashava Master Plan in the light of climate change induced flood and suggests adaptation strategies in the face of climate change induced flood. The methodology of the study follows GIS based flood exposure analysis of selected infrastructure. Considering the data availability, climate change induced flood for the year 2040 has been used for flood exposure analysis. Based on the exposure analysis the infrastructure plan has been evaluated. These infrastructures include transport and communication infrastructure, educational infrastructure, health infrastructure, and other community facilities. It is evident from the study that infrastructure in Ullapara Pourashava would be highly exposed to climate change induced flood for longer duration. The duration of inundation may stay up to 19 days where about 90.14% land of the whole Pourashava would be exposed to more than 1m inundation level due to climate change. The study also finds that about 33.99% Pucca road will be exposed to 1.5-2m inundation level; proposed one bus terminal would be exposed to 2.5-3.0m inundation level; seven primary school, six secondary school and four colleges would be highly exposed to 2.0-2.50m inundation level; four health facilities would be exposed to 1.0-2.0m inundation level due to future climate change. The study finds that in 2007 flood the physical damage of roads, hospitals, Police Station and Fire service was equivalent to about 8.57 crore Tk. The study also finds that about 17,251 students were in problems to access the educational institutions; about 26,550 patients were in problem to access the health facilities; about 18,180 business men were in trouble with their business due to inundation of road. It is evident that newly proposed infrastructure including educational infrastructure and different urban facilities like community center, waste disposal site will also be highly exposed to future climate change induced flood. This inundation scenario for long duration will lead to dysfunction of concerned infrastructure and, in turn, undermines the stability of a socio-economic system of Ullapara Pourashava. In such a context this study suggests adaptation strategies to cope with the climate change induced flood. To devise adaptation strategies, expert opinions were taken from various organizations. This study suggests that integrated landuse planning, land zoning, height enhancement, relocation, climate proofing material; construction of floodwall may be the adaptation strategies for infrastructure to tackle with climate change induced flood in Ullapara Pourashava. The study suggests some structural interventions to adapt with climate change induced flood. The total cost of proposed intervention will be about 29.04 crore Tk. Based on the expert opinions, literature review and researcher’s own judgments this study argues that climate change adaptation can only be adequately addressed if action is taken at all levels of government: international, national, regional, and local. Hence the study emphasizes to adopt multi-level governance approach for infrastructure planning to face the challenges of climate change.

Chapter 1: Introduction

1.1 Background

Bangladesh is one of the most flood prone countries in the world with about 21 percent of the country is subject to annual flooding and an additional 42 percent is at risk of flood with varied intensity (Ahmed and Mirza, 2000; WMO & GWP, 2003). Approximately 20% to 25% of its territory is inundated during the monsoon season (Hossain, 2003). Two-thirds of Bangladesh is less than 5 meters above sea level, making it one of the most flood prone countries in the world. Severe flooding during a monsoon causes significant damage to crops and property, with severe adverse impacts on rural livelihoods (IFAD, 2012). A number of research works have identified that the monsoon flood scenario will be aggravated with future climate change context (Ahmed and Mirza, 2000; WB, 2010b; WMO and GWP, 2003; OECD, 2003). The IPCC fourth Assessment Report (AR4) and research conducted on the future climate of South Asia indicates that climate change will increase the vulnerability of Bangladesh to severe floods. The IPCC AR4 predicted that monsoon rainfall will increase this century in South Asia resulting in higher flows in the rivers of Bangladesh from Nepal, India, China and Bhutan (IPCC, 2007a).

In 2008, Local Government Engineering Department (LGED) has launched a project titled “Upazila Towns Infrastructure Development Project (UTIDP)” aiming at preparing master plan (2011-2031) for 223 Pourashavas in Bangladesh. The duration of the master plan is 20 years. The core objective of the project is to prepare Land Use Plan, Drainage Master Plan, Traffic Management Plan and to provide necessary infrastructure facilities in order to ensure planned development and to meet the increasing demand of the citizen for basic services (LGED, 2008). This plan is mainly concerned with landuse and infrastructure plan. It is evident from the Terms of Reference (ToR) of the project that it did not consider future climate induced flood scenario which poses a question towards the sustainability of the plan in a flood prone country like Bangladesh (ACAL, 2012; SPL, 2012; DDC, 2012).

Ullapara Pourashava is one of the Pourashavas under this project falling under Sirajganj district which is situated on the bank of the Brahmaputra (Jamuna) river and one of the flood prone areas in Bangladesh. It is home of around 47,639 people (BBS, 2011). In an average flood event about 62% area of Sirajganj district become flooded (CIRM & IWM, 2010). In this area the flood inundation scenario will be amplified with future climate change due to upstream Himalayan glaciers melting, sea level rise, increased runoff and precipitation due to its geo-physical settings beside the Jamuna River (DoE, 2008; IPCC, 2007b). The mean elevation of Ullapara is about 10.78m (IWM, 2009). This low elevation and geo-physical settings of Ullapara Pourashava make it most vulnerable to flood and the infrastructure within this Pourashava will be at risk in climate induced flood due to high level of exposure (DoE, 2008). Exposure is a measure describing the external stress brought about by climate change threats (sea level rise, change in temperature, changes in precipitation and extreme weather events) in relation to population, resources and property. It indicates the nature and degree to which a system is exposed to significant climatic variations (IPCC, 2001a). Exposed elements refer to the elements located in an area where hazard event is occurred (Cardona, 1990; UNISDR, 2004; UNISDR, 2009a). Where exposure to events is unavoidable, land use planning and location decisions can be accompanied by structural or non-structural methods for preventing or mitigating risk (UNISDR, 2009b; ICSU-LAC, 2010).

1.2 Objective of the study:

This study aims to evaluate Ullapara Pourashava master plan (2011-2031) considering climate change induced flood exposure This will enable the planning authority and concerned infrastructure providing authority to come across the possible remedies envisaging the extent of infrastructures to be exposed to climate change induced flood. It is expected that findings from this research will help the policy makers to identify the modifications to be needed in planning approach to incorporate flood adaptation strategies in the plan preparation process. The specific objectives for this study are as follows:

a) To evaluate the proposed land use and infrastructure plan in Ullapara Pourashava considering climate change induced flood.
b) To suggest remedial measures considering climate change induced flood scenario.

1.3 Rationale for the study:

The most of the works on climate change impacts so far conducted globally are mainly related to agriculture; and other sectors are touched upon only (Schmandt and Clarkson 1992; Rosenberg, 1993; Cohen 1996; Huang and Cohen et al. 1998). However, the number of studies conducted on regional, and integrated impacts of climate change is increasing. These studies suggest that the impact of climate change on infrastructures far exceed agricultural impacts (Ruth and Kirshen, 2001).

Given the pervasive impacts of climate-related risks on monsoon flooding over time, the government of Bangladesh has highlighted severe monsoon floods as a significant hazard. In Bangladesh Climate Change Strategy and Action Plan (BCCSAC) there are six themes/pillars where adequate flood protection of infrastructure has been considered as one of the pillars (3^{rd} pillar) (GoB, 2009). In Bangladesh, most of the climate change studies are concentrated on agriculture and rural livelihood. But, systematic studies of the impact of climate change on infrastructure are scarce in Bangladesh. Analytical work has been confined to relatively limited sets of locations and adaptation measures only (WB, 2010b).

“Upazila Towns Infrastructure Development Project (UTIDP)” is the first initiative to prepare master plan at Pourashava level in Bangladesh. Under this project, the preparation of master plan is in process for 223 Pourashavas. Although in 1985, Urban Development Directorate (UDD) prepared Upazila land use master plan but those plans were not comprehensive and failed to be implemented. Due to lack of legal status and financial constraints the plans remained unimplemented. These towns are now growing in a haphazard manner (PDC, 2006). According to the expert opinion, this failure leads to further delay in master plan preparation in the country. After long period, LGED has initiated UTIDP to prepare master plan in the Upazila level Pourashava of Bangladesh with intention to prepare Land Use Plan, Infrastructure plan Drainage Master Plan and Traffic Management plan in order to ensure planned development and meet the increasing demand of the citizen for basic services.

In view of above, it is of paramount importance to successfully prepare and implement the plans to meet the objectives and to develop consciousness among people as well as to draw the attention of policy makers regarding the need for and benefit of planned development. It necessitates the plan to be comprehensive and exhaustive to meet the challenges. Having been conceived its importance, LGED has collected relevant documents, plans and policies from concerned ministries and departments to prepare planning standard for the preparation of master plan. But unfortunately the future climate change induced flood scenario, a much talked issue in Bangladesh, has neither been included in the Terms of Reference (ToR) of the project nor addressed in the plan preparation process. This poses a question towards the sustainability of the plan in a flood prone country like Bangladesh (ACAL, 2012; SPL, 2012; DDC, 2012).

1.4 Scope and limitation of the study

This study aims to evaluate Ullapara Pourashava master plan (2011-2031) in light of climate change induced flood exposure. Proposed Master plan of Ullapara Pourashava covers many aspects of planning including infrastructure, landuse, traffic and transportation, drainage and environment etc. But this study only covers the evaluation of infrastructure planning. In this study infrastructures include transport and communication infrastructure, educational infrastructure, health infrastructure, and other community facilities. The evaluation of infrastructure plan is based on climate change induced flood exposure analysis. Other planning aspects have not been considered because other planning considerations have already been addressed in making the master plan. Considering the data availability, climate change induced monsoon flood for the year 2040 has been used in this study (please see the section 3.5.2 of Chapter-3 to know more about flood data). Flood exposure analysis has been conducted to anticipate how existing and proposed infrastructures would be exposed to future climate change induced flood. At the same this study also collected the data on past damages and losses due to inundation of infrastructure. Finally, based on the flood exposure analysis, past damages and losses, literature review, expert opinions, and local level consultation this study suggests possible adaptation strategies regarding existing and proposed infrastructure of Ullapara Pourashava considering climate change induced flood.

In this study it has been tried to achieve best outcome so that the study result can be utilized in practical field. However there were some limitations to conduct the study. The study relies on model result for flood inundation. Detail field survey for flood inundation was not conducted due to financial limitation. The flood inundation data was collected from secondary sources where they used climate change prediction made in IPCC fourth assessment report because fifth IPCC report was not published at that time. If prediction from fifth IPCC report was used in flood modelling then it might be more accurate.

1.5 Organization of the thesis

This research work has been organized and represented under seven Chapters in this Thesis paper. Chapter-1 is introductory Chapter. It describes the background, justification of the study. It also states objectives, scope and limitations of the study. Chapter-2 is concerned with Conceptual Framework of the study. This Chapter mainly comprises with literature reviews stating the theoretical and conceptual framework of the research. This Chapter brings several contemporary national and international studies on flood exposure analysis along with their methods and findings. It helps understanding the background of the study by upbringing the aspects behind the backdrop of the study in a sequential manner. Chapter-3 outlines the methodology of the Research. It intends to portray the ways, methods and methodologies of the research sequentially based on various studies. Chapter-4 outlines the study area profile. This Chapter concentrated on an overview of the study area incorporating its socio-economic, demographic, environmental characteristics, physical features, landuse and flood scenario. Chapter-5 conducts flood exposure analysis of the infrastructure in the study area considering climate change induced flood in 2040. Result of flood exposure analysis has been presented in tables, graphs and maps. In this Chapter the impact of such flood inundation has been discussed and based on exposure analysis this Chapter evaluates the proposed Master plan of the study area. Chapter-6, based on the findings from Chapter-5, intends to devise some adaptation strategies that will be required to face the challenge climate change induced flood in Ullapara Pourashava. To devise adaptation strategies the author studied different research works and projects done in Bangladesh and abroad. The researcher also took expert opinions in this regard. In Chapter-7, some recommendations have been made regarding the adaptation strategies for Ullapara Pourashava and other flood prone Pourashava of Bangladesh. Finally this research has been concluded with this Chapter.

Chapter 2: Conceptual Framework

2.1 Introduction

This Chapter discusses the connected set of ideas, theories and approaches relating to the study that serves as the basis for understanding and conducting the study. Five major themes that are closely related to this study have been discussed in this Chapter. These are master plan, flood, climate change and approach to flood exposure analysis and selected studies on flood exposure analysis. The first three topics have been discussed for conceptualization of the research and last topics, approach to flood exposure analysis, has been discussed drawing some examples from recent studies which act as a strong basis for development of the methodology to conduct the study.

2.2 Master plan and master planning authority at Pourashava level in Bangladesh

Planned development is foremost important for a sustainable better living environment. Introduction of this planned development is guided through a master plan prepared by the public authority within a regulatory framework. Bangladesh is somewhat practicing the method of planned development through master planning activities. According to Pourashava Act 2009, there is provision for preparation of master plan at Pourashava Level. Pourashava itself is responsible to prepare such plan. However, if any Pourashava is unable to prepare such plan other authority may help prepare master plan for that Pourashava.

2.2.1 Concept of master plan

According to the Building Construction Act 1952 (E.B. Act II of 1953) the term 'Master Plan' means "the master plan prepared and approved under any law for the time being in force for the utilization of any land anywhere in Bangladesh." According to Pourashava act 2009, "Master plan of municipality" means structure of development planning within boundary of municipality; use of land, transportation and management, sanitation and defines principles of environmental management and technique and specific implementable development project under municipality development program. A master plan or a development plan or a town plan may be defined as a general plan for the future layout of a city showing the existing and proposed streets or roads, open spaces, public buildings, etc. The master plan of a town or city or an urban centre can be described as a mosaic of land uses woven together by a network of streets and transportation routes, water, sanitation and communication channels (DIT, 1959). A Master Plan is a policy guide and a framework for future land use and development. It includes assessments of existing resources and issues, projections of future conditions and needs, and consideration of community goals and desires. However, there is no universal definition of a master plan. Its nature, contents and coverage may vary from country to country depending on their respective social, economic, physical, environmental and other conditions.

2.2.2 Pourashava level master plan in Bangladesh

Large scale local level master plan preparation in Bangladesh has been started in mid 1980s when Urban Development Directorate (UDD) started to prepare land use master plan at Upazila level. Urban Development Directorate (UDD) is the principal central government agency mandated with preparing rural and urban land use plans. This organization has mandate to advise the Government on matters of policy relating to urbanization, land use, and land development; and to prepare and coordinate regional plans, master plans, and detailed layout and site plans for existing as well as the new urban centers, excluding the areas covered by the town development authorities in Bangladesh (ADB, 2009). UDD is also responsible for the gazetting of urban and master plans for Upazila and other local-level administrative units. UDD has also taken the lead in spatial development legislation. During the period 1984-1991 UDD prepared land use master plan for 392 Upazilas out of 486 in Bangladesh. At the same time it prepared master plan for 50 district towns in Bangladesh. Upazila land use master plan included most of the Pourashavas of Bangladesh (UDD, 2013). But the land use Master Plan prepared by UDD was not implemented. Because, role of UDD was to prepare the Master Plan only and the land use Master Plan is simply an indicative guideline for future uses. They did not have any legal and regulatory authority for its implementation. Even the land use Master Plan could not provide any guidelines for implementation and the plan proposals were not practical and directly implementable. Due to lack of legal status and financial constraints the plans remained unimplemented (PDC, 2008).

Later in 2008, Local Government Engineering Department (LGED) has launched a project titled “Upazila Towns Infrastructure Development Project (UTIDP)”. In this project master plan (2011-2031) is in the process of preparation for 223 Pourashavas. The core objective of the project is to prepare Land Use Plan, Drainage Master Plan, Traffic Management plan and to provide necessary infrastructure facilities in order to ensure planned development and to meet the increasing demand of the citizen for basic services (LGED, 2008). This plan is supposed to be more comprehensive Pourashava plan ever prepared in Bangladesh. LGED has also started preparation of master plan for district level Pourashava in same year under the project titled “District Towns Infrastructure Development Project (DTIDP)”

2.2.3 Master planning authority in Bangladesh

In Bangladesh there are several statutory bodies responsible for preparation of master plan. At present, there four types of planning authority in Bangladesh. The following Figure-2.1 illustrates the Master planning authority in Bangladesh at a glance.

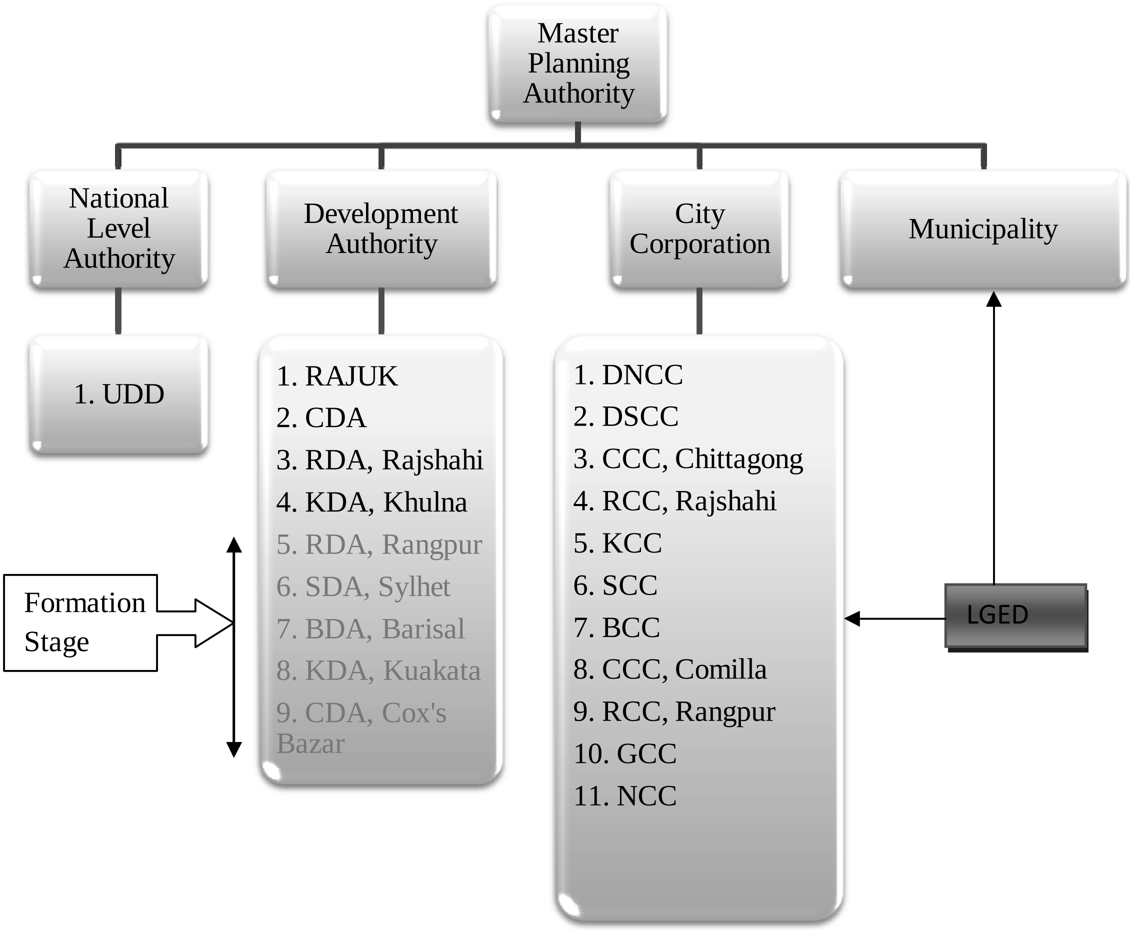


Figure-2.1: Master Planning Authority in Bangladesh

Urban Development Directorate (UDD) is the national body for preparing master plan in the country. It was established through a government order in 17th July 1965. This directorate is working under the Ministry of Housing and Public Works. Since its inception, UDD is contributing in developing Master Plan/Land Use Plan for small, medium and large town and cities of Bangladesh. The main function of UDD is to formulate, up-grade and co-ordinate three-tiered planning package i.e. Structure Plan, Urban Area Plan and Detailed Area Plan up to the lowest level of administrative set-up of the country.

Another type of planning authority in Bangladesh is Development Authority. At present there are four development authorities in the country. These are Rajdhani Unnayan Kartipakkha, (RAJUK) Chittagong Development Authority, Rajshahi Development Authority and Khulna Development Authority. These bodies prepared there master plan for different time period. Different authorities according to the different regulations have permitted to prepare the master plan but only Development Authorities are maintaining the role. In addition to these four development authorities five other development authorities are in the process of formulation. These are Cox’s bazaar Development Authority, Kuakata Development Authority, Sylhet Development Authority, Rangpur Development Authority and Barisal Development Authority. The draft Bills have been prepared to establish these authorities. The cabinet on February 27, 2012 approved the draft of Cox's Bazar Development Authority Act, 2012, seeking planned improvement of the beach town and safeguard of its ecological balance. However, these authorities are not formed till now.

City Corporations are another type planning authority in Bangladesh. According to section 16, 3rd schedule of Local Government (City Corporation) Act 2009 the city corporation can prepare its own Master plan. At present there are 11 city corporations in the country. In practice it is found that no city corporations prepared their master plan of their own. Because where the development authority exists in the same city, the development authority prepared the master plan. In other cases UDD (e.g Barisal, Sylhet) and LGED (e.g Comilla and Rangpur) are preparing the master plan

Pourashavas (Municipality) are contained in separate jurisdictional areas and is also responsible for the preparation of master plan for its jurisdiction area. According to the Pourashava Act, 2009 a Pourashava shall prepare a Master Plan for the municipality within five years from the date of creation of a new Pourashava, or from the date of enforcement of the Ordinance for the old or already created Pourashava. The master plan should include (a) a survey of the municipality including its history, statistics, public services and other prescribed particulars; (b) development, expansion, and improvement of any area within the municipality; and (c) restrictions, regulations and prohibitions to be imposed with regard to the development of sites, and the erection and re-erection of buildings within the municipality. However, in practice no Pourashava prepared the master plan of their own. At present LGED is preparing master plan for different Pourashava in the country.

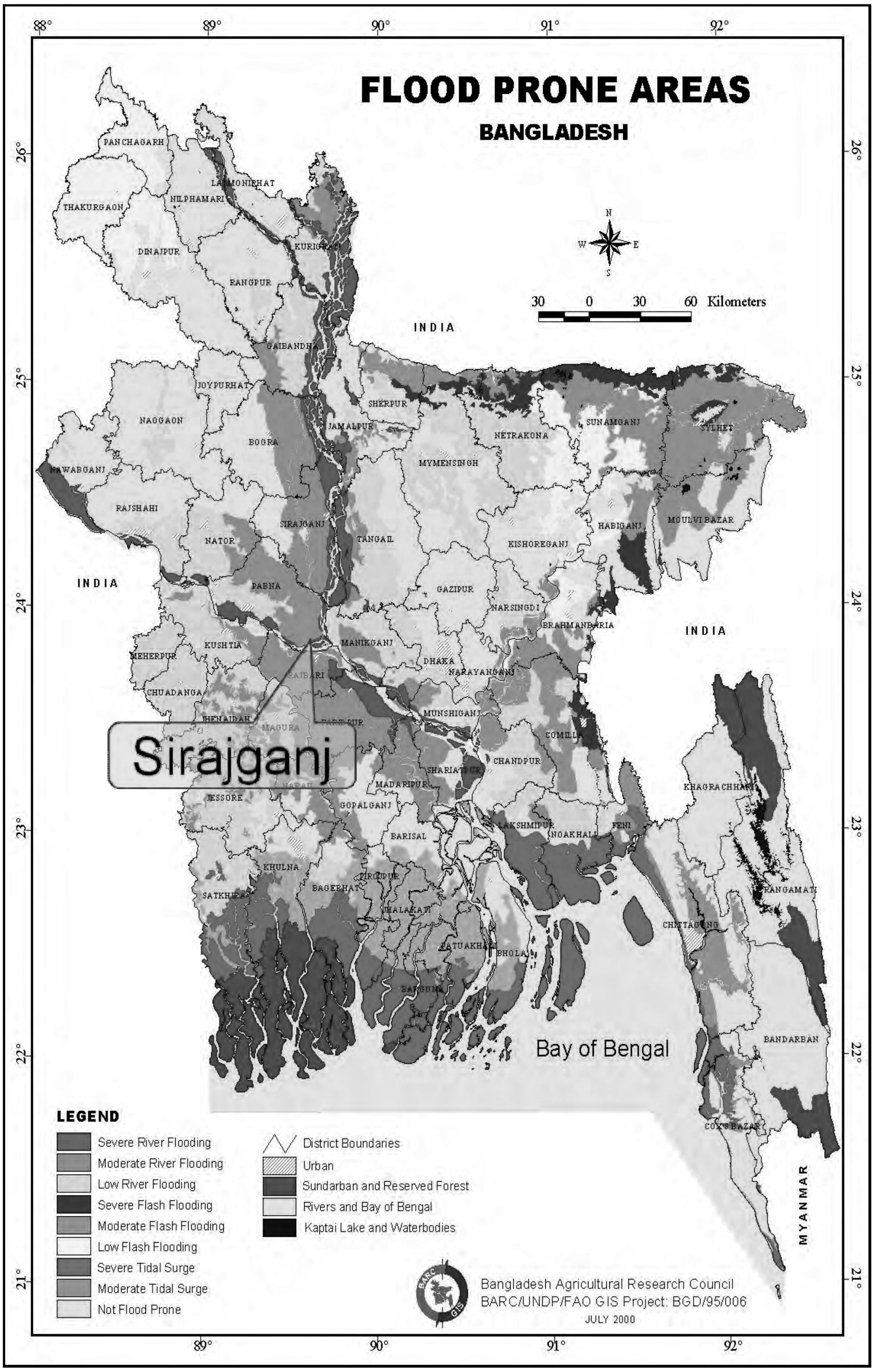
Although LGED is not a planning department but it started preparing master plan for Pourashava and even for newly declared city corporation of Bangladesh. Due to the lack of dynamic leadership and lack of planners in UDD, this organization fails to meet the demand of master planning activities in the country (ADB, 2009). Consequently, LGED came forward to fill the vacuum and started performing activities that were mandated for UDD. In connection with this, LGED is strengthening its Urban Management Wing by appointing a senior engineer dedicated to urban development, and by consolidating capacity development programs through Urban Management Support Unit (UMSU) (LGED, 2014). Even through a gazette notification in 19 February, 2014 the Local Government Division of Ministry of Local Government, Rural Development and Cooperatives (MoLGRDC) achieved permission for preparation, approval and notification in official gazette of Master Plan of Upazila, Pourashava and City Corporation areas except cities where government has established development authorities by gazette notification. In this connection, it has started several projects on master planning e.g "Upazila Towns Infrastructure Development Project (UTIDP)" and "District Towns Infrastructure Development Project (DTIDP)". Under these projects master plan (2011-2031) is in the process of preparation for 223 Upazila level Pourashavas (UTIDP) and 23 District level Pourashavas (DTIDP). And even LGED is preparing master plan for the newly created Comilla and Rangpur City Corporations.

2.3 River flood (monsoon flood) in Bangladesh

Bangladesh is one of the most flood prone countries in the world (WMO & GWP, 2003). The climate of Bangladesh is tropical monsoon climate influenced by the

Himalayan Mountains in the north and northeast, and the Bay of Bengal in the south. High monsoon rains associated with Bangladesh's unique geographical location in the eastern part of the delta make it extremely vulnerable to recurring floods (Rahman, Hossain and Bhattacharya, 2007). Bangladesh generally experiences four types of flood and those are i) Flash Flood ii) Rain fed Flood iii) River Flood and iv) Coastal Flooding (WMO & GWP, 2003). In this study river flood in monsoon period has been considered.

River flood is a most common phenomenon in the country from time immemorial. Normally, 25-30% of the area is inundated during monsoon season along the river. In case of extreme flood events 50-70% of the country is inundated extending the areas far beyond the riverbanks. The worst floods experienced by the country in last 40 years in 1987, ’88 and ’98. Flood of 1998 was the severest one in terms of magnitude and duration. At present, Bangladesh faces serious flooding that may submerge over 60% of the country every four to five years (PC, 2009). Flooding in Bangladesh is a result of a complex set of factors. Most of Bangladesh is located in the delta of three large rivers, the Ganges, the Brahmaputra and the Meghna. Uncertain trans-boundary flow, the low and flat topography of Bangladesh, heavy rainfall during monsoon season, high vulnerability of the country to tidal waves and cyclonic storm surges and congested drainage channels contribute to the inundation problem. Records indicate that Bangladesh was affected by a significant number of above-normal floods during 1890 and 2007. Time-series analysis indicates above-normal flooding in Bangladesh has not followed any regular pattern historically. A period of fairly frequent flooding 1892-1922 was followed by a relatively few above normal floods (1923 -1973), and, then, the frequency of above-normal floods is showing an increasing trend since 1950 (Hofer and Messerli, 2006). Specifically, Bangladesh has experienced two catastrophic, four exceptional, four severe and 11 moderate floods during 1950 – 2009 (WB, 2010b). Map 2.1 shows flood prone areas in Bangladesh according to type and severity.



Map 2.1: Flood prone areas in Bangladesh according to type and severity

(Source: BARC, 2000)

2.4 Climate change and climate change induced flood in Bangladesh

Bangladesh is extremely vulnerable to climate change impacts because of its geographical location, high population density, high levels of poverty, and the reliance of many livelihoods on climate-sensitive sectors, particularly rural agriculture and fisheries. The climate of Bangladesh is influenced by monsoon climate and characterized by high temperature, heavy rainfall, often-excessive humidity and marked seasonal variations. The climate is controlled primarily by summer and winter winds, and partly by pre-monsoon (March to May) and post-monsoon (late October to November) circulation.

2.4.1 Concept of climate and climate change

According to IPCC (2007a), Climate in a narrow sense is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. On the other hand Climate change is defined as an average weather condition of an area characterized by its own internal dynamics and by changing in external factors that affect climate (Trewartha et al., 1980). According to IPCC climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2001a).

2.4.2 Climate change and sea level rise

The 4th IPCC prediction of the global sea level rise for the IS92a scenario is shown in the Figure 2.2. From this prediction it has found that the sea level will rise up to 59 cm in 2100. Sea level rise for different year according to IS92a scenario has been calculated from the Figure 2.2 and has been shown in Table 2.1. In this study sea level rise of 17 cm for the year 2040 has been used. The year 2040 has been chosen in order to detect the change of climate (whose average period is about 30 years).

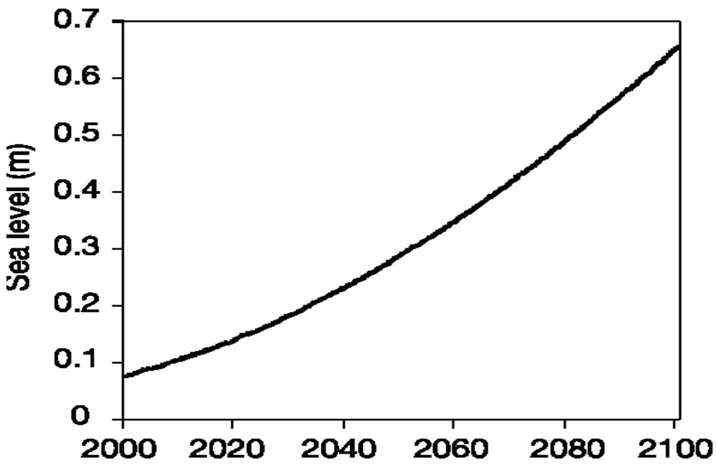


Figure 2.2: Prediction of sea level rise according to IS92a scenario (IPCC, 2007b)

Table 2.1: Predicted sea level rise for the next 100 years (2000-2100)

Year	Sea Level Rise (cm) above year 2000 level
2020	8
2030	12
2040	17
2050	23
2060	29
2070	36
2080	43
2090	51
2100	59

(IPCC, 2007b)

2.4.3 Climate change scenario and precipitation in Bangladesh

Over the past 100 years, the broad region encompassing Bangladesh has warmed by about 0.5°C. In the future, Bangladesh may get warmer and wetter. For the IPCC (1990) "Business-as-Usual" emissions scenario, Bangladesh is projected to be 0.5 to 2.0°C warmer than that of 1990 by the year 2030, based on a range of global climate model results. In Warrick et al. (1996), it is reported that monsoon rainfall may increase by 10-15% by the year 2030 and by 15-20% by the year 2050 from the year 1990. 11% and 28% increases in monsoon rainfall over Bangladesh by the year 2030 and 2075, respectively, are reported in Alam et al. (1999). IPCC (2007a) has projected 11-15% increase in monsoon rainfall over South Asia by the end of this century. Though Bangladesh occupies only 7% of the combined catchment area of the Ganges-Brahmaputra-Meghna River basin, the country has to drain out 92% of the flow into the Bay of Bengal. Too much water in the monsoon period affects different sectors, livelihoods and food security. Climate change scenario projections show mean monthly rainfall may significantly change over normal (i.e. current variability). Monsoon rainfall may increase by 11% by 2030 and 27% by 2070 (GoB, 2009). It can be mentioned that climate change induced flood data for the year 2040 has been collected from IWM. They used 13% increased precipitation due to climate change for the year 2040 (for the Months June-July-August, please see Table 2.2) The Precipitation pattern of Bangladesh cannot be obtained directly from the 4th IPCC report. But precipitation condition of South Asia for different scenario can be calculated from the report which is presented in the Table 2.2. From this information precipitation condition of Bangladesh can be estimated. The scenario are described slightly in Box-2.1

Table 2.2: Predicted precipitation change (%) for the next 100 years

Sub-regions	Season	2010 - 2039		2040 - 2069		2070 - 2099	
	Scenario	A1Fl	B1	A1Fl	B1	A1Fl	B1
South Asia	DJF	-3	4	0	0	-16	-6
	MAM	7	8	26	24	31	20
	JJA	5	7	13	11	26	15
	SON	1	3	8	6	26	10

Note: DJF: December January February, MAM: March April May, JJA: June July August and SON: September October November (IPCC, 2007b)

Box-2.1: Climate change Scenario

A1 Scenario: based on homogeneous world of very rapid economic growth, high global population that peaks in mid-century and the rapid introduction of new and more efficient technologies. It represents a convergent world with a substantial reduction in regional per capita income. Based on emission it is divided into three categories such as A1Fl, A1T and A1B. **A1Fl Scenario:** Based on fossil fuel intensive – represent very high emission **B1 Scenario:** based on convergent world with the same global populations as in A1 but with rapid change in economic structures and the introduction of clean and resource-efficient technologies. Special emphasis is given on global solution to economic, social and environmental sustainability including improved equity. It represents very low emission.

2.4.4 Climate change induced flood in Bangladesh

The IPCC AR4 and research conducted on the future climate of South Asia is indicating climate change will increase the vulnerability of Bangladesh to severe floods. The IPCC AR4 predicted that monsoon rainfall will increase this century in South Asia resulting in higher flows in the rivers of Bangladesh from Nepal, India, China and Bhutan (IPCC, 2007a). Although Bangladesh accounts for only 7% of the GBM basin area, it drains the entire GBM basin (1.72 million km^2) because of its location at the mouth of the basin. Hence, the timing, location, and extent of flooding in Bangladesh depend on the rainfall in the entire GBM basin. Mirza and Dixit (1997) have estimated that a 2°C warming combined with a 10 percent increase in precipitation would increase runoff in the GBM Rivers by 19, 13, and 11 percent respectively. In Bangladesh, increased depth of flooding will be pronounced in the lowlands and of the Faridpur, southwest Dhaka, Rajshahi, Pabna, Comilla, Sylhet, and Mymensingh greater districts. In a study, Mirza et al. (1998) reported that an increase in precipitation over the GBM basins of about 5 percent combined with a temperature increase of around 1°C could result in up to a 20 percent increase in area flooded in Bangladesh. Severity of extreme floods, such as the 20-year flood event, is estimated to increase marginally. Another study conducted in 1998 concluded that an increase in monsoon rainfall by 11 and 20 percent will increase surface runoff by 20 to 45 percent in Bangladesh (Ahmed and Alam, 1998). For Bangladesh alone, the median predictions of 16 General Circulation Models for three emission scenarios considered by the IPCC AR4 point to a warming of 1.55°C and an increase in precipitation of 4% by 2050 (Yu et al. 2010). In sum, the warmer and wetter climate predicted for the GBM basin by most of the climate-related research indicates vulnerability of Bangladesh to severe monsoon floods will increase with climate change.

2.5 Literature review

2.5.1 Studies on flood exposure analysis

Exposure is the presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected (IPCC, 2014). It indicates the nature and degree to which a system is exposed to significant climatic variations (IPCC, 2007a). The Figure-2.3 illustrates the concept of flood exposure. Exposure is a component of risk, which refers to the susceptibility of people and infrastructure to flooding in terms of their location and physical defenses (ADPC, 2005). It also refers to the people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses (ADPC, 2010). Exposed elements refer to the inventory of elements in an area in which hazard events may occur (Cardona, 1990; UNISDR, 2004; UNISDR, 2009a). In a nutshell, exposure is the "people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses". Measures of exposure can include the number of people or types of assets in an area.

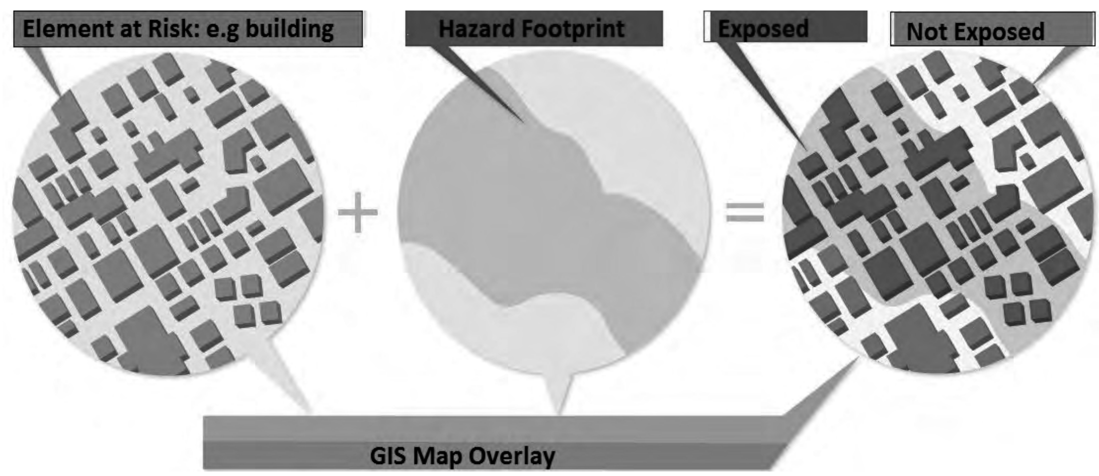


Figure 2.3: Concept of flood exposure

The analysis of exposure aims at identifying the physical as well as social elements that are at risk. Quantifying the exposure of sectoral assets illustrates the proportion of the assets that are located in the hazardous areas, thus improving an understanding of the stock of the assets that is prone to damage and losses caused by various hazard intensities. The assessment provides information for policy makers, decision makers and planners about assets which may need mitigation intervention effort. The degree of economic losses and amount of damage to buildings and infrastructure are determined by the different levels of exposure of the population, infrastructure, facilities, etc. of each locality.

Flood exposure analysis has been carried out worldwide by various institutions, organization, and flood prone countries, especially in Asian countries, envisaging the devastating impact of climate change incident. Amongst them flood exposure analysis by Asian Disaster Preparedness Center (ADPC), Federal Emergency Management Agency (FEMA), International Institute for Geo-Information Science and Earth Observation, Enschede, The Netherlands (ITC), Queensland Department of Community Safety, Australia and World Bank are very important and straightforward and all of them had used ArcGIS platform for the study (ADPC, 2011; FEMA, 1982; QDCS, 2011; ITC, 2002; WB, 2010b). Some important study relating flood exposure analysis is discussed below.

World Bank (2010b) studied on Climate Proofing Infrastructure in Bangladesh. This study has been conducted in 2010 for the whole Bangladesh to understand how infrastructure will be exposed in future climate change induced flood and what cost it will incur. The infrastructure assets considered for the analysis includes: national highways, regional highways, feeder roads-type A, feeder roads-type B, railways, bridges, embankments and drainage systems. It is calculated from the study that about 87% road will be inundated by up to 0.5 meters due to climate change The study also finds that the estimated population exposed to inundation depths greater than 0.9 meter is expected to increase at about 22% form baseline scenario in 2001 to the climate change scenario in 2050. The study estimated the cost for elevating the entire road network to offset additional risk due to climate change is Tk 148.56 billion or $2.12 billion.

Neuhold and Nachtnebel (2010) assessed flood risk associated with waste disposals in Austria. In that study they focused to derive and to apply a qualitative flood risk assessment approach for waste disposal sites in flood plains. Exposure level of waste disposal sites was identified for different return period flood. GIS based exposure analysis and overlay operation was done to assess the probability of inundation to different flood depth.

Multi Hazard Risk Assessment was conducted in the Rakhine State of Myanmar by ADPC (2011) to assess the vulnerability of communities to various natural hazards and provide a comprehensive picture of the impact of natural hazards as well as determining their degree of exposure to future hazardous events including flood, cyclone etc.

California Department of Water Resource (CDWR) (2013) initiated "Statewide Flood Management Planning (SEMP)" program in 2012 (CDWR, 2013). This programme conducted flood hazard exposure analysis that uses existing Geographic Information System (GIS) data to identify the population, property, structures, facilities, and crops located within 100-year and 500-year, (where available) floodplains.

In 2009, a study on "Nepal Hazard Risk Assessment" has been conducted in Nepal which is commissioned by Government of Nepal and is carried out by ADPC in association with Norwegian Geotechnical Institute (NGI) and Centre for International Studies and Cooperation (CECI). Under this study, GIS based flood exposure analysis for different return period has been performed in seven river basins namely Rapti, Babai, Bagmati, Narayani, Tinau, Kankai and Kamalashow which cover 21 districts of Nepal. The flood exposure analysis was the basis for vulnerability and risk assessment in that region. The study finds that about 28.76%

health infrastructures, 76.86% population, 59.84% land would be severely affected to 1 in 10 year flood.

Nicholls et al. (2008) ranked port cities with high exposure and vulnerability to climate extremes where they studied 136 port cities around the world that have more than one million inhabitants. The analysis focused on the exposure of population and assets to a 1 in 100 year surge-induced flood event and investigated how climate change is likely to impact each port city's exposure to coastal flooding by the 2070s, alongside subsidence and population growth and urbanization. They found that across all cities, about 40 million people (0.6% of the global population) are exposed to a 1 in 100 year coastal flood event.

Department of Community Safety (DCS), Australia (2011) conducted state-wide natural hazard assessment to support long term natural disaster planning. The analysis has been conducted by identifying and Mapping infrastructure's level of exposure to bushfire, coastal hazards, floods and tropical cyclone winds.

In Bangladesh, at present, ADPC is conducting flood exposure analysis for the study on multi hazard risk and vulnerability assessment in Bangladesh under Disaster Management bureau (DDM, 2014).

2.5.2 Studies on adaptation strategies in response to flood

Adaptation is the "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007). Adaptation thus includes both anticipatory and reactive actions in order to reduce vulnerability or enhance resilience in response to already observed and expected changes in climate (IPCC, 2007c).

UN-HABITAT (2010a) recommends to elevate homes and buildings and other infrastructure in responses to climate change induced floods. They also suggested that retrofits can be attractive, especially for low-income or middle-income residents when new constructions are too expensive or otherwise not possible. In contrast, wealthy residents may tend to be much more able and likely to rebuild or relocate their structures entirely, by virtue of greater financial resources.

Several studies including studies conducted in Asian countries suggested to raise road elevation to adapt with climate change induced flood (JICA, 2002; Douven, 2009; ADB, 1993; ADPC, 2008).

Planning principle for all transportation networks should avoid flood-sensitive areas as much as possible, and incorporate climate change into all relevant decisions concerning transportation infrastructure (Ministry of Agriculture and Forestry of Finland 2005; Coffee et al. 2010).

Horton (2009) suggested that infrastructure can be built to a higher standard considering climate change induced flood. Examples of this include the following: increasing the elevation of road, using flood sensitive construction material, increasing bridge clearances to accommodate higher water levels; increasing design specifications for culvert diameters; and reconsidering the design of road underpasses to account for heavy rains and flooding.

According to WHO (2011), Expanding health care services for the urban poor is a direct way to reduce climate change vulnerability and enhance adaptive capacity. Increased accessibility of formal health clinics and medical personnel to serve the poor enhances not only the well-being of poor residents but also their resilience to climate change impacts.

Systems to monitor disease and provide early warnings about disasters can help to improve resilience by influencing behavior (WHO, 2002). This is especially true if such systems are deployed in conjunction with public awareness campaigns that effectively leverage community sources of knowledge and communications, such as women, kinship networks and community leaders (Wolf et al., 2010). Structural improvements in housing, transportation, water supply and sanitation are important long-term investments that can enhance living conditions, helping to avoid the public health risks (WHO, 2011).

Reducing vulnerability to solid waste-related flooding in cities requires improvement in solid waste management practices. One step is to develop regular and proactive collection of solid waste from drains, streets, and waterways; this can be taken as a low-cost measure in advance of an anticipated storm (Simply Green, 2009). Solid waste authorities can also reduce waste-related flooding risks by improving landfill siting decisions with information about geology, groundwater tables, flooding hazards, proximity to surface water, and proximity to vulnerable populations (UNEP 2009).

Cities can reduce vulnerability to health risks through practices that avoid or reduce high concentration of pollutants in water after periods of floods. In collection and disposal services, cities can increase the use of corrosive resistant, lined and lidded storage systems; minimize accumulation of waste and informal disposal; increase the frequency of collection to remove organic wastes; and minimize the number and spatial coverage of waste disposal sites (UN-HABITAT, 2011).

FEMA (2007) prepared a design guide for improving critical facility safety from flooding and high winds where they mentioned about constructing flood wall around existing critical facilities including fire station, police station, and health facilities etc to adapt with climate change induced flood.

In Bangladesh there exists National Adaptation Programme of Action (NAPA) prepared by the Ministry of Environment and Forest (MOEF), Government of the People’s Republic of Bangladesh. NAPA suggested various adaptation strategies. Among others relevant adaptation strategies for this study are a) Capacity building for integrating climate change in planning, designing of infrastructure, conflict management and land water zoning for water management institutions; b) Mainstreaming adaptation to climate change into policies and programmes in different sectors and c) Enhancing resilience of urban infrastructure and industries to impacts of climate change (NAPA).

Recently in 2014, LGED has completed a project titled “Coastal Climate Resilient Infrastructure Project (CCRIP)” with financial assistance from ADB and IFAD where they raise the height of existing road above anticipated flood due to climate change (IFAD & ADB, 2014). In this project RCC pavement has been used as pavement instead BC to adapt with climate change induced flood.

Chapter 3: Methodology of the Research

3.1 Introduction

This research focuses on evaluating Ullapara Pourashava Master Plan from climate change induced flood. To help conduct the study two objectives have been set. These are the evaluation of proposed infrastructure plan and suggesting adaptation strategies considering climate change induced flood. This Chapter discusses the sequential steps to achieve these objectives. A methodological flowchart has been presented in the following Figure-3.1.

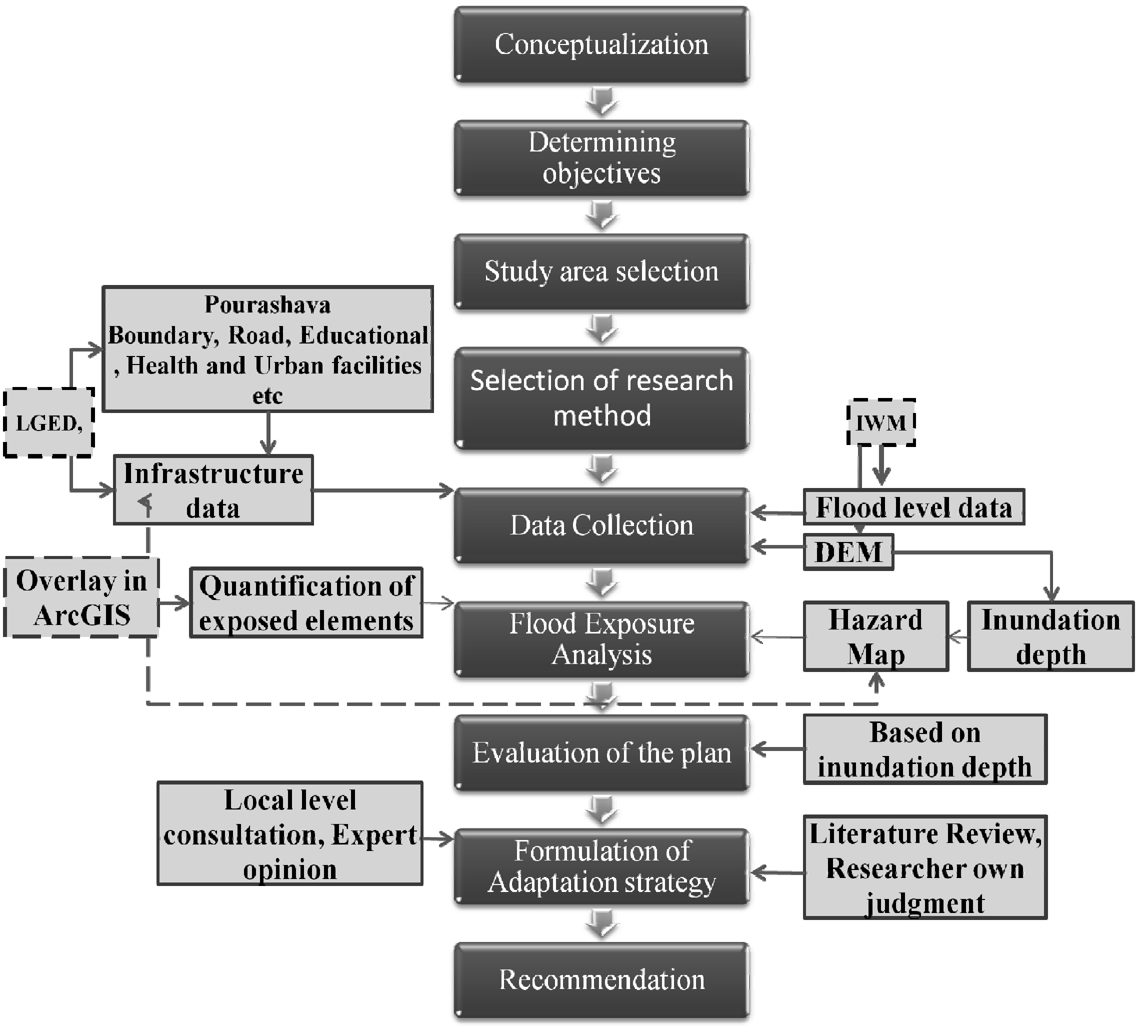


Figure-3.1: Flowchart of the methodology for the study

3.2 Conceptualization

Conceptualization is the process of development and clarification of concepts. It enables to invent or formulate an idea. The conceptualization phase of a research occurs in the initial design activity when the scope of the research is drafted. Conceptualization is very much important to conduct a good research. However, the researcher reviewed various literature, books, thesis, reports, journal papers and articles and similar studies conducted in home and abroad to develop a clear understanding of the research topic and its associated phenomena including, master plan, climate change, climate change induced flood and approach to flood exposure analysis etc.

3.3 Study area selection

Ullapara Pourashava has been selected for this study. Several factors narrow down to select the Ullapara Pourashava as study area. Firstly, Ullapara Pourashava is one of the Pourashavas under master plan preparation project in the country. Secondly, the urban character, important landuse activities, enriched infrastructures and geo-physical settings of Ullapara Pourashava make it most vulnerable to climate induced flood exposure. Due to its geo-physical settings, it represents other flood prone Pourashavas across the country. Thirdly, Ullapara Pourashava, being located in Sirajganj district, represents the impact of climate induced flood near the area of Jamuna River (Brahmmaputra), one of the rivers of GBM basin (Ganges-Brahmmaputra-Meghna) through which the impact of climate induced flood will be observed across the country. Fourthly, the availability of data on climate induced flood: at present climate induced flood scenario is available for seven districts across the country namely Sirajganj, Gaibandha, Pabna, Faridpur, Sunamganj, Satkhira and Barisal. On the other hand master plan had not been completed for 223 Pourashavas. Only limited number of Pourashavas has been completed at the commencement of the study. Ullapara Pourashava is one of those Pourashavas.

3.4 Selection of research method

To achieve the objectives, this research has been conducted in two steps through flood exposure analysis of infrastructure; and finding possible adaptation strategies regarding infrastructure. Flood exposure has been conducted to evaluate the infrastructure plan from climate change induced flood perspective. First part of the study, the flood exposure analysis, is very much important and thus the method of flood exposure analysis is also important.

Flood exposure analysis has been carried out worldwide by various institutions, organization, and flood prone countries, especially in Asian countries, envisaging the devastating impact of climate change incident. Amongst them flood exposure analysis by Asian Disaster Preparedness Center (ADPC), Federal Emergency Management Agency (FEMA), International Institute for Geo-Information Science and Earth Observation, Enschede, The Netherlands (ITC), Queensland Department of Community Safety, Australia and World Bank are very important and straightforward and all of them had used ArcGIS platform for the study (ADPC, 2011; FEMA, 1982; QDCS, 2011; ITC, 2002; WB, 2010b). A brief description of studies on flood exposure analysis has been presented in section 2.5.1 of Chapter-2. The literature review shows that methods for flood exposure analysis are similar for all cases except prediction of climate change induced flood. Due to differences in geographical locations and local context they considered different climate change scenarios for future flood modeling. However, this study did not emphasize on method on flood modeling because the flood modeling data has been collected from secondary source. It is also noticed that all the studies are conducted in GIS platform. It is found that the methodology developed by ADPC is being used in many Asian countries (MoHA, 2009; MoFA, 2009). Even, at present, ADPC is conducting a study on multi hazard risk and vulnerability assessment in Bangladesh under Disaster Management bureau and it has collaboration with other organizations in Bangladesh to conduct natural hazard risk assessment (DDM, 2014; UDD, 2011). Considering the sate-of-the-art methodology, software used and data availability the flood exposure analysis for this study has been conducted following the methodology developed by ADPC. A brief description of the methodology developed by ADPC has been presented in Appendix-C.

Secondly the adaptation strategies have been devised by studying different research works and projects done in Bangladesh and abroad; taking expert opinion; focus group discussion at field level; and applying own judgment of the researcher. Different national and international studies conducted on adaptation strategies have been presented in section 2.5.2 of Chapter 2. The researcher participated a national seminar on "Climate Resilient Infrastructure Planning, Design and Operational Considerations" held on 20 June, 2013 at Planning Commission, Dhaka. In that seminar national experts presented their thoughts regarding climate resilient infrastructure planning and design. The researcher also discussed with the experts regarding adaptation strategies particularly for this study. Focus group discussion has also been conducted in the Pourashava with the presence of Pourashava Mayor, Councilor and other local people. Finally, the researcher applied his own judgment to devise the adaptation strategies for infrastructure in the Ullapara Pourashava.

3.5 Data Collection

3.5.1 Primary Data Collection

Most important primary data collected for this study include past experience of floods in terms of damages and loss due to the inundation of infrastructures. Road inundation of previous floods and associated damages and losses have been collected in consultation with the Pourashava Engineers and surveyors; inundation of educational infrastructures and associated losses and impacts have been collected in consultation with teachers, inundation of health infrastructures and associated losses and impacts have been collected in consultation with health officials; similarly inundation of other infrastructure and associated impacts have been found out in discussion with the concerned people. In addition councilors and local peoples have been consulted to know past flood scenario, past inundation and damage scenario, consequence of past flood on normal life of people (Please see the appendix-A for the list of people consulted in local level). Local level consultation has been conducted for two times. The first consultation was conducted to know the people's perception regarding flood and what they want in response to climate change induced flood. The second consultation was conducted to verify the suggestion proposed by the researcher. In the second consultation face to face discussion was made to know past damage and loss scenario due to flood. The researcher showed them the proposed master plan by LGED and future climate change induced flood and discussed the probable future inundation scenario so that the people can anticipate the future scenario. In addition the researcher also presented his own proposal to them. Then they were asked to express their views on possible adaptation strategies in the face of climate change induced flood. To find the suitable adaptation strategies opinions were taken from the expert working in this field so that the study result and proposed adaptation strategies can help better climate resilient planning in the country. Expert opinions were also taken from various Government, Autonomous, Semi-government, NGO and Private organizations including IWM, RHD, BWDB, WARPO, IWFM (BUET), BRAC, LGED and DoE. A list of experts consulted has been presented in Appendix-B.

3.5.2 Secondary Data Collection

This study has been carried mainly based on secondary data which includes climate change induced flood level data for the year 2040, Digital Elevation Model (DEM), selected infrastructure and landuse data. The flood level data for the year 2040 and DEM has been collected from Institute of Water Modelling (IWM). This is 10-year return period flood. This flood level map has been developed under the project "Impact Assessment of Climate Change and Sea Level Rise on Monsoon Flooding" commissioned by Department of Environment (DoE, 2008). In that study the year 2040 has been considered to incorporate climate change whose usual period is about 30 years (please note that the aforementioned study by DoE was conducted in 2008). In this research infrastructure include transport and communication infrastructure, educational infrastructure, health infrastructure, and other community facilities. These data has been collected from LGED that has been prepared under UTIDP. Detail list of the data has been presented in the Table 3.1.

Table 3.1: List of data used in this study

Sl No	Data	Data Type	Feature type	Format	Source
1	Flood Water Level	Raster	Cell base (20m resolution)	GRID	IWM
2	Land elevation	Raster	Cell base (20m resolution)	GRID	IWM
3	Road Network	Vector	Line/Polygon	Shapefile	LGED, ACAL
4	Terminal Facilities	Vector	Point/Polygon	Shapefile	LGED, ACAL
5	Educational Infrastructure	Vector	Point/Polygon	Shapefile	LGED, ACAL
6	Health Facilities	Vector	Point/Polygon	Shapefile	LGED, ACAL
7	Community center	Vector	Point/Polygon	Shapefile	LGED, ACAL
8	Fire station	Vector	Point/Polygon	Shapefile	LGED, ACAL
9	Police station	Vector	Point/Polygon	Shapefile	LGED, ACAL
10	Solid waste disposal site	Vector	Point/Polygon	Shapefile	LGED, ACAL
11	Landuse	Vector	Polygon	Shapefile	LGED, ACAL
12	Pourashava ward boundary	Vector	Polygon	Shapefile	LGED, ACAL

3.6 Data preparation

3.6.1 Generation of flood hazard map

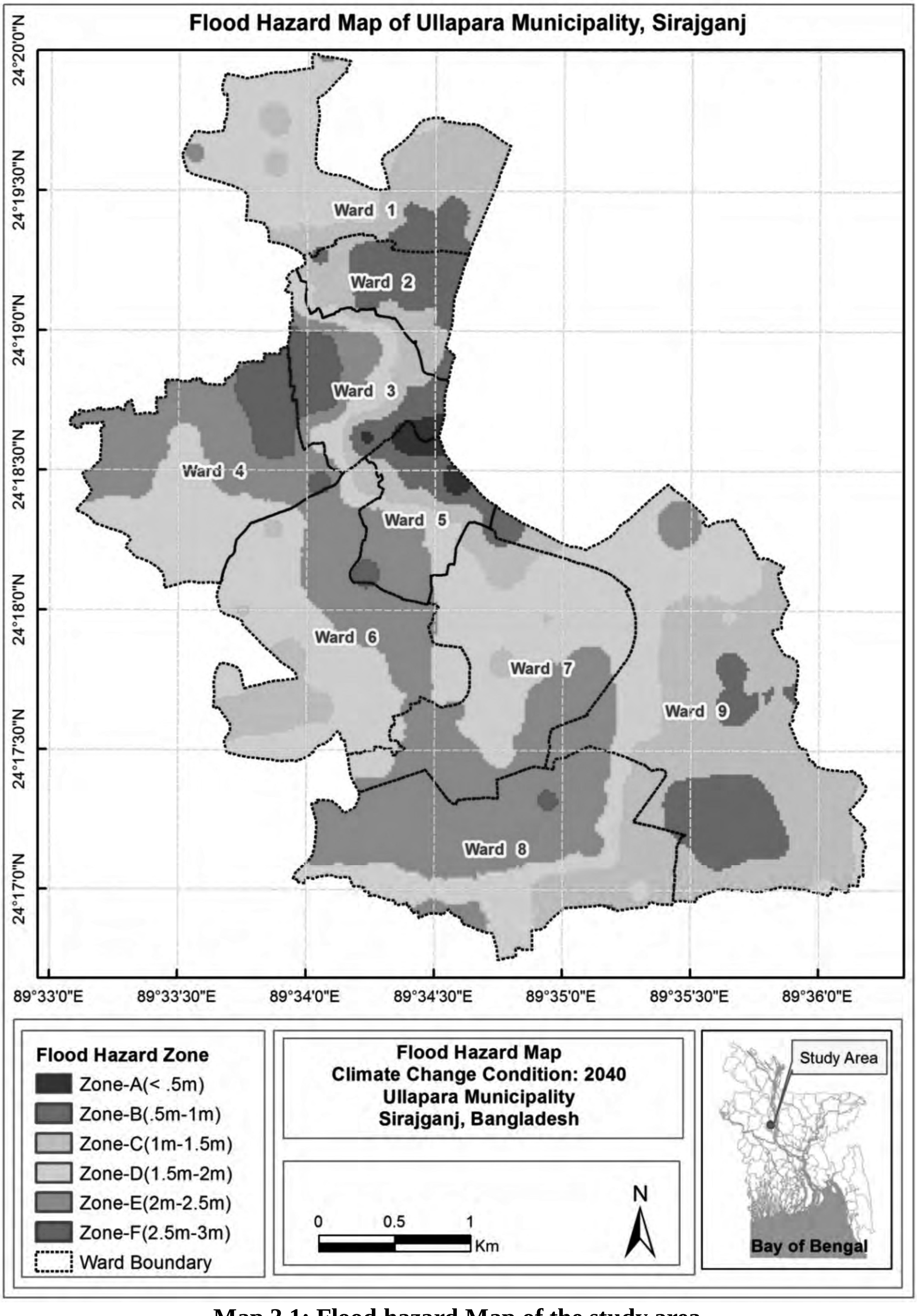
To meet the goals and objectives of the study the flood exposure analysis has been conducted first; for which generation of flood hazard Map is an indispensable part. It can be mentioned that flood level map and flood hazard Map are not same. Flood level map means spatial representation of flood water level (height) as continuous data where land elevation is included in flood level map. Whereas flood hazard Map (inundation depth) represents flood water level minus land elevation. So the flood hazard map is only flood water height excluding land elevation. Thus in this stage flood hazard map has been generated from flood map and Digital Elevation Model (DEM) through raster calculation in ArcGIS 10.1 software. It can be mentioned that cell size of both flood level data and DEM have is 20m and thus the cell size of generated flood hazard map is 20m also. The process of generating flood hazard map from flood map and DEM has been illustrated in the following Figure-3.2.

Figure 3.2: Generation of flood inundation depth Map

3.6.2 Classification of flood hazard Map

The flood inundation depth is not same across the Pourashava. So the inundation of infrastructure and land will not be same everywhere. In some places inundation will be higher and in some places inundation will be lower and even there may be flood free area. Thus it requires classifying the flood hazard map to understand level of exposure and vulnerability of specific infrastructure in particular location. So in this step the flood hazard map has been classified in 0.5 meter interval to assess the exposure level of infrastructure at different inundation depth. A recent study by World Bank (2010b) follows 0.5m interval for flood hazard classification. This study also follows the classification used by World Bank.

Flood hazard mapping delineates flood hazard areas using design flood levels established as part of flood hazard studies. In this study climate change induced flood for the year 2040 has been considered as design flood level in Ullapara Pourashava. Flood hazard is the probability of occurrence of a potentially damaging flood event of a certain magnitude within a given time period and area (Brooks, 2003). To conduct flood exposure analysis it is necessary to classify flood hazard map. The interval of classification was different in many studies. Following the World Bank (2010b) classification six categories of flood hazard zones have been identified based on extent of flood inundation depth. These hazard zones are Zone-A, Zone-B, Zone-C, Zone-D, Zone-E and Zone-F and these zones are characterized with 0-.5m, 0.5-1m, 1-1.5m, 1.5-2m and 2-2.5m and 2.5-3m inundation depth respectively. The climate change induced flood hazard zone has been presented in the Map 3.1.



Map 3.1: Flood hazard Map of the study area

Source: Prepared by author; Data collected from IWM, LGED and ACAL

3.7 Flood exposure analysis

After the flood hazard map has been classified, the exposed infrastructure and land have been determined by overlaying infrastructure map and flood hazard map. Thus in this stage overlaying and intersection operation has been done in ArcGIS 10.1 software to identify the exposed infrastructure and land at various inundation depths. Quantification of exposed infrastructure and land has also been made in terms of number (e.g school, hospital) and length (e.g road) and area (e.g land) and the result has been presented in tables, graphs and maps. The following Figure-3.3 shows the overlay operation in ArcGIS 10.1 software.

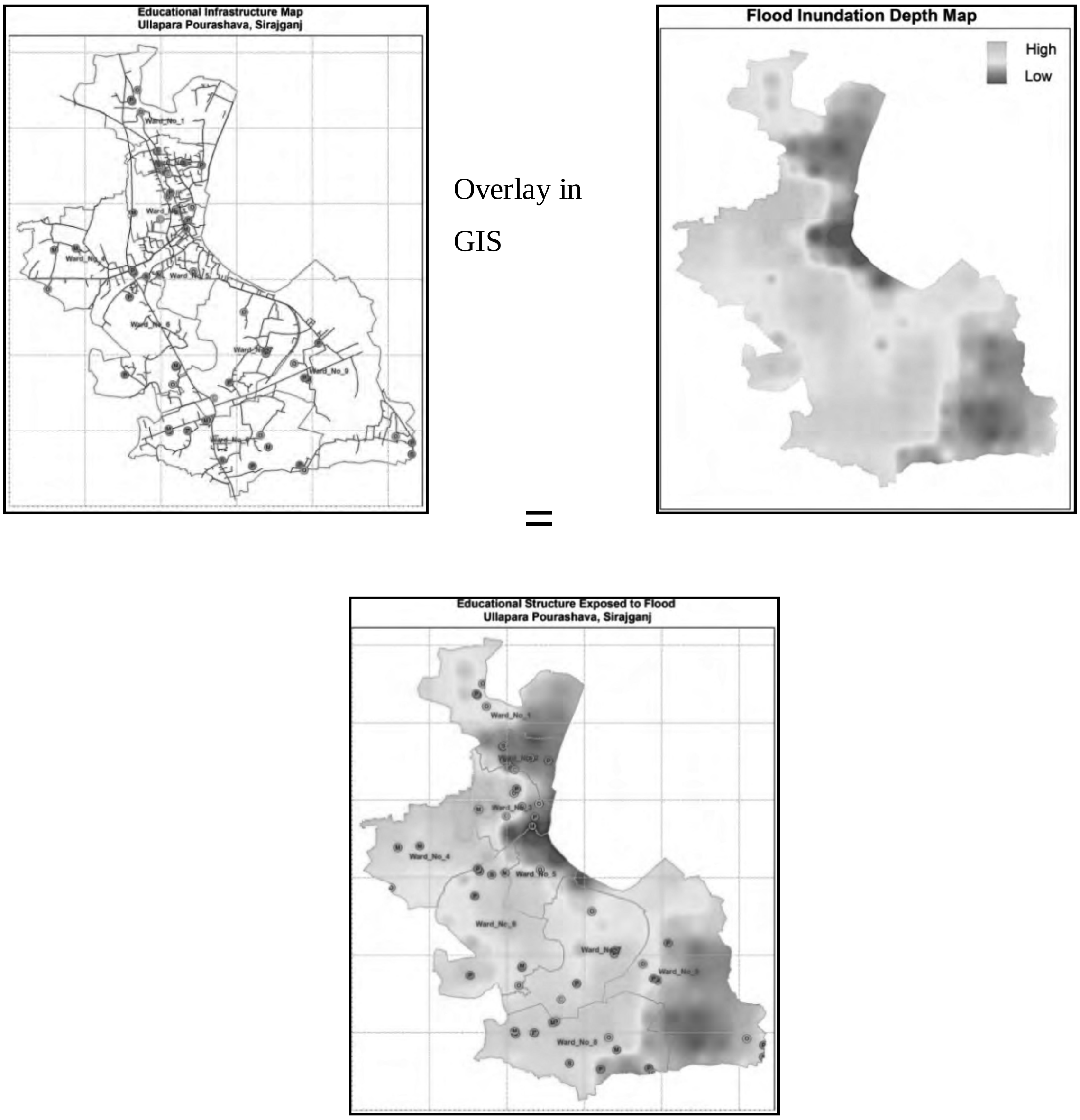


Figure 3.3: Identifying Exposed Educational Infrastructure

3.8 Evaluation of the plan

After identifying the extent and spatial distribution of the exposed infrastructure and different types of land, the proposed plan has been evaluated from flood exposure analysis. Only flood inundation depth has been considered to evaluate the infrastructure plan because the study has been conducted from the perspective of climate change induced flood; and on the other hand other aspects had been already considered in preparing the plan. Only climate change induced flood had not been considered in the plan making process. In this evaluation process various spatial analyses have been done in ArcGIS 10.1 software through overlay and intersect analysis.

3.9 Finding possible adaptation strategies regarding infrastructure plan

It is assumed that the climate induced flood will lead to increase the exposure of infrastructure and land. So it will be necessary to find suitable location for future infrastructure in accordance with future population and climate induced flood. In this stage an attempt has been made to find possible remedies regarding spatial distribution and planning of exposed infrastructure taking into account the future flood scenario. Local level consultation with the Pourashava Engineers, surveyors, councilors, teachers, health officials, and other local peoples have been conducted to find the adaptation strategies. In addition some expert opinions were taken to find the suitable adaptation strategies. The researcher also reviewed various contemporary national and international studies to come across appropriate studies in the face of climate change induced flood. Adaptation strategies have been discussed and summarized in local, regional and national level perspective.

3.10 Recommendation

Finally, based on the findings of the study, possible adaptation strategies regarding proposed infrastructure has been suggested considering climate change induced flood, contemporary study and expert opinions. Finally some recommendations have been made regarding adaptation strategies.

Chapter 4: Study Area Profile

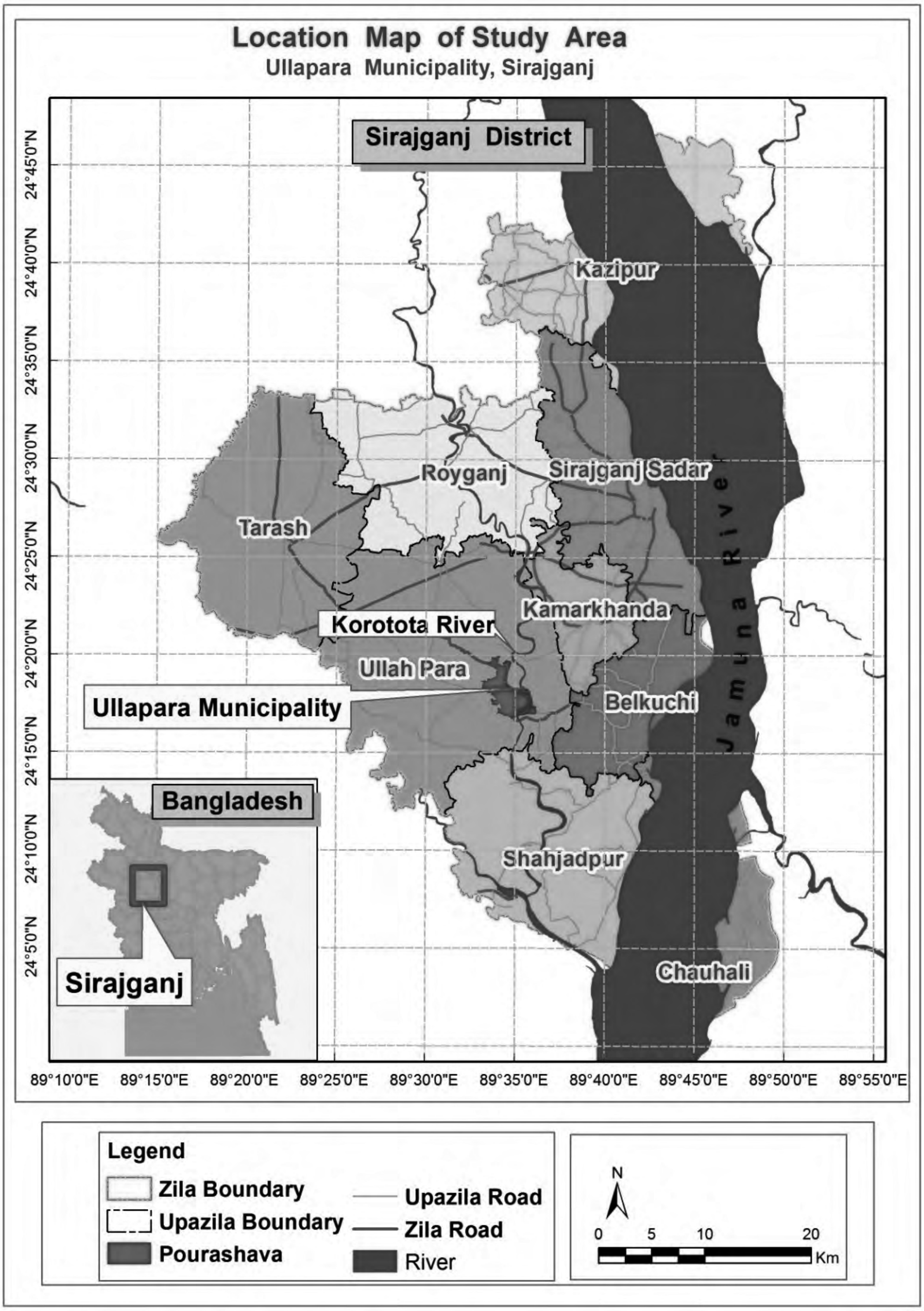
4.1 Introduction

This Chapter provides an overview of the study area from several aspects including socio-economic, geo-physical settings, physical features, landuse, environment and climate vulnerability. Flood scenario of the study area has also been discussed in this Chapter.

4.2 Historical background and location of the study area

Ullapara Upazila came into existence in 1813. It is learnt that there came one religious leader named Hazrat Sufiullah to preach Islam in this area and settled here. He built a mosque, which still exists at Ullapara. It is generally believed that Upazila might have been named Ullapara at the time of its creation after the name of that religious leader. The Upazila occupies an area of 409.06 sq. km. It lies between 24°12' and 24°26' north latitudes and between 89°24' and 89°38' east longitudes. The Upazila is bounded on the north by Royganj Upazila, on the east by Kamarkhanda and Belkuchi Upazilas, on the south by Shahjadpur Upazila and Faridpur Upazila of Pabna zila and on the west by Tarash Upazila and Bhangura Upazila of Pabna zila (BBS, 2011). Ullapara Upazila is located in the south-western part of Sirajganj District and about 22km from the Sirajganj main town. Sirajganj District is located in the north-western quadrant of Bangladesh. It is west side of and about 151.1 Km from Dhaka, the capital of Bangladesh.

Ullapara Pourashava has been declared as a Class “B” Pourashava through a government notification dated on June 23, 1994. Later in 2010, this Pourashava has been upgraded as Class “A” Pourashava based on its annual income level which is the basis for upgradation of Pourashava class. The Pourashava is located in eastern side of Ullapara Upazila and is bounded by $24^0$16’47.83” N and $24^0$20’02.11” N Latitude and $89^0$32’57.01” E and $89^0$36’01.61”E Longitude. It stands on the bank of the Korotoa River. The area has a good road connection to Sirajganj district and to the other Pourashavas of Sirajganj. The location Map of Ullapara Pourashava has been shown in the Map 4.1



Map 4.1: Location Map of the Study Area

Source: Prepared by author; Data collected from IWM, LGED and ACAL

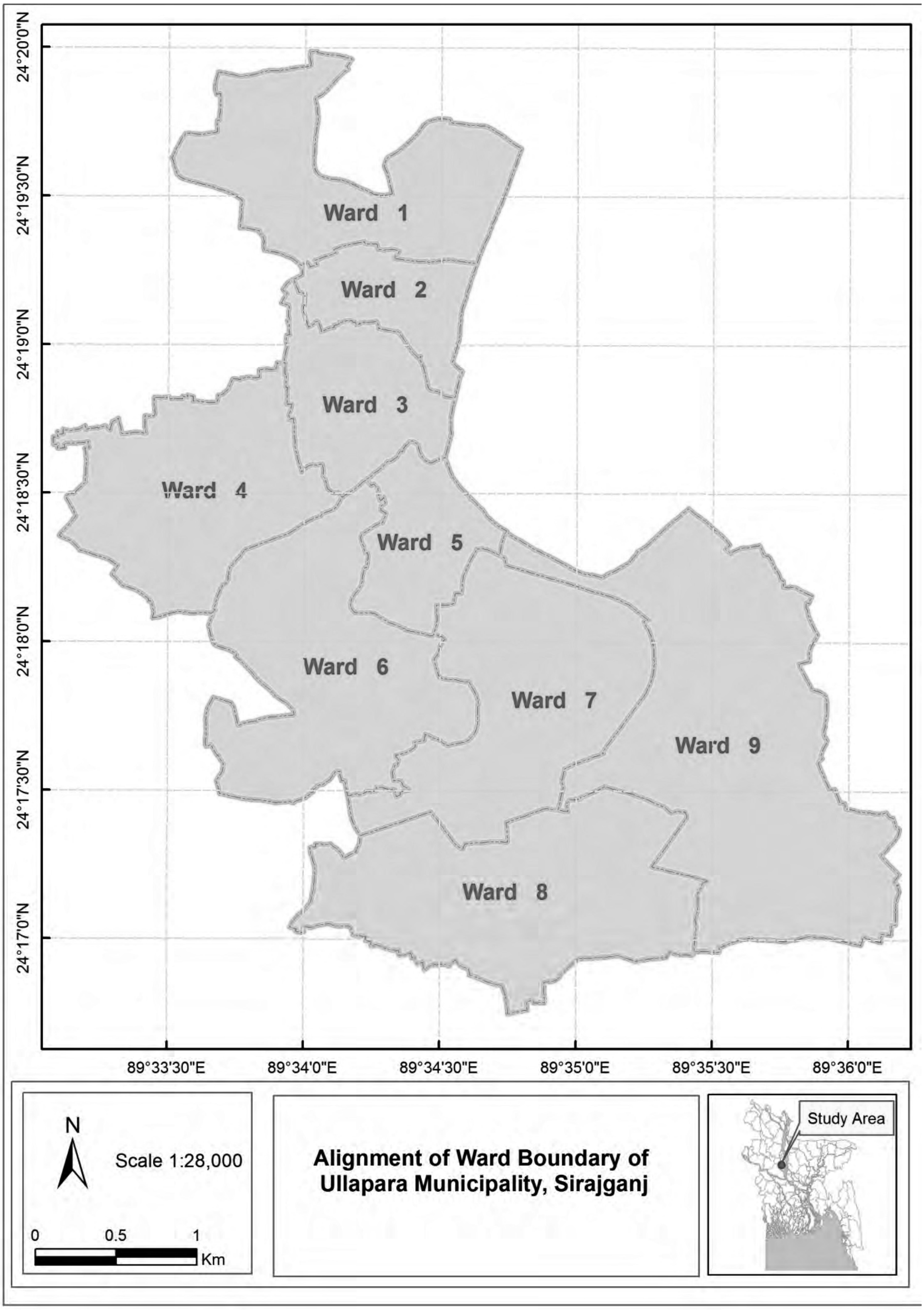
4.3 Area and physical composition of Ullapara Pourashava

Ullapara Pourashava is comprised of nine wards and 10 mouzas. It is bounded by Chala in the north, Paikpara in the south, Matikora in the east and Bhadrakola in the west. Total area of the Pourashava is about 13.91 Sq.km (ACAL, 2012). The Table 4.1 shows the ward-wise area of the Pourashava and name of mouzas falling each ward. From the Table 4.1 it is seen that ward-9 is the largest ward which is located in southern part of the Pourashava and ward-2 is smallest and is located north eastern part. Ward-5 is centrally located in the Pourashava. Map 4.2 shows the demarcation of ward boundary of Ullapara Pourashava.

Table 4.1: Ward-wise area and mouza of Ullapara Pourashava

Ward No	Area (Sqkm)	Percentage of Total Area	Name of Mouza
Ward 1	1.48	10.64	Sreekola, Baraia
Ward 2	0.56	4.00	Jhikra (Part)
Ward 3	0.82	5.92	Bahuka (Part), Jhikra (Part)
Ward 4	1.55	11.15	Bahuka (Part),
Ward 5	0.64	4.62	Ghoshganti
Ward 6	1.90	13.69	Bhatta kauk (Part)
Ward 7	1.80	12.91	Enayetpur (part), Bhatta kauk (Part)
Ward 8	2.06	14.78	Sreephalganti, Singhaganti, Newargacha
Ward 9	3.10	22.30	Enayetpur (part),
Total	13.91	100.00	Total 10 mouzas

(Source: ACAL, 2012)



Map 4.2: Ward boundary of Ullapara Municipality, Sirajganj

Source: Prepared by author; Data collected from IWM, LGED and ACAL

4.4 Population distribution in the Pourashava

The Table 4.2 shows the population distribution in the Pourashava. According to BBS Population Census 2011, there are about 47,693 populations in this Pourashava. Ward-wise population distribution has been shown in the Table 4.2. Average density in the Pourashava is about 35person/acre or 8657person/sqkm. The Table 4.2 shows that the highest number of population resides in ward-7 and lowest number population resides in ward-1. Population density is highest in ward-2 which is located north-eastern part and lowest density in ward-9 which is located in southern part of the Pourashava.

Table 4.2: Ward-wise population distribution in Ullapara Pourashava

Ward No	Population (2001)	Population (2011)	Percentage of Total Population (2011)	Density (Person/sqkm) (2011)
Ward 1	3693	4246	8.90	2868
Ward 2	3167	4819	10.10	8657
Ward 3	5088	6484	13.60	7871
Ward 4	4226	6270	13.15	4043
Ward 5	3827	4388	9.20	6830
Ward 6	3780	4866	10.20	2556
Ward 7	4618	6710	14.07	3737
Ward 8	4268	5629	11.80	2738
Ward 9	4008	4281	8.98	1380
Total	36675	**47693**	**100.00**	2777

(Source: BBS, 2001, 2011)

4.5 Socioeconomic profile

According to BBS 2011, there are 10,526 households in Ullapara Pourashava and average household size is about 4.4 people. About 50.67% of the population is male and 49.33% is female and sex ratio is 103. In this Pourashava the highest percentage (25.2 %) of peoples falls under the group 30 to 49 years. About 9.3 % falls under children group. Literacy rate in Ullapara Pourashava is about 61.9%; literacy rate for male is about 65.6% and for female is about 58.2%. About 92.4% people use tubewell for their primary water source and only 6.6% use piped water supply. About 75.8% household has electricity connection. About 25.7% household has *pucc*a structure (housing), 26.8% has *semi-pucca* structure and 47.1% has *katcha* structure.

About 32.2% of total household has sanitary latrine and about 66.3% do not have sanitary latrine. The dominant occupation in Ullapara Pourashava is small business (31.68%) and the next dominant occupations are agricultural works (23.36%), government employee and private service. The income level of household in Ullapara Pourashava is moderate. A maximum number of people (30.94 %) have income range between 10,000 to 15,000 BDT. The most of the housing structures (about 78%) in Ullapara Pourashava are *katcha*. This Pourashava is not facilitated with available service facilities. In Ullapara Pourashava there are three bazar named Sreekoa Bazar, Ullpara Central Bazar and Rail Bazar. Ullapara central bazar is centrally located and people can reach the bazar within very short time. This is the everyday-bazar and the duration of bazaar is about 3.00pm to 8.00pm (ACAL, 2012).

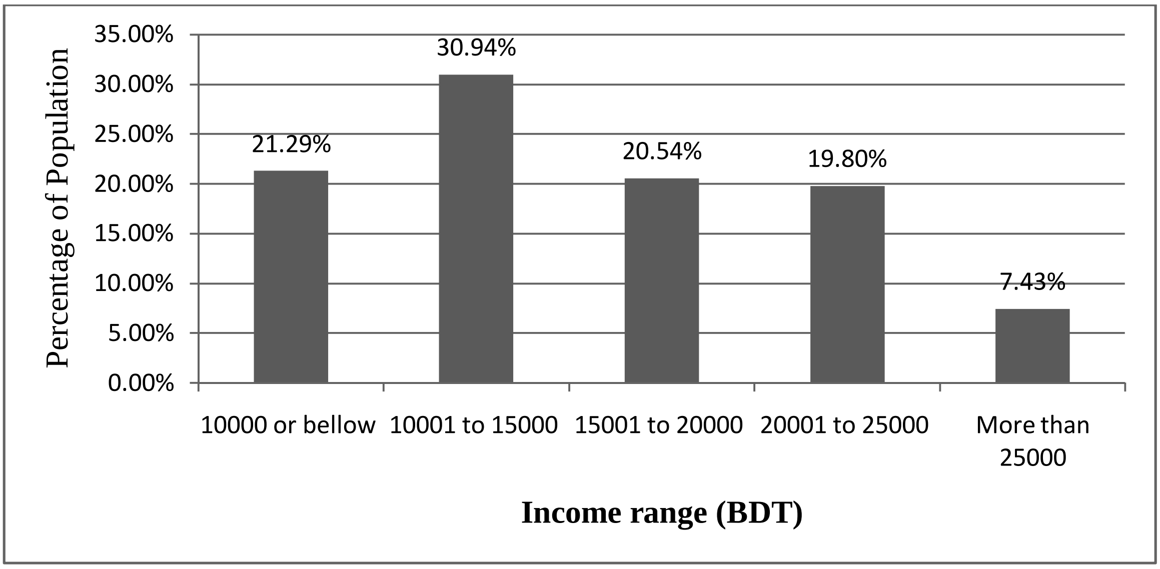


Figure 4.1: Level of income of the people of Ullapara Pourashava (ACAL, 2012)

4.6 Physical features of the study area

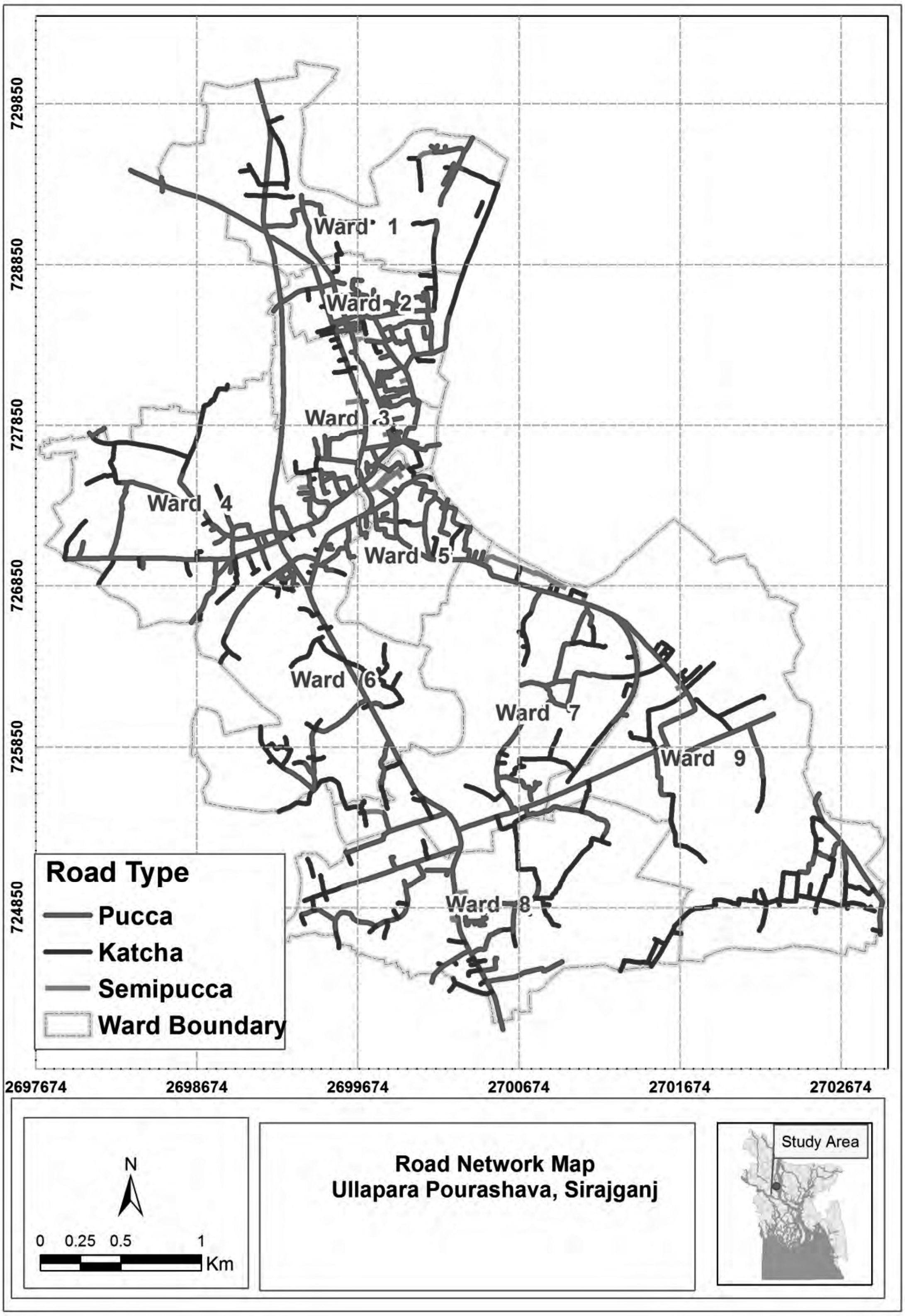
4.6.1 Road network

Ullapara Pourashava has direct transport communications with the Dhaka and other nearer regional centers like Bogra, Pabna etc. The road network and hierarchy within the Pourashava boundary is at moderate level. The area along the Ullapara-Sirajgonj road is predominantly urban and with some commercial development. Better urbanization is taking place along this road and this road is experiencing rapid change with development of residential settings. The road network and hierarchy within the Pourashava boundary is poorly established. Most new development is taking place without any coherent road system. Most of the areas lack in internal road network and suffer from lack of alternative access facilities within the town. More or less all the wards are facing accessibility problem. The following Table 4.3 shows the construction type of road. In Ullapara Pourashava there are about 53.032 km road is Pucca, 1.99 km road is semi-pucca and 27.37 km road is *Katcha*. In this Pourashava there is hardly Pucca Road. The Map 4.3 shows the types of Roads on the basis of construction pattern in Ullapara Pourashava. The Table 4.3 also indicates that in ward 2 there is highest concentration of road (11.61 Km/Km^2) and in ward 9 there is lowest concentration of Road (4.22 Km/Km^2).

Table 4.3: Type of Roads in Ullapara Pourashava (Based on Surface Types)

Ward No	Length (Km)				Concentration (Km/Km^2)
	Pucca	Semi-	Katch	Total	
1	4.28	0.12	2.51	6.90	4.66
2	5.18	0.00	1.32	6.50	11.61
3	8.29	0.25	0.97	9.51	11.60
4	6.14	0.07	2.39	8.59	5.54
5	4.14	0.59	0.56	5.29	8.27
6	6.28	0.00	4.49	10.77	5.67
7	6.81	0.12	3.42	10.35	5.75
8	6.62	0.15	4.64	11.41	5.54
9	5.29	0.70	7.07	13.07	4.22
Total	**53.032**	**1.99**	**27.373**	**82.395**	**5.92**

(Source: ACAL, 2012)



Map 4.3: Road network Map in the Study Area

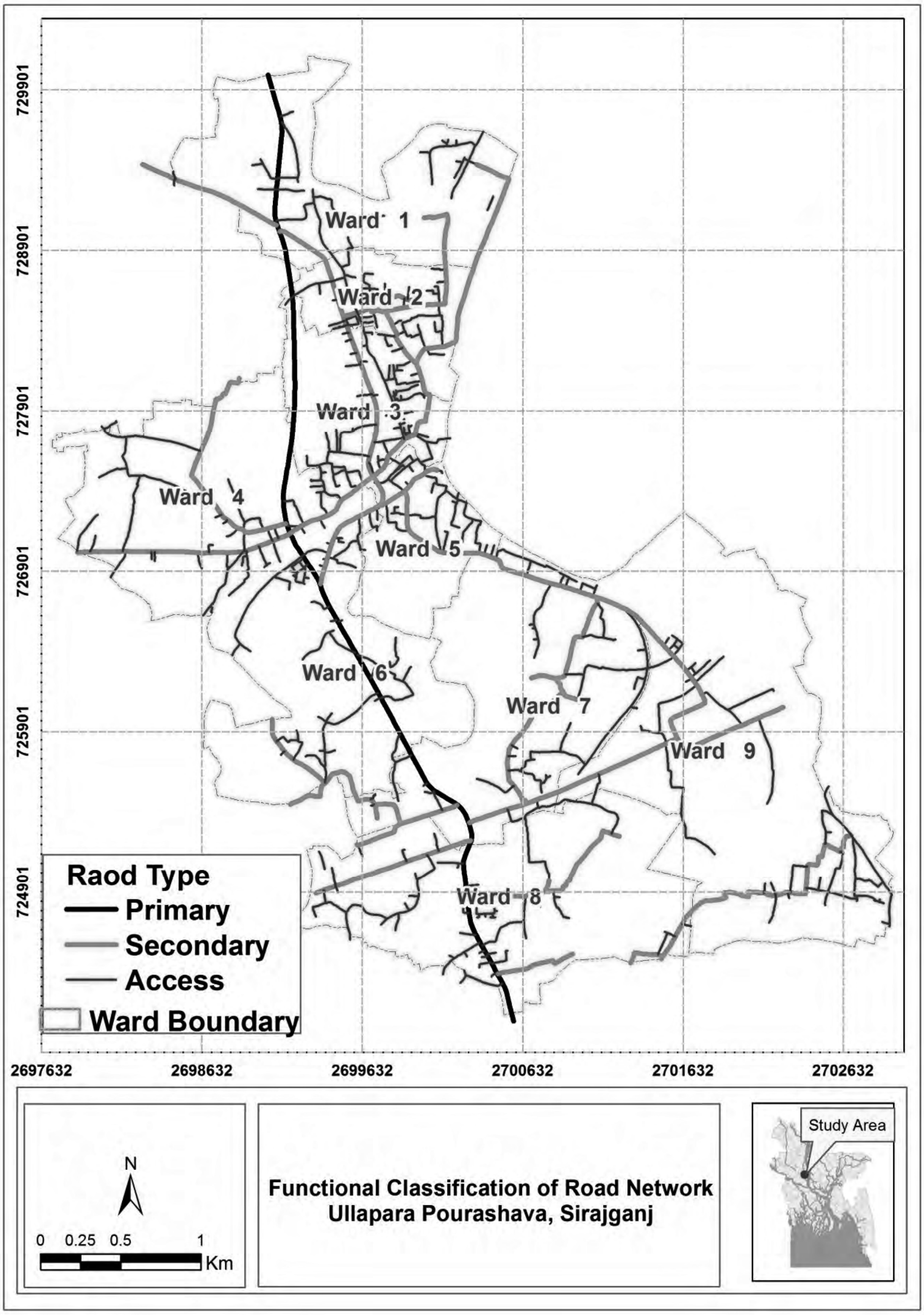
Source: Prepared by author; Data collected from IWM, LGED and ACAL

The Map 4.4 shows the functional classification of road network in Ullapara Pourashava. In this Map Roads have classified as Primary, Secondary and Access road on the basis of function of road. Roadways serve a variety of functions, including but not limited to the provision of direct access to properties, pedestrian and bicycle paths, bus routes and catering for through traffic that is not related to immediate land uses. Primary Road serves to carry long distance through traffic external to specific areas and it ensures mobility. Secondary Roads allow connections between local areas and Primary arterial roads; connections for through traffic between arterial roads. Local access roads provide direct access to properties, pedestrian movements, and local cycle movements. In Ullapara Pourashava there is only one primary road which connects Sirajganj and Pabna districts and passes through the Pourashava. Thus this road serves as major thoroughfare for this area. The road length of this primary road is about 6.4 km within this Pourashava and its average width is about 7.08m. There some secondary roads in the Pourashava and rest of the roads are local access road. Most of the access roads are haphazard. The following Table 4.4 shows the inventory of different types of road (based on functional classification) in Ullapara Pourashava. The Map 4.5 shows average height (from base) of the existing roads in Ullapara Pourashava.

Table 4.4: Functional Classification of Road in Ullapara Pourashava

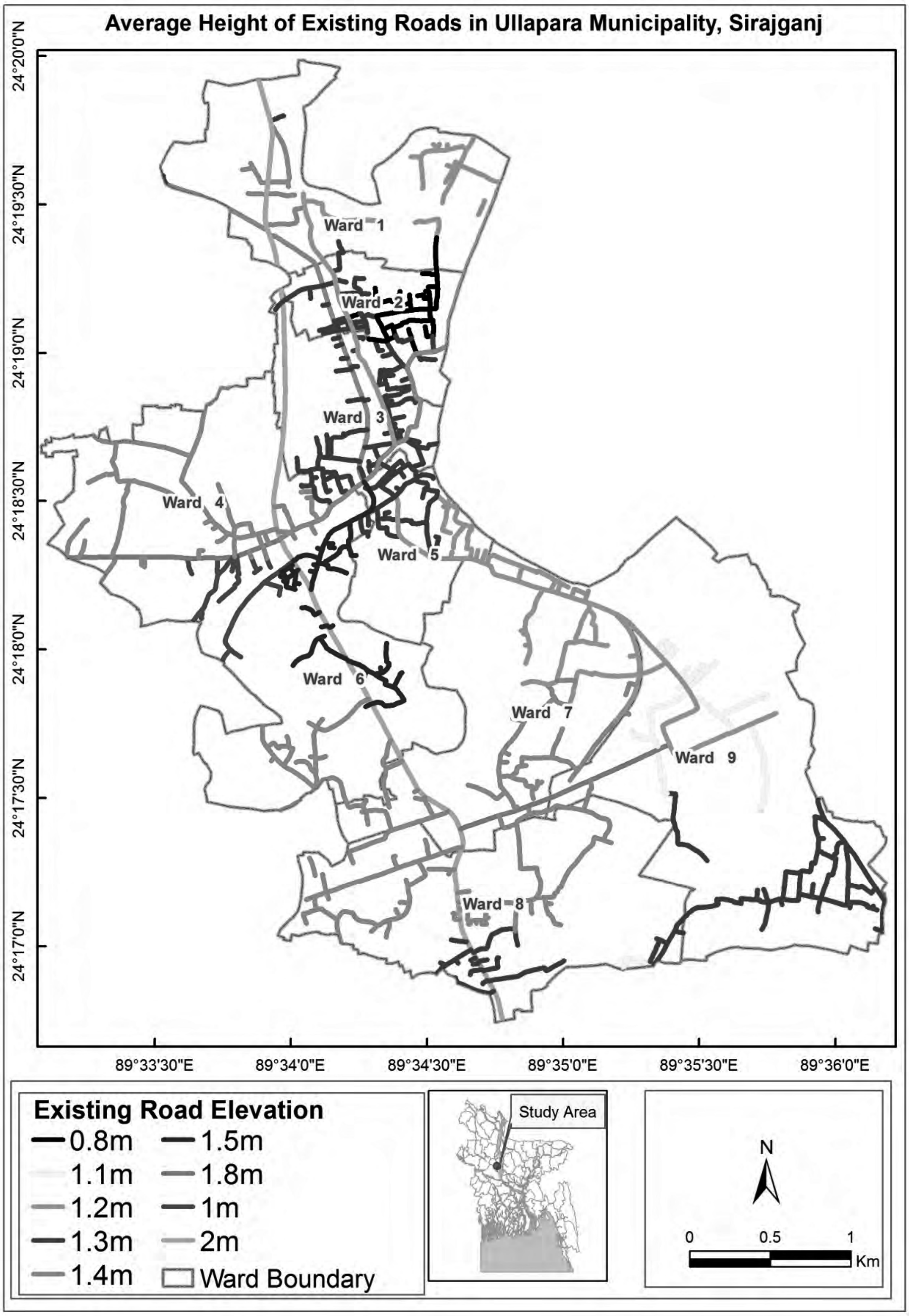
Road Type	**Length (Km)**
Primary Road	6.36
Secondary Road	26.05
Access Road	52.10

(Source: ACAL, 2012)



Map 4.4: Functional Classification of Road in Ullapara Pourashava

Source: Prepared by author; Data collected from IWM, LGED and ACAL



Map 4.5: Average height of existing road in Ullapara Pourashava

Source: Prepared by author; Data collected from IWM, LGED and ACAL

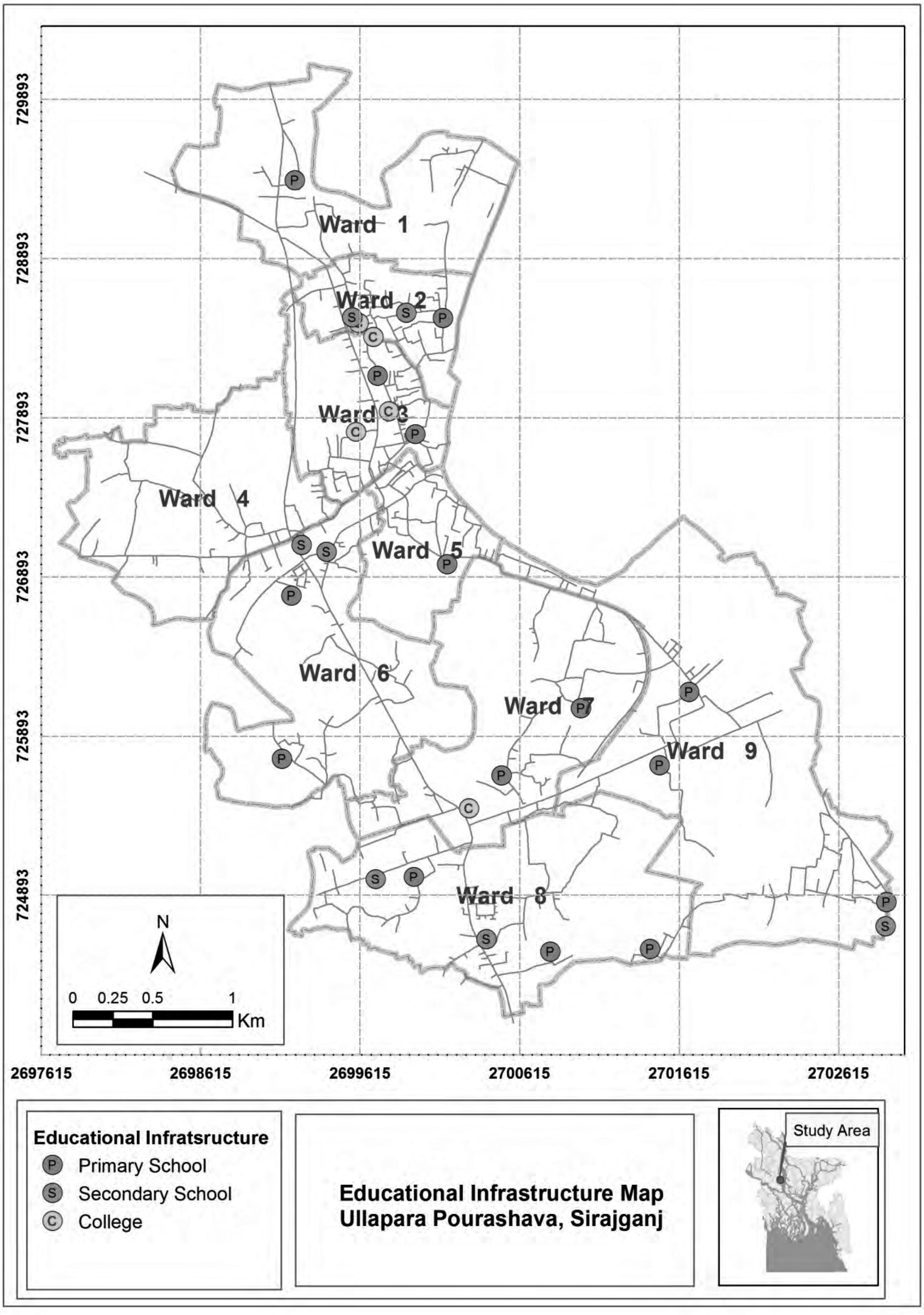
4.6.2 Educational institution

There are different types of educational facilities in Ullapara Pourashava. The Table-4.5 shows the distribution of educational facilities among various wards in the Ullapara Pourashava. From the Table 4.5 it is seen that in ward No.3 and 8 have highest number of education facilities whereas in ward No. 4 and 5 there are little number of educational facility.

Table 4.5: Educational Infrastructure in the Study Area

Ward No	Type of Educational Institution				
	Primary School	High School	College	NGO/Others	Grand Total
1	1	0	0	2	3
2	1	2	1	0	4
3	2	0	3	2	7
4	0	0	0	1	1
5	1	0	0	1	2
6	2	2	0	1	5
7	2	0	1	1	4
8	3	2	0	3	8
9	3	1	0	2	6
Total	15	7	5	13	40

(Source: ACAL, 2012)

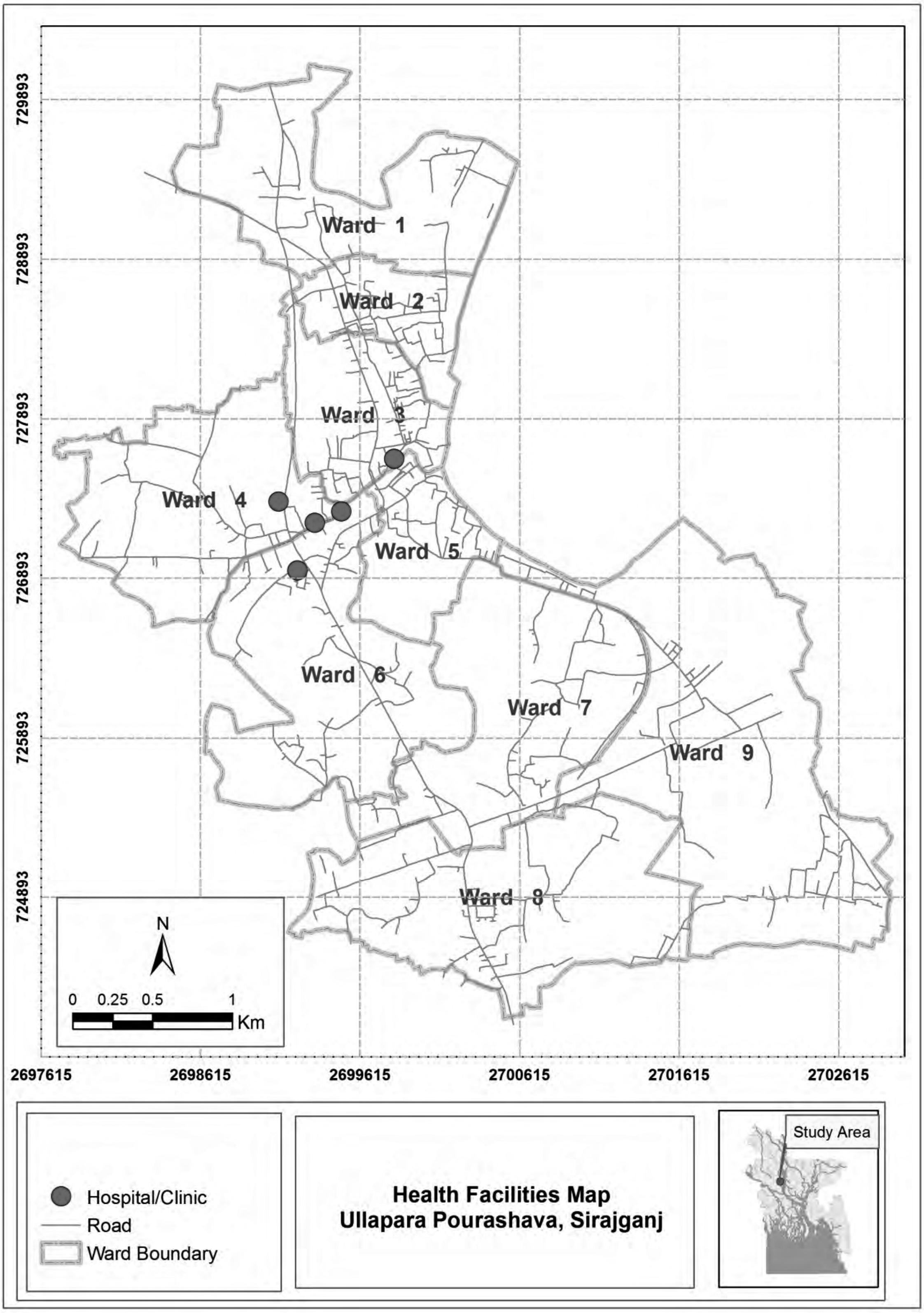


Map 4.6: Educational Infrastructure in the Study Area

Source: Prepared by author; Data collected from IWM, LGED and ACAL

4.6.3 Health facilities in the Ullapara Pourashava

Provision of health facilities is very important to ensure good health of the people. In Ullapara Pourashava limited health facilities are found throughout the area. The Map 4.7 shows health facilities in the study area. From this Map it is seen that there is only one hospital in Ullapara Pourashava which is located in ward 6. Besides, there are only one Union Health and Family Planning Centre and four private clinics. This Map indicates that the people of other wards experience problem due to lack of health facilities. Health facilities should be equally distributed over the area considering the density population. The number of health facilities present in the study area is not sufficient in terms of total population. The number of health facilities should be increased



Map 4.7: Location of Health Infrastructure in Study Area

Source: Prepared by author; Data collected from IWM, LGED and ACAL

4.7 Topographical characteristics

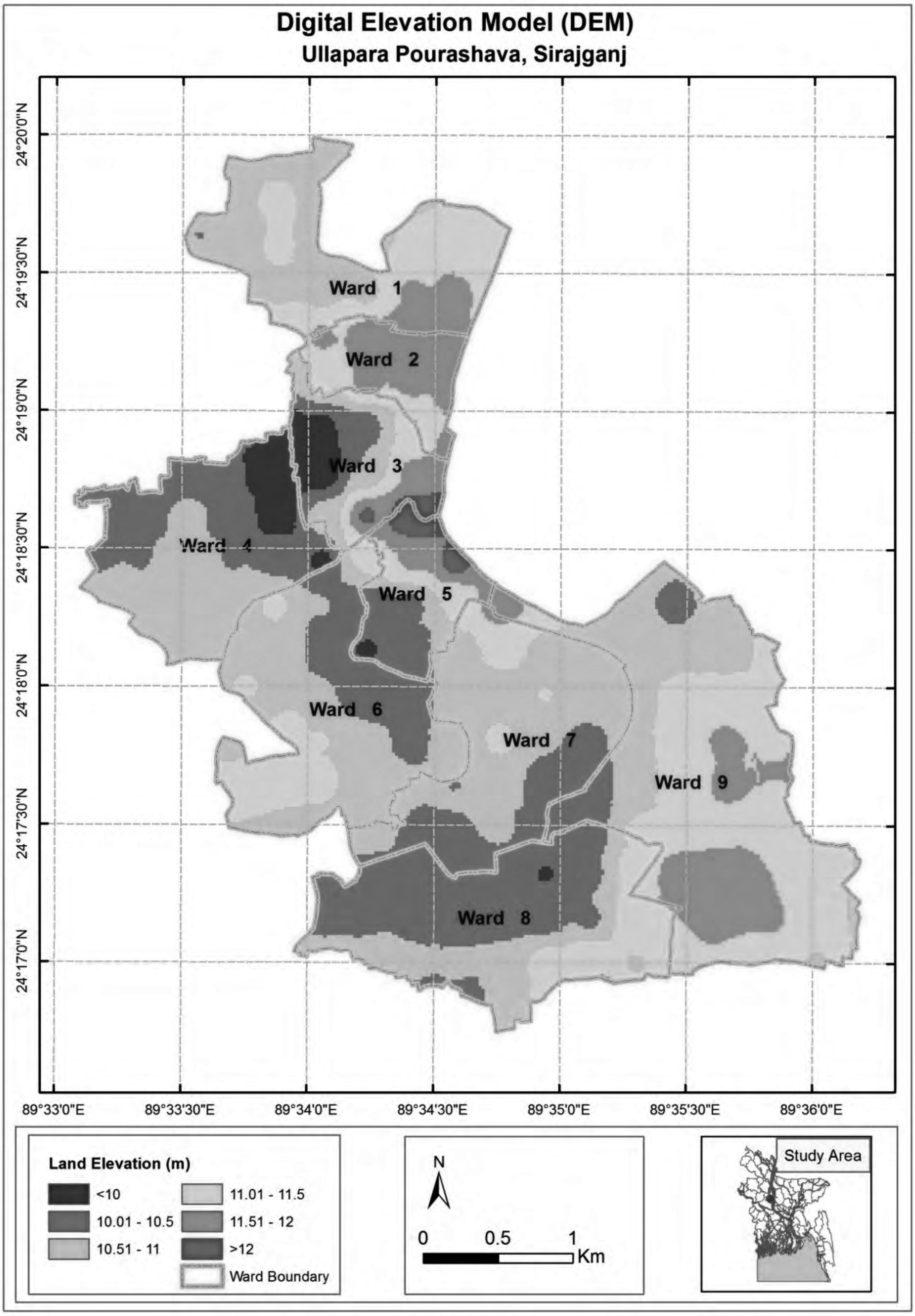
Sirajganj district has some low land and marsh land. The land level of the area varies from 3-4 meter at south to 13-15 meter at north. About 10% area of the Chalan Beel is located in the Tarash Upazila of this District. Total cultivable land is 179,964 hectares, fallow land 15,702 hectares, forestry 50 hectares. 74.34% of the cultivated land is under irrigation facilities either by indigenous local practices or small to medium scale irrigation projects of Bangladesh Water Development Board (BWDB, 1975). Ullapara Pourashava is located in south-western part of Sirajganj District which is relatively low. The following Table 4.6 shows the ward-wise highest, lowest and average land height of Ullapara Pourashava. Average land elevation gives the indication of relative land level of various wards. From the average height given below it seen that ward 1 and 2 are comparatively high land area with average spot levels of 10.11 m and 10.34 m respectively from sea level.

Table 4.6: Summary of Land Level (mPWD) Data of Ullapara Pourashava

Ward No	Lowest Land Level	Highest Land Level	Average Land Level
1	7.41	12.69	10.11
2	0.73	12.33	10.34
3	0.84	15.88	9.96
4	9.03	11.8	9.95
5	2.25	11.79	9.76
6	7.21	11.8	9.57
7	7.56	12.14	9.5
8	-4.66	14.3	9.36
9	-4.96	15.79	7.15
Pourashava	-4.96	15.88	9.52

(Source: ACAL, 2012)

About 82% land of the study area is up to 8.1 to 11m in Ullapara Pourashava. The average land level of Ullapara is 9.52m. From the topographic Map 4.8 it is seen that the middle part of the Pourashava is comparatively higher than other areas. The middle part comprises of parts of ward 2 and 3. From the surface analysis Map it is found that the rive-side portion in ward 9 is much lower compared to other wards.



Map: 4.8: Topographic Map of Study Area

Source: Prepared by author; Data collected from IWM, LGED and ACAL

4.8 Drainage network

In Ullapara Upazila there is a river named Korotoa River. This River passes beside the Pourashava from north to south. The drainage system in the study area is of two types. One is the natural drainage system that has emerged as a natural process following the natural slope of the ground, for the movement of storm run-off. It is observed that most of the rainfall runoff follows the natural landscape through two canals and a number of secondary drains. These canals discharge storm water into the Korotoa River to the eastern side of the Pourashava. The other is the man-made drainage system that is provided by the municipal authority to drain out the domestic wastewater or storm water from the urban area to the river. The Map-4.9 shows the water bodies and drainage network in the study area. The following Table 4.7 shows the drainage coverage and type based on construction pattern. From the Table 4.7 it is seen that all the drains Ullapara Pourashava are *Pucca* and some *katcha* drain. The Table 4.8 shows the status of water bodies in Ullapara Pourashava.

Table 4.7: Ward-wise drainage coverage in Ullapara Pourashava

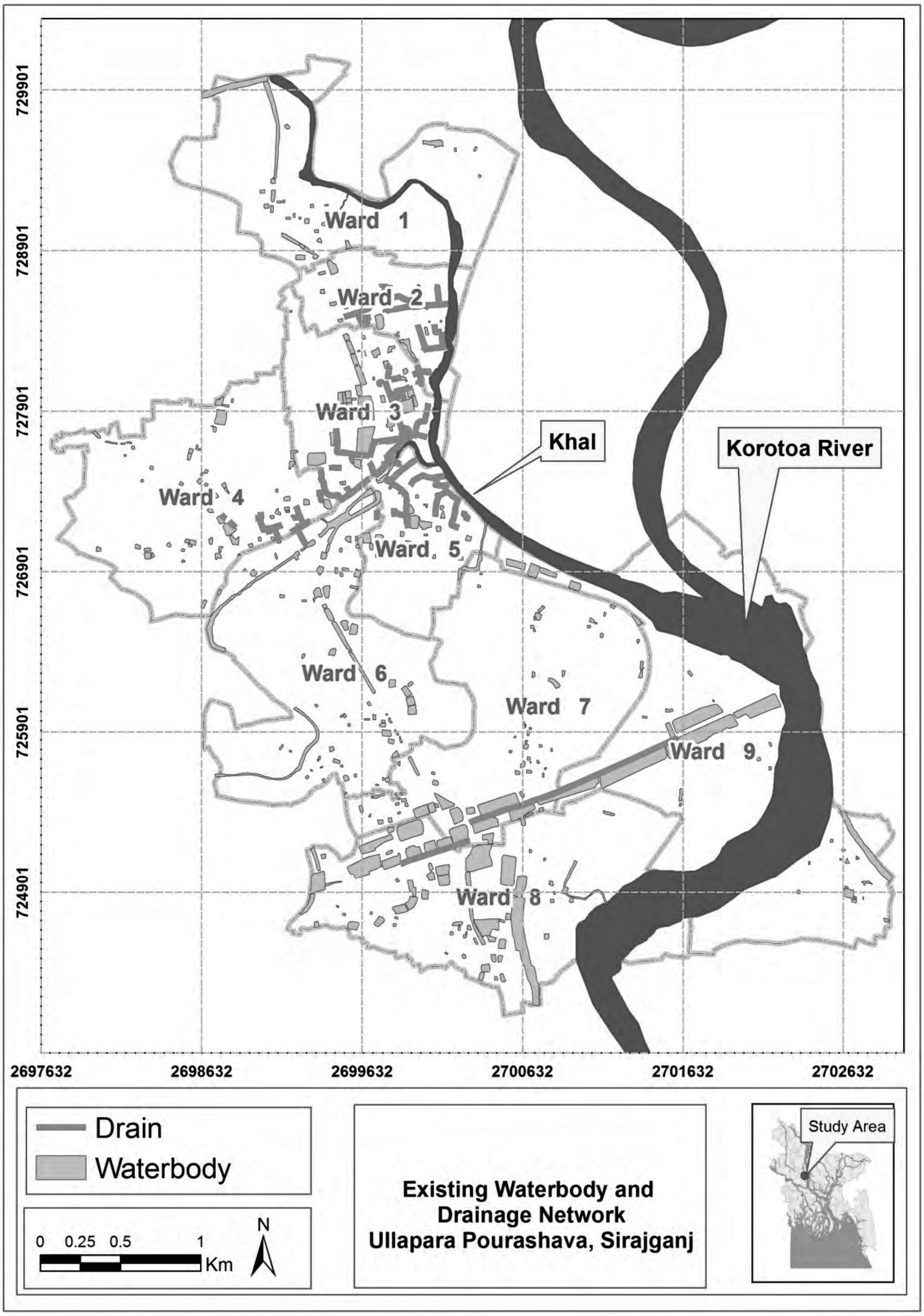
Ward No	**Length(km)**			
	Pucca		Katcha	
	km	**%**	**km**	**%**
1	0.00	0.00	0.00	0.00
2	2.01	18.14	0.00	0.00
3	3.73	33.69	0.00	0.00
4	1.06	9.54	0.00	0.00
5	2.12	19.16	0.00	0.00
6	0.29	2.58	0.00	0.00
7	0.71	6.43	0.00	0.00
8	0.34	3.07	0.00	0.00
9	0.82	7.39	0.00	0.00
Total	**11.06**	100.00	0.00	0.00

Source: (ACAL, 2012)

Table 4.8: Water body in Ullapara Pourashava

Type	Area (acre)
Ditch	89.27
Khal	35.12
Pond	99.05
River	354.94
Total	578.38

Source: (ACAL, 2012)



Map 4.9: Existing water body and drainage network in the Study Area

Source: Prepared by author; Data collected from IWM, LGED and ACAL

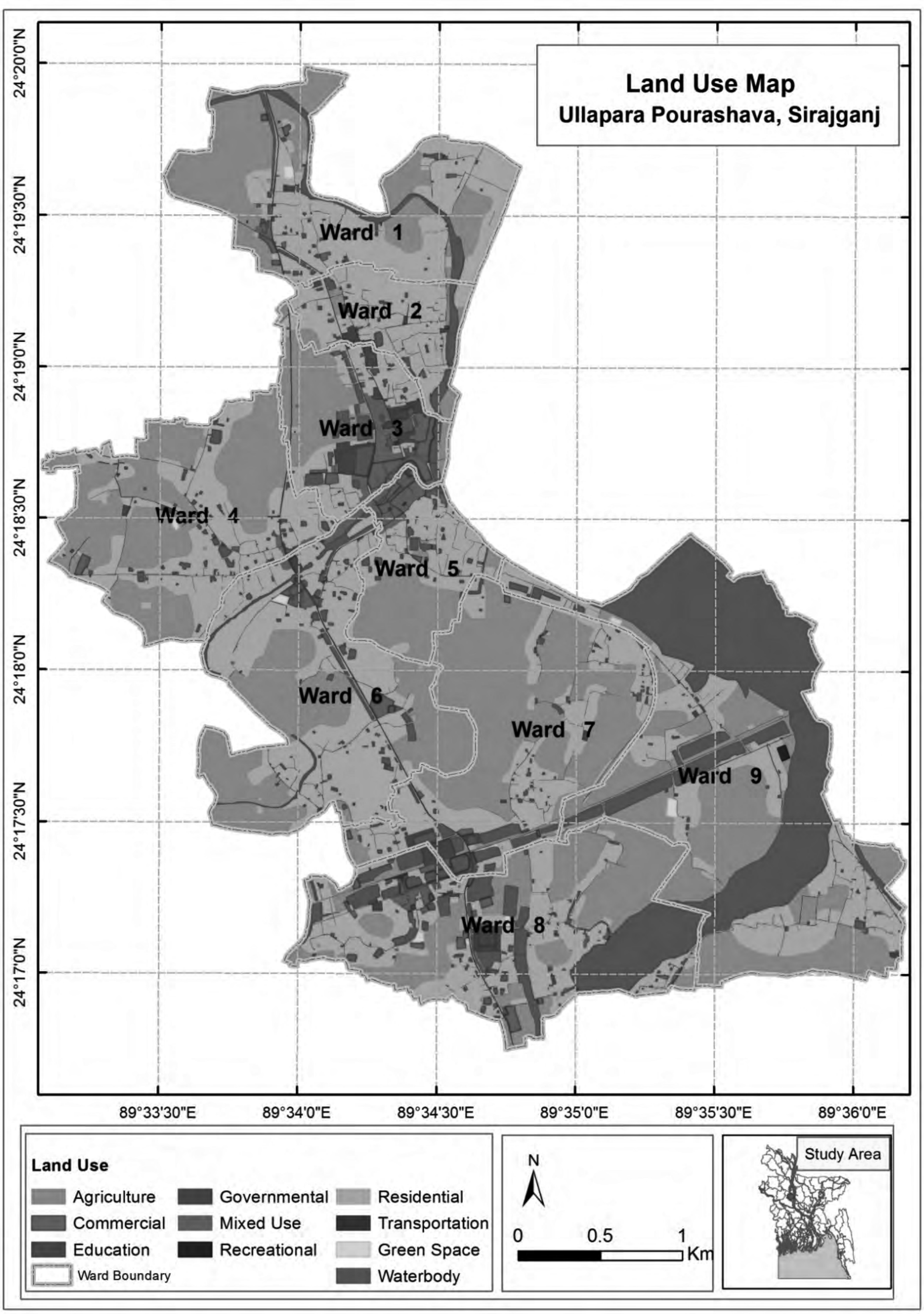
4.9 Landuse

The Table 4.9 shows the generalized landuse category in Ullapara Pourashava. It is evident that agriculture is a dominant landuse. It is found that 40.11% (5.58 sqkm) area is used for agriculture in the entire Pourashava. However, the presence of this use is found in the peripheral area rather than core area. The second dominant land is residential. About 34.85% (4.85 sqkm) land is used for residential purpose. From the landuse Map 4.10 it is seen that ward 3 has lowest proportion of the residential landuse and ward 6 which is inside the core area has highest percentage of residential landuse. Commercial land occupies about 2.3 % of the total land.

Table 4.9: Major Landuse Scenario in Ullapara Pourashava

Land Use Category	Area (Sqkm)	Percentage
Agriculture	5.581	40.11
Commercial Activity	0.321	2.30
Education and Research	0.098	0.70
Governmental Services	0.080	0.57
Mixed Use	0.148	1.06
Recreational Facility	0.005	0.04
Residential	4.849	34.85
Transport and Communication	0.268	1.92
Urban Green Space	0.065	0.47
Waterbody	2.500	17.97

(Source: ACAL, 2012)



Map 4.10: Landuse Map in the Study Area

Source: Prepared by author; Data collected from IWM, LGED and ACAL

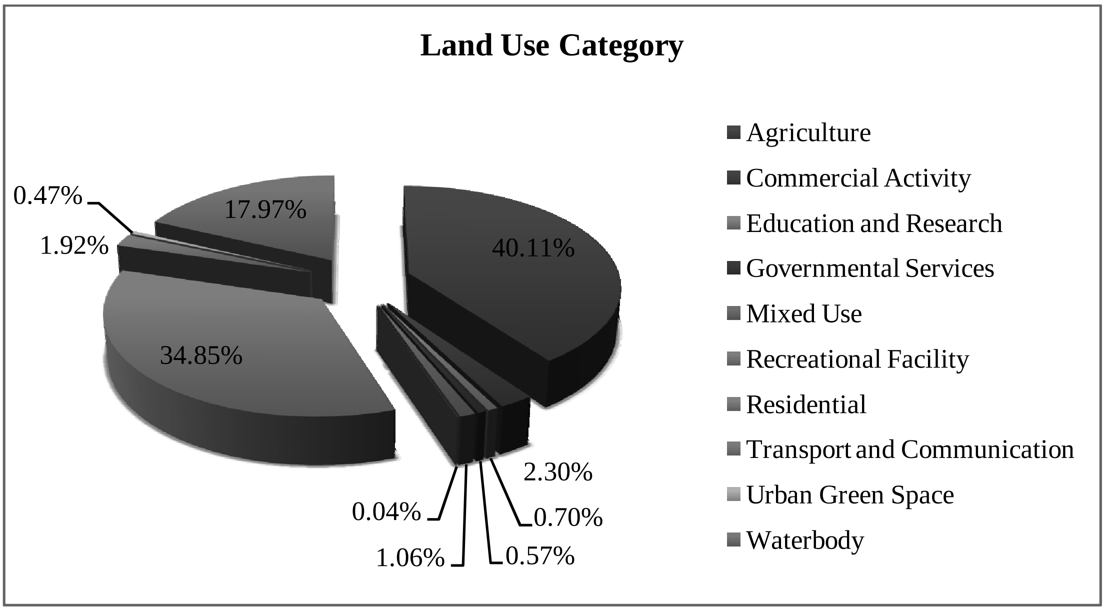


Figure 4.2: Distribution of Major Landuse in Ullapara, Sirajganj

Source: Prepared by the Author, Data collected from ACAL (2012)

4.10 Climate scenario of the study area

Temperature

The climate of the study area is typically tropical; mild winter (October to March); hot, humid summer (March to June); humid, warm rainy monsoon (June to October). The following figures show the temperature, humidity and rainfall characteristics in Ullapara Pourashava. Figure 4.3 shows the monthly temperature pattern in Ullapara Pourashava. From the figure it is seen that temperature increases at highest in the month of April. Throughout the month of April daytime temperatures will generally reach high which is 35°C and at night the average minimum temperature drops down to around 22°C.

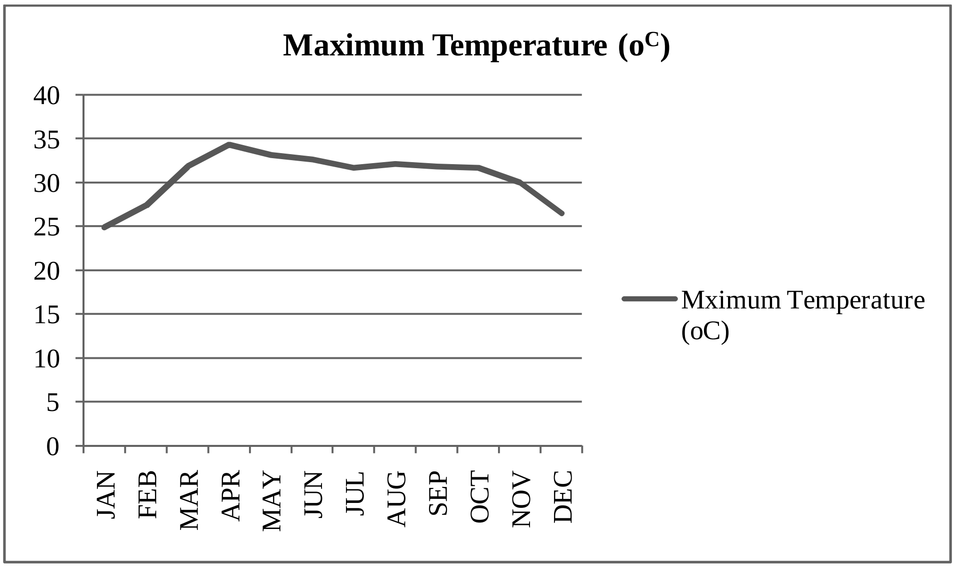


Figure 4.3: Maximum Temperature profile across the month in Ullapara Pourashava, Sirajganj (BMD, 2013)

Humidity

Figure 4.4 shows the monthly humidity pattern in Ullapara Pourashava. From the figure it is seen that humidity increases at highest in the month of September which is 86% and decreases at lowest in the month of March to about 66%.

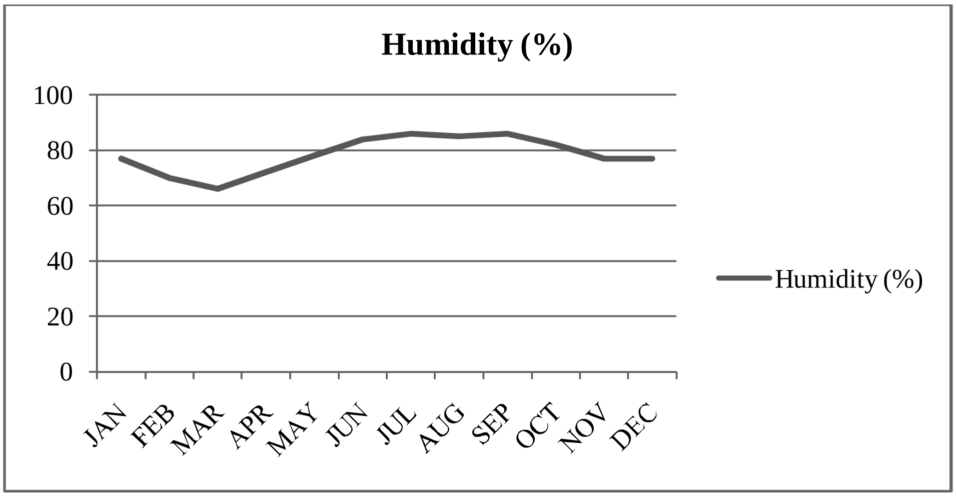


Figure 4.4: Humidity profile across the month in Ullapara Pourashava, Sirajganj (BMD, 2013)

Rainfall

Rainfall in Bangladesh varies from 1527 mm in the west to 4197 mm in the east. The gradient of rainfall from west to east is approximately 7 mm km^{-1}. The rainfall is very much seasonal in Bangladesh, more than 89% of rainfall occurs during May to October. The main mechanism of the rainfall in Bangladesh during the summer monsoon season is caused by tropical depressions known as monsoon depression in the Bay of Bengal (Ahmed and Kim, 2003). Figure 4.5 shows the monthly rainfall pattern in Ullapara Pourashava. From the figure it is seen that rainfall increases at highest in the month of which is 406 mm and decreases at lowest in the month of January to about 8.7 mm.

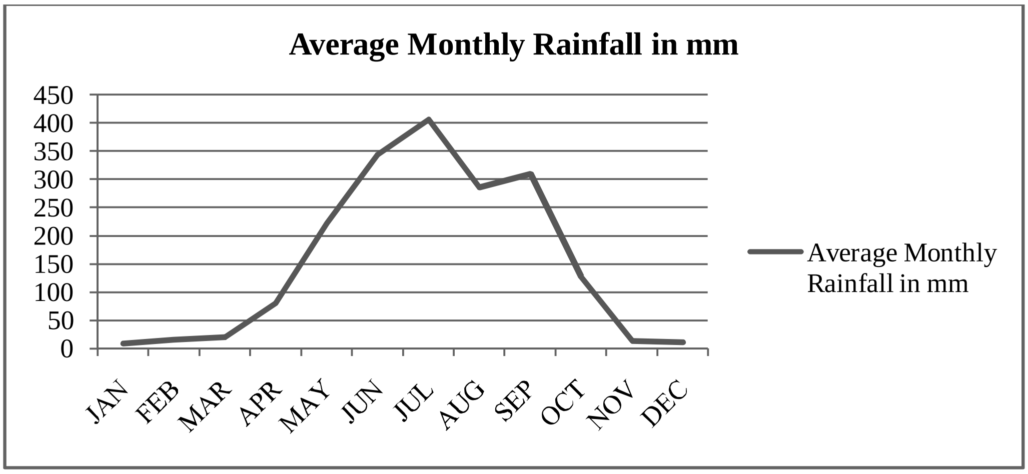


Figure 4.5: Average Monthly Rainfall profile across the month in Ullapara Pourashava. (BMD, 2013)

4.11 Flood scenario in Ullapara

Being located in Sirajganj district, Ullapara Pourashava is one of the most flood prone areas of north Bengal in Bangladesh. The people of this area are vulnerable due to flood as around 35% areas of the district are situated in the Jamuna River Basin. Remarkable increase of water in the Jamuna River started from beginning of July due to heavy rainfall. Ullapara falls under sever and moderate flood prone areas of Bangladesh (Map 2.1). In Ullapara, severe flood occurred in the year 1988, 1998, 2004 and 2007. In 1998, Bangladesh experienced one of the worst floods in terms of severity, destructiveness and duration. Never in the history of flood in Bangladesh, it was so protracted and the sufferings of the people so great. Earth structures such as flood, rail and road embankments, bridge abutments and piers were threatened. The road link with the capital city was disrupted. The two-thirds of the country went under water. Many people left their houses for a shelter. Some lived on embankments and on raised lands under the open sky. Sirajganj was one of the most victims of the flood. Massive infrastructural destruction happened in this flood. The maximum water level during the 1998 flood at Sirajganj was +14.76m PWD. The peak discharge of Jamuna was around 90,000 m3/s (Alam & Zakaria, 2002). According to UNO office and Union Disaster Management Committee, Ullapara, in 2004 flood, the water in the river Jamuna at Sirajgonj point crossed the danger level first on 11th July 2004 and that was 14.81 cm where the danger level is 13.75cm. This flood also crossed the flood 1998. Due to increase of water level and continuous rainfall, those enhanced the flood. About 380,699 families out of about 491,924 and 62 unions out of 82 unions are badly affected in Sirajgonj. Ullapara was one of the most affected areas in that flood. The communication in the area disrupted completely and people forced to leave their houses. All the educational institutions were suspended. A large number of weaving (handloom) factories forced to stop their business especially in Ullapara. The day labourer, van-rickshaw puller and the agricultural labourer had to spend whole the day idle in the sheltered place and were completely jobless. The flood victims were suffering with a miserable condition and were facing sanitation problem, scarcity of safe drinking water, shortage of ready food and fuel, and security. In this flood about 264km road, 38 educational institutions and 25 bridges and 24 Km embankment are damaged (NDP, 2004)

In 2007 flood, the flow at the Jamuna River was 1.20 cm above danger level (13.75cm) that causes severe flood in almost all the areas resulting loss of crops, displacement of households, and lack of opportunity for earning daily income of the poor people due to heavy rainfall and stormy weather. In this flood, around 90% of the homesteads of the District had been submersed by flood water and 40% of the households had left their houses and took shelter at the flood shelters, road sides (MMS, 2007). In this flood about 145km road and 19 bridges are damaged (NDP, 2007). Ullapara is one of the areas to which emergency response had been taken in 2007 flood due to severity (Map 2.1).

Chapter 5: Flood Exposure Analysis and Evaluation of Infrastructure Plan

5.1 Introduction

The first objective of the study is to evaluate the infrastructure plan of Ullapara Pourashava considering climate change induced flood. In this Chapter the infrastructure plan has been evaluated based on flood inundation depth derived through flood exposure analysis. Damage, loss and impact of previous flood have also been discussed. Previous damage, loss and impact scenario has been collected from field level discussion with Pourashava Engineer, Teachers, hospital officials and local people of Ullapara Pourashava. To conduct flood exposure analysis of infrastructure it is first needed to know the exposure level of land. So land exposed to different inundation level has been calculated first. Then subsequent analysis of selected infrastructures has been conducted. This infrastructure includes transport infrastructure (road), educational infrastructure, health infrastructure and some urban facilities.

5.2 Land exposed to flood

The following Table 5.1 shows the ward-wise land exposed to different flood inundation depth in Ullapara Pourashava. From the Table 5.1 it is seen that about 24.61%, 36.57% and 25.80% land will be exposed to 1.0-1.5m, 1.5m-2.0m and 2.0-2.5m inundation due to climate change induced flood in Ullapara Pourashava. This table also indicates most of the land in ward 4, 5, and 8 will be highly exposed to flood. About 45.21%, 33.23% and 54.70% land of these wards will be exposed to 2-2.5m inundation respectively. This high level of exposure indicates that infrastructure in these wards will be significantly vulnerable and need special design and planning considerations to adapt with future climate change induced flood. About 90.14% land of the whole Pourashava would be exposed more than 1m inundation level.

Table-5.1: Ward-wise land to be exposed to climate change induced flood

Ward No	Area (Acre) by different inundation zone												Total Area
	<0.5m		**.5-1.0m**		**1.0-1.5m**		**1.5m-2.0m**		**2.0-2.5m**		**2.5-3.0m**		
	%	Acre	%	Acre	%	Acre	%	Acre	%	Acre	%	Acre	Acre
1	0.00%	0.00	9.89%	35.91	37.51%	136.23	51.59%	187.40	1.01%	3.68	0.00%	0.00	365.80
2	0.00%	0.00	57.17%	78.47	39.66%	54.44	3.18%	4.36	0.00%	0.00	0.00%	0.00	137.56
3	4.04%	8.21	14.13%	28.72	17.14%	34.84	23.44%	47.64	21.16%	43.02	20.10%	40.85	203.57
4	0.00%	0.00	0.00%	0.00	0.00%	0.00	39.75%	151.35	45.21%	172.15	15.05%	57.30	383.20
5	11.37%	18.03	20.20%	32.02	15.61%	24.74	16.02%	25.40	33.23%	52.68	3.56%	5.65	158.76
6	0.00%	0.00	0.00%	0.00	15.89%	74.54	53.42%	250.62	30.44%	142.79	0.25%	1.18	470.42
7	0.00%	0.00	0.63%	2.80	7.95%	35.27	58.90%	261.33	32.52%	144.29	0.00%	0.00	443.74
8	0.00%	0.00	0.20%	1.00	19.44%	98.40	25.00%	126.55	54.70%	276.86	0.66%	3.35	507.94
9	0.00%	0.00	17.39%	132.75	50.37%	384.52	25.93%	197.92	6.31%	48.13	0.00%	0.00	766.41
Total	0.77%	26.23	9.10%	311.68	24.61%	842.99	36.57%	1252.57	25.80%	883.61	3.16%	108.33	3437.40

(Source: Calculated by author, data collected from IWM, LGED, ACAL)

The Map-3.1 in Chapter 3 illustrates how land of different wards in Ullapara Pourashava will be exposed due to future climate change induced flood. In the following sections it has been analyzed how different infrastructure will be exposed to different inundation zone.

Flood inundation duration is one of the key factors to characterize the impact of flood due to climate change. It has been predicted that the duration will be increased in the Jamuna River due to increase of precipitation over the GBM basin. The Table-5.2 shows the status of inundation duration in Sirajganj station.

Table 5.2: Change of flood level and duration due to climate change

Station	Duration of flood		
	Flood Level (m PWD)	Flood Event (Year)	
		2004	2040
Sirajganj	13.75 (Danger Level)	17 days	19 days
	14.5	6 days	10 days
	14.7	3 days	8 days
	15	0 days	3 days

Source: DoE (2008)

It is seen from the Table 5.2 that The duration of flood at its danger level in Sirajganj station (danger level 13.75m PWD as considered by FFWC) will increase from 17 days to 19 days while flood level of 6 days duration (14.5m, PWD) will prolong to 10 days due to climate change in a moderate flood event at Sirajganj in the Jamuna river. So from the above discussion it is clear that inundation duration in Ullapara Pourashava will be increased to a larger extent due to climate change induced flood.

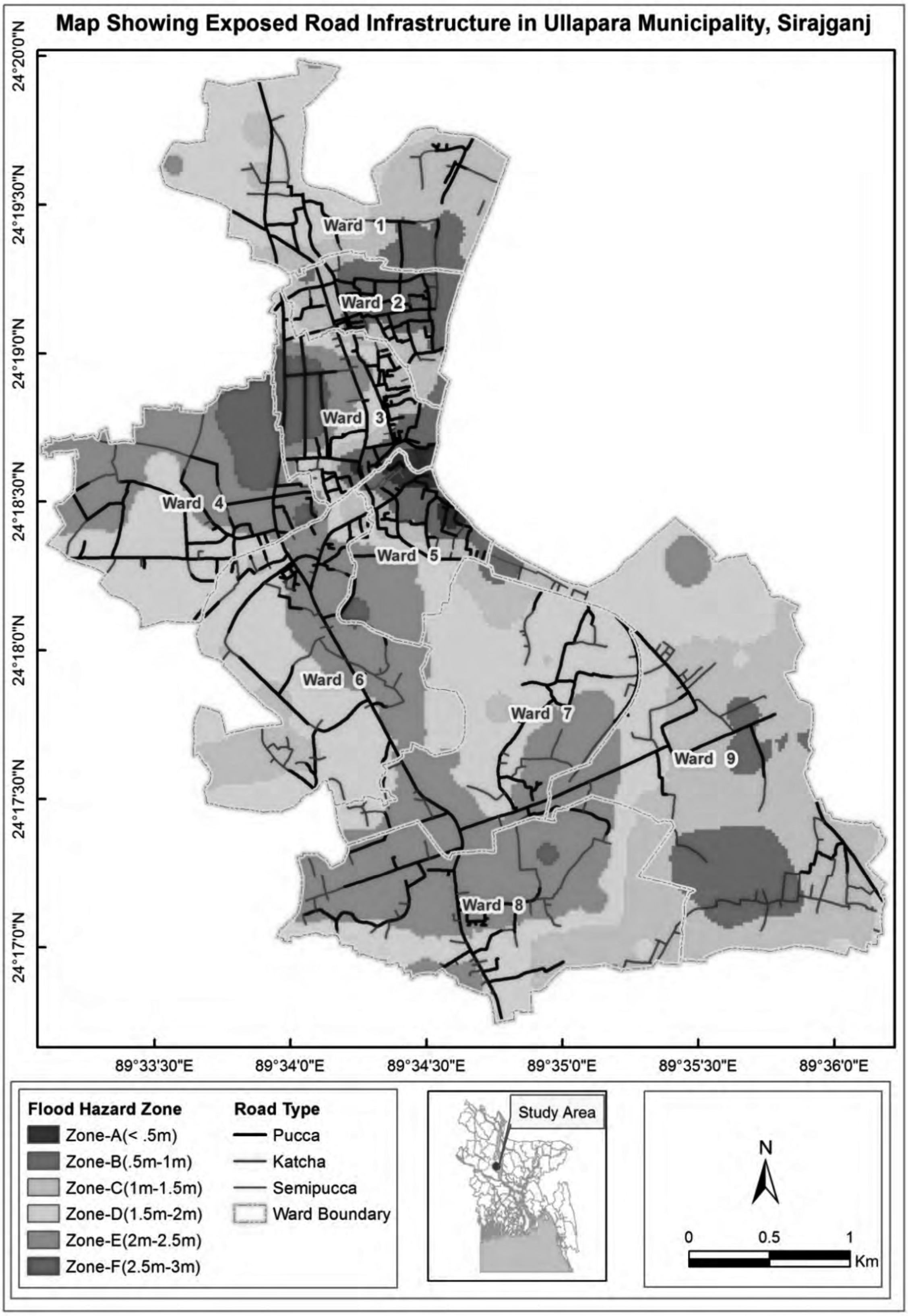
5.3 Transport infrastructure

5.3.1 Road infrastructure

5.3.1.1 Flood exposure analysis

Transport and communication infrastructure is a key element for the economic growth and development. More efficient infrastructure enables a better mobility of people and goods as well as a better connection between regions enhancing economic and social development. The impact of climate change on infrastructure is an important economic, environmental and social issue. A recent study by World Bank finds that about 87% road will be inundated up to 0.5m in the year 2050 due to additional flood inundation to be caused by climate change induced flood in Bangladesh. This study also finds that the cost of adaptation for road infrastructure to offset this additional inundation due to climate change alone is 1958.343 million US$ (WB, 2010b). Thus the provision and development of infrastructure is subject to much analysis and studies.

The Map 5.1 illustrates how road infrastructure is supposed to be exposed due to climate change induced flood in the Ullapara Pourashava. The Map 5.1 shows the distribution of different types of road in Ullapara Pourashava with respect to climate change induced flood inundation depth. From the Map it is observed that most of roads are concentrated in north central part of the Pourashava which falls under ward-2, ward-3 and ward-5. The Map clearly illustrates that the roads in ward-7 and ward-8 will be most exposed and vulnerable to due to climate change induced flood. However, a significant number of roads is subject to different inundation depth.



Map-5.1: Road infrastructure to be exposed to climate change induced flood

Source: Prepared by author; Data collected from IWM, LGED and ACAL

According to Ullapara Pourashava Master Plan there is about 64.36% Pucca and 33.22% Katcha road. The Figure 5.1 shows to what extent road infrastructure will be exposed to climate change induced flood. It illustrates that about 20.41%, 33.99% and 26.35% Pucca road will be exposed to 1-1.5m, 1.5-2m and 2-2.5m inundation respectively. About 28.69%, 28.72% and 29.99% Katcha road will be exposed to 1-1.5m, 1.5-2m and 2-2.5m flood inundation respectively.

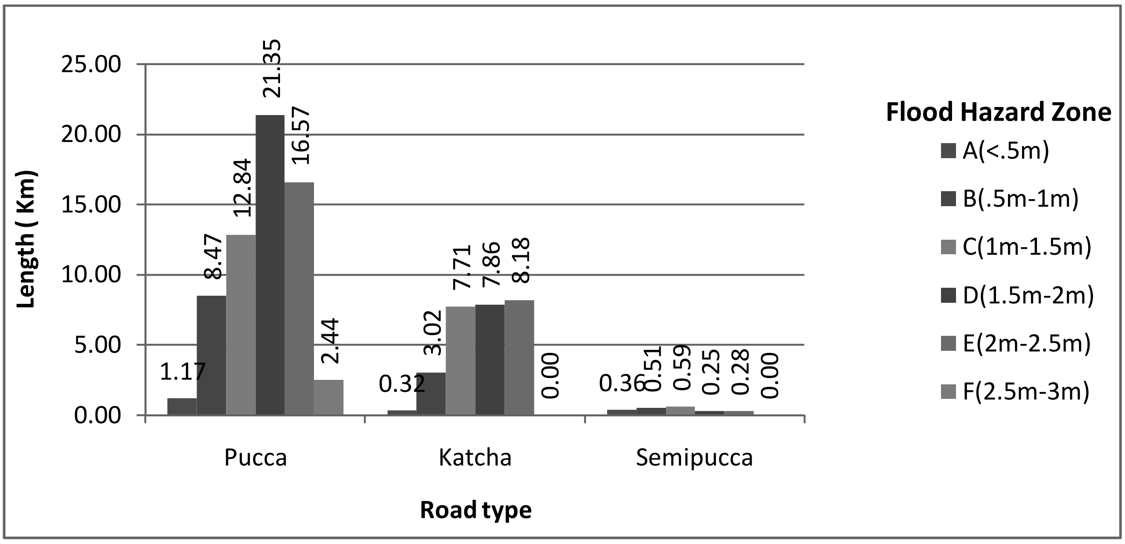


Figure-5.1: Different types of road exposed to flood hazard zone in Ullapara Municipality

(Source: Calculated by author, data collected from IWM, LGED, ACAL)

The Table 5.3 shows a comparative analysis with respect to flood inundation of road among various wards. This table shows that ward-4 and ward-8 are most vulnerable in respect of flood inundation where 52.71 % road of ward-4 and 67.71% road of ward-8 will be exposed to 2-2.5m inundation level due to climate change induced flood. In ward 1, 3, 6 and 7 about 47.50%, 28.64%, 43.11% and 60.82% road will be exposed to 1.5m-2.0m inundation. Overall 23.00%, 32.05% and 27.23% road will be exposed to 1-1.5m, 1.5-2m and 2-2.5m inundation respectively in whole Pourashava indicating about 82.28% road will be exposed to more than 1m flood inundation depth.

Table-5.3: Ward-wise distribution of road with respect to inundation depth

Ward	Road Length (Km) by different inundation zone												Total Length
	<.5m		.5-1.0m		1.0-1.5m		1.5m-2.0m		2.0-2.5m		2.5-3.0m		
	Km	%	Km	%	Km	%	Km	%	Km	%	Km	%	Km
1	0.00	0.00%	0.70	9.04%	3.38	43.45%	3.69	47.50%	0.00	0.00%	0.00	0.00%	7.77
2	0.00	0.00%	4.80	61.57%	2.78	35.72%	0.21	2.71%	0.00	0.00%	0.00	0.00%	7.79
3	0.44	3.68%	1.79	14.96%	3.07	25.73%	3.42	28.64%	1.56	13.07%	1.66	13.92%	11.95
4	0.00	0.00%	0.00	0.00%	0.00	0.00%	4.61	42.86%	5.67	52.71%	0.48	4.44%	10.76
5	1.41	21.58%	1.92	29.36%	1.61	24.66%	0.45	6.90%	0.91	13.85%	0.24	3.65%	6.54
6	0.00	0.00%	0.00	0.00%	2.26	18.08%	5.39	43.11%	4.79	38.32%	0.06	0.49%	12.49
7	0.00	0.00%	0.13	1.28%	0.33	3.21%	6.29	60.82%	3.59	34.69%	0.00	0.00%	10.34
8	0.00	0.00%	0.00	0.00%	1.00	8.81%	2.66	23.48%	7.67	67.71%	0.00	0.00%	11.33
9	0.00	0.00%	2.66	20.55%	6.71	51.84%	2.74	21.14%	0.84	6.47%	0.00	0.00%	12.94
Total	1.85	2.01%	12.00	13.05%	21.14	23.00%	29.46	32.05%	25.03	27.23%	2.44	2.66%	91.93

(Source: Calculated by author, data collected from IWM, LGED, ACAL)

5.3.1.2 Past experience of flood: damage and loss

It has been discussed with the Pourashava Engineers and some local peoples to know the past experience of flood. It has been found from the discussion that in Ullapara Pourashava there were devastating floods in 1988, 1998, 2004 and 2007. In 2012 and 2014 there were floods above normal flood situation but less than 2007 flood. It was reported by the local people that in 2007, the intensity of the flood submerged the homestead and dwelling creating people homeless, extinction of Kacha and semi-Pucca dwelling by huge overflowing, damaged of agricultural crops, spoil of roads and infrastructure, and overall public lives become endangered. According to the Executive engineer of Ullapara Pourashava, in 2007 flood, all roads except Pabna-Ullapara-Sirajganj road were submerged for more than one month. Only the Pabna-Ullapara-Sirajganj road was not submerged in the flood. The submergence of roads for longer period along with heavy water flow caused to damage of the road. The following tables (Table-5.4, Table-5.5, and Table-5.6) show the damage of roads and associated repairing cost due to inundation of 2007 flood. According to Ullapara Pourashava about 12.7km pucca road was severely damaged while about 24.8 km pucca road and about 8.2km katcha road was partially damaged in 2007 flood (Table-5.4, Table-5.5, and Table-5.6).

Table 5.4: List of severely damaged pucca roads in 2007 flood and corresponding rehabilitation cost Llakh Tk)

SL No	Road Name	Length (Km)	Cost (Lakh Tk)
1	Ullapara-Sirajganj Road (Ch. 4860m-5860m)	1	48.5263
2	Shaymoli Moddhopara Jame Mosque Road (Ch. 3532m-4532m)	1	34.2563
3	Pourashava Road (Ch. 658m-1358m)	0.7	31.2563
4	Newargacha-Enayetpur Road (Ch. 859m-2359m)	1.5	56.3562
5	Nayanpur Jame Mosque Road (Ch. 2489m-3989m)	1.5	49.5632
6	Purbopara Madrasa Road (Ch. 1289m-2589m)	1.3	42.6523
7	Land Office Road (Ch. 1371m-2871m)	1.5	52.3256
8	Jhikra-Baraia Road (Ch. 1568m-2568m)	1	35.2145
9	Goshganti-Enayetpur Road (Ch. 2684m-3684m)	1	31.0125
10	Bhatta Kauak-Jhikra Road (Ch. 5146m-5846m)	0.7	26.2314
11	Bhatta Kauak-Enayetpur Road (Ch. 2596 m-4096m)	1.5	51.2356
Total		**12.7**	**458.6302 (= 4.59 crore)**

(Source: Ullapara Pourashava, 2014)

The Executive Engineer told that the severely damaged pucca roads were reconstructed by LGED which costs about 4.59 crore BDT (Table 5.4). The reconstruction project was financially supported by World Bank through "Emergency 2007 Flood Restoration and Recovery Assistance Program (FRRAP)" (WB, 2007). He also added that partially damaged roads were repaired by GOs and NGOs through various programmes including Test Relief (TR), KABIKHA (Food for Work), KABITA (Money for Work) programme. In addition to GO's programmes there were various NGO's programmes for the repairing of the roads. National Development Programme (NDP), ASA, Muslim Aid, BRAC, TMSS, CARE etc NGOs took several progammes for the repairing of the partially damaged roads. According to the Pourashava the repairing cost of the partially damaged pucca and katcha road were about 3.07 crore BDT (Table 5.5) and about 73.9 Lakh BDT (Table-5.6) respectively. The flood of 2014 was less severe compared to 2007 and about 3 km pucca road and 4 km Katcha was damaged in the 2014 flood. Repairing is on progress of those roads.

Table 5.5: List of partially damaged pucca roads in 2007 flood and corresponding repairing cost (Lakh Tk)

SL No	Location and Name of Road	Damage length (Km)	Cost (Lakh Tk)
1	Ward No.8, Chakidoho bridge to Neorgasa cold storege	1.2	14.52
2	Ward No.5, Ghoshgati Tetul Alom's house to Ghatina	1.5	16.35
3	Ward No.6, Sreekola turn to turn of Kaowak Three head.	1	12.23
4	Ward No.2, Old Bus-stand to house of Shumod commissioner at Sreekola	0.8	10.25
5	Ward No.2, Science college more to house of Aowlia commissioner	1.6	18.56
6	Ward No.2, Sreekola more to Chakidoho bridge	1	12.35
7	Ward No.2, Sreekola more to house of Gazi Abdul Hakim	1	13.25
8	Ward No.2, House of Aowlia comissionar to turn of Pourashava	1	11.28
9	Ward No.2, Turn of police station to Jhikra Kalibari	1.5	19.25
10	Ward No.5, turn of police station to Ghoshgati bridge	1	13.50
11	Ward No.3, Police station more to Gas line	1.5	19.50
12	Ward No.6, Badulla Pramanik's house to Aroj Pramanik house	1	12.50
13	Ward No.6, Nabogram to house of Siddik BDR	1.6	18.65
14	Ward No.6, Vottrokawoak to Aman Fewvia to Sili	1.2	14.35
15	Ward No.9, Railgate to Char Gahtina	1.1	13.25
16	Ward No.9, Railgate to Inatpur Heli-pad	2.4	26.55
17	Ward No.9, Ullapara rail station to Chanpur	1.5	19.23
18	Ward No.9, Gurden of Simky Imam to house of Hiru Miya	0.5	7.50
19	Ward No.6, Station Godaun to house of Nakkor master	0.6	8.60
20	Ward No.7, Shibpur school to house of Mohir commissioner	0.8	10.50
21	Ward No.5, Ghoshgti Kalanattro to Kamar Dokkin para	0.5	7.00
22	Ward No.4, Ullapara Mohila Madrasha to Mohonpur road	0.5	8.00
Total		**24.8**	**307.17 (=3.07 crore)**

(Source: Ullapara Pourashava, 2014)

It was found from the discussion with the Pourashava Engineer and local people that the total communication system of Ullapara Pourashava was disrupted due to the inundation and damage of road. Due to the inundation of road, students could not attend in the school. Even in 2014 flood five primary schools, two secondary schools and two colleges were not inundated nevertheless those institutions were remained close for about one month as the road was inundated. There was no alternative means of communications. Similarly the disruption of communication system affect the many patients to access the health facilities although health facilities were not inundated in 2014 flood. This situation was more complicated for women as told by an official of Ullapara health complex. Even in 2007 flood some poor pregnant women could not reach to the clinic for delivery due to the collapse of communication system. They had to deliver at their homes in unhealthy condition and without necessary delivery support. It was reported by an official of Ullapara Upazila health complex that one poor expectant was died while delivering at her home during 2014 flood. Due to the inundation of road the economic system was also hampered. A businessman in the locality told that during the flood their business dealings were reduced. He noticed that his profit was reduced by 50% during flood period. This scenario is also for other business men. According to his statement inundation of road is one of the main reasons for the reduction of business dealings of whole Hat/Bazars because people could not go to the Hat/Bazar due to the unavailability of communications. On the other hand business men could not bring sufficient goods in the Hat/Bazar. Thus inundation of roads hampers the total socio-economic system of Ullapara Pourashava. Due to inundation of road, about 17,251 students (total number of students for Primary school, secondary school and college) were in problems to access the educational institutions (please see Table-11, Table12 and Table-13); about 26,550 patients (considering average number of daily patients in respective hospital/clinics and 45 days inundation in 2007 flood, please see Table-18) were in problem to access the health facilities; about 18,180 business men were in trouble with their business; about 472 Rickshaw pullers and about 152 Auto-rickshaw drivers; about 85 CNG drivers were workless (These numbers have been calculated from the occupation pattern from the Ullapara Pourashava Master Plan report).

Table 5.6: List of partially damaged katcha roads in 2007 flood and corresponding repairing cost (Lakh Tk)

SL No	Location and Name of Road	Damage length (Km)	Cost (Lakh Tk)
1	Ward No.2, house of Khokon comissionar to primary school	0.5	5.5
2	Ward No.1, Baroyea school to burial-ground	0.5	6.0
3	Ward No.6, Kawoak -nill to Vottro-kawoak	1	8.5
4	Ward No.9, House of Monira comissionar to Abbus house	1.2	10.5
5	Ward No.9, JS filling station to near the river side	1	8.4
6	Ward No.4, Ullapara eidgah to Bakhua three head	0.5	5.6
7	Ward No.7, Shibpur-dala to Jwel house	1	8.6
8	Ward No.8, Neoirgasa cold storage to near the river side	0.5	4.8
9	Ward No.3, PurboChairman's house	1	8.5
10	Ward No.6, Kakon's house to Khalia para Arif's house	1	7.5
Total		**8.2**	**73.9**

(Source: Ullapara Pourashava, 2014)

5.3.1.3 Evaluation of road infrastructure

In urban areas, roads generally comprise the most important part of the transport infrastructure system. Access to roads by people depends chiefly on the availability of roads, their condition, design and the means by which people can reach them and travel on them (Matthias, 2003). Transport and communications infrastructure as a means of access to basic services, residence, workplace, and other urban facilities is the key factor to accelerate economic growth and sustainable development. So provision and development of road infrastructure should be well planned with long term vision keeping in mind possible future threat that may be harmful to these infrastructures (UN-HABITAT, 2010). If road infrastructure does not perform its function properly economic growth and development will be hampered. Several studies carried out in different counties show that future climate change will negatively affect the road infrastructure through increased precipitation, increased temperature and other weather events. The intensity of such impact will be higher in developing countries (Paul et al, 2012; WB, 2010a; AUSTROADS, 2004).

Flood exposure analysis of road infrastructure of Ullapara Pourashava has been conducted previously. At present the total road length in Ullapara Pourashava is about 84.51 km. In newly proposed master plan only 16.39km additional road has been proposed. In this plan it recommended and emphasize has been given to widen the road width to meet the increasing demand of transport facilities. The section 5.3.1.1 discusses, in detail, what would be the inundation scenario of road infrastructure of Ullapara Pourashava in future climate change induced flood. This inundation scenario indicates that most of the road will be exposed in future climate change induced flood which will result in disruption of communication during flood and even after flood due to damage of roads. Previously at the end of section 5.3.1.1 it was discussed the damage and impact of road inundation in 2007 flood. Detail damage and loss has been presented in Table-4, Table-5, and Table-6. That discussion makes it clear that there was huge loss and impact of road inundation in 2007 flood. In future the inundation scenario will be increased and road infrastructure would be highly exposed due to climate change induced flood. This exposure to flooding will shorten the life expectancy of roads in Ullapara

Pourashava. The stress of water may cause damage, requiring frequent maintenance, repairs, and rebuilding. High level of exposure of and damage to road infrastructure in Ullapara Pourashava will causes long-term impacts, such as disruptions to clean water (in case of piped water supply), electricity connection, gas connection, access to education and health care and other basic urban services. In this area, due to inundation and damage of road infrastructure, communication will be disrupted and economic activities will come to a standstill, resulting in dislocation and the dysfunction of normal life for a period much beyond the duration of the flooding. Student will not be able to attend the educational institution for long duration which may lead to dropout from the school; patient may find it difficult to access health care facilities which may cause to increase intensity of disease or death. Business people will find it difficult to access their workplace leading to lessen their income.

In Ullapara Pourashava master plan there is proposal of road network system including existing road with intervention of new road construction, road widening and indication of surface type. In this plan, there is no consideration of future climate change induced flood and thus there is no indication and/or guideline of road height and construction material which is a major concern of climate proofing infrastructure planning. So it is clear from the above discussion that existing and proposed road system in Ullapara Pourashava will not suffice to maintain smooth communication during climate change induced flood in this area rather the severity will be increased in 2040 compared to 2007 flood.

5.3.2 Terminal facilities:

5.3.2.1 Flood exposure analysis

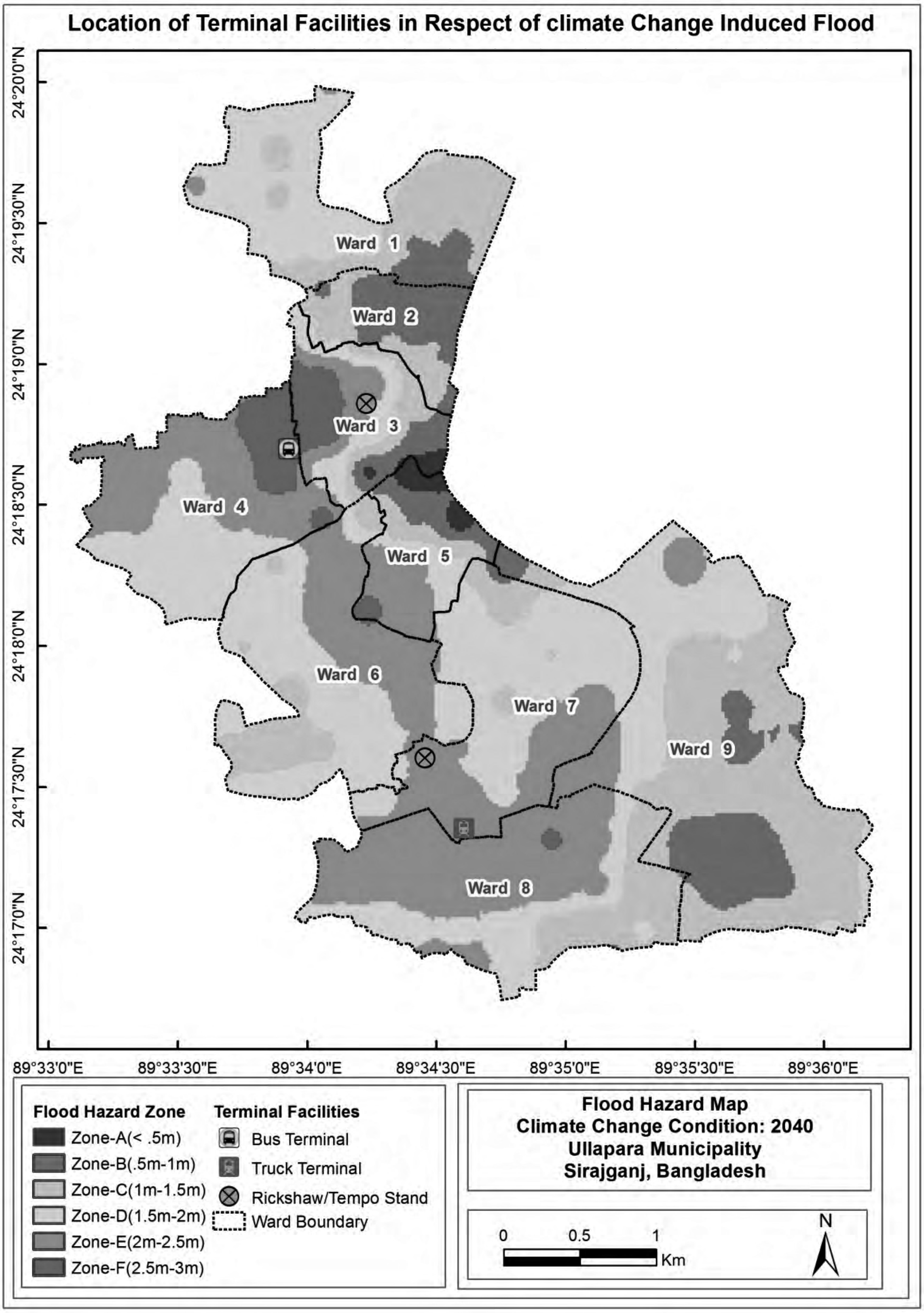
At present there are no bus or truck terminal facilities and even there is no designated place for tempo or rickshaw stand in Ullapara Pourashava. But in Ullapara Pourashava Master Plan one bus terminal, one truck terminal and two Tempo and/or Rickshaw Stand have been proposed. No other terminals have been proposed. Bus terminal has been proposed in ward no-4 and truck terminal has been proposed in ward no-7. The following Table 5.7 shows the flood exposure result of terminal facilities in Ullapara Pourashava. The Table-5.7 states that if the terminals are constructed without any height enhancement then the bus terminal will be exposed to 2.5-3.0m inundation level, truck terminal and Tempo/Rickshaw stand will be exposed to 2.0-2.5m inundation level due to climate change induced flood in Ullapara Pourashava.

Table-5.7 Number of terminal facilities to be exposed to different inundation depth

Transport facilities	Inundation depth		Ward No
	2.0-2.5m	2.5-3.0m	
Bus terminal		1	4
Truck terminal	1		7
Tempo/Rickshaw Stand	2		3, 7

(Source: Calculated by author, data collected from IWM, LGED, ACAL)

The Map-5.2 illustrates how terminal facilities in Ullapara Pourashava will be exposed to future flood.



Map-5.2: Location of terminal facilities in respect of climate change induced flood

Source: Prepared by author; Data collected from IWM, LGED and ACAL

5.3.2.2 Evaluation of terminal facilities:

Bus stations and terminals are a significant element in the operation of bus services. Their design and location affect the efficiency of a transport system, and its impact on other road users. At present there is no Bus terminal, truck terminal and tempo/rickshaw stand. In recently prepared master plan, one bus terminal, one truck terminal and two tempo/rickshaw stand have been proposed. Bus terminal and truck terminal has been proposed in ward-4 and in ward-7 respectively. Tempo/rickshaw stands have been proposed in ward-3 and ward-7. The location of the proposed terminals is low land and thus falls under most flood hazard zone. Truck terminal and tempo/rickshaw stands fall under Zone-E and Bus terminal fall under Zone-F. The flood exposure analysis of terminal facilities shows that the bus terminal will be exposed to 2.50m-3.0m inundation level; and truck terminal and tempo/rickshaw will be exposed to 2.0m-2.5m inundation level due to climate change induced flood in Ullapara Pourashava. If these terminal are inundated during flood for long time the total communication system will be disrupted which will affect both economy and employee engaged in transport sector. In Ullapara Master Plan there is no consideration of climate change induced flood in planning for terminal facilities. Terminal facilities have been proposed just on ad-hoc basis. From the Map-5.2 it is clear that the terminals facilities will be highly exposed to climate change induced flood and thus the proposed terminal facilities will not be able to serve during flood.

5.4 Educational infrastructure

Educational infrastructure is considered as one of the critical facilities that are supposed to be heavily affected by climate change induced flood in developing countries. In Bangladesh, there are already evidences of negative impact flood on educational infrastructure (Das, 2010). The severity of this negative impact would be increased in more flood prone areas. In Ullapara Pourashava there are different types of educational institutions out of which Primary School, Secondary School and College have been considered for flood exposure analysis. According to the Ullapara Pourashava Master Plan there will be about 18 Primary School, 11 Secondary School and 8 colleges in the year 2031. The following section discusses the flood exposure of the educational infrastructure in Ullapara Pourashava.

5.4.1 Flood exposure analysis

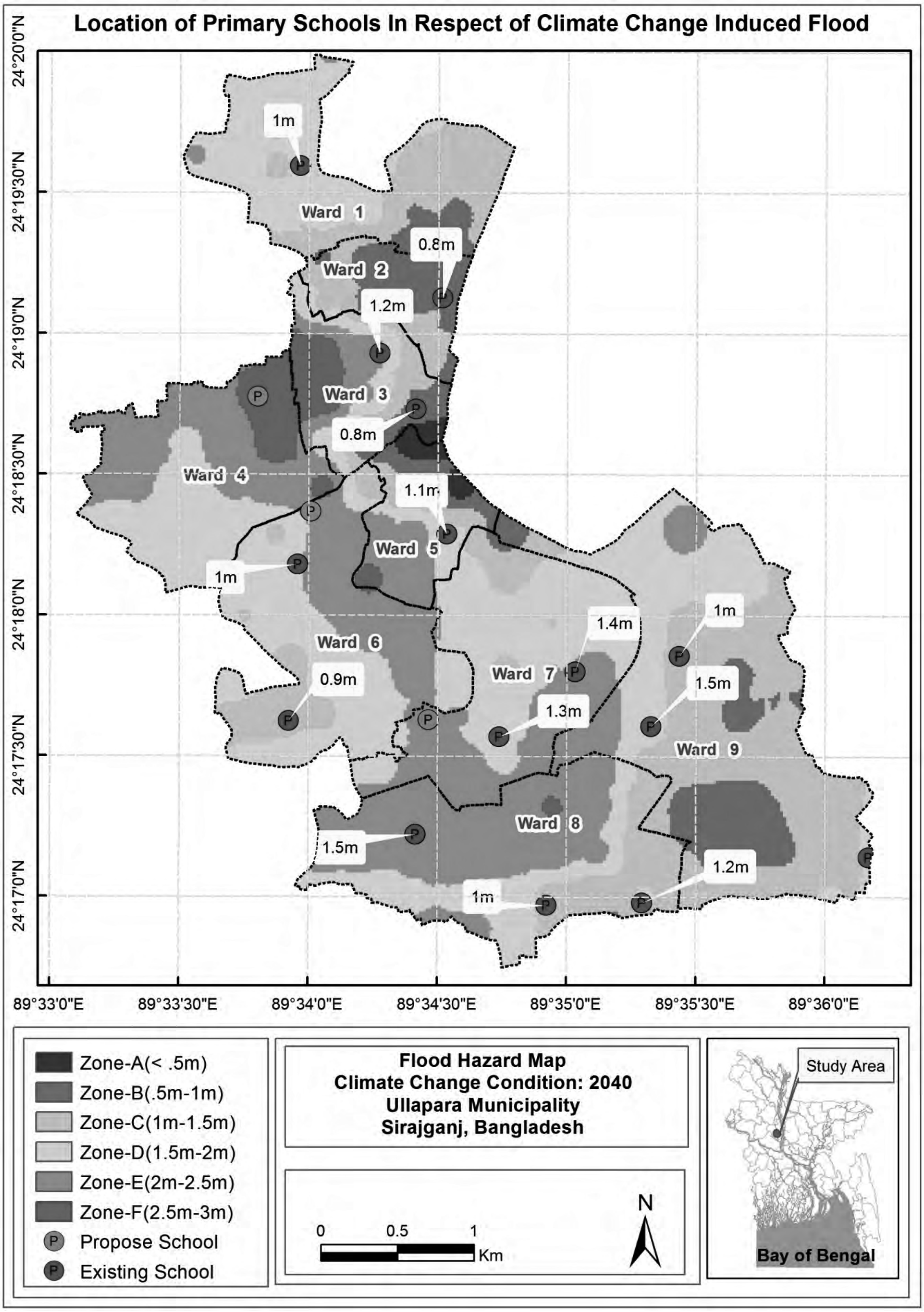
5.4.1.1 Primary school

As per proposed master plan in Ullapara Pourashava, there will be total 18 primary schools in the year 2031. The proposed distribution of primary school with respect to future flood inundation scenario has been presented in the Map-5.3 which illustrates how primary school will be inundated in future climate change scenario in the study area. The Table-5.8 shows that 2 primary schools will be exposed to 0.5m to 1.0m inundation depth, 3 will be exposed to 1.0m to 1.5m inundation, 7 will be exposed to 1.5m to 2.0m inundation and 6 will be exposed to more than 2m inundation. The table also indicates that level of flood exposure of primary school in ward-6 7, 8 and 9 are higher. Total three primary schools will be exposed in each of these wards and they are most vulnerable to climate change induced flood in terms of flood exposure of primary school. The Table-5.8 suggests that highest percentage of primary school (38.89%) will be exposed to about 1.5m-2.0m inundation due to climate change induced flood in Ullapara Pourashava.

Table-5.8: Number of primary school to be exposed by climate change induced flood

Ward	Flood Inundation depth						Total
	<0.5m	.5-1.0m	1.0-1.5m	1.5m-2.0m	2.0-2.5m	2.5-3.0m	
1	0	0	0	1	0	0	1
2	0	1	0	0	0	0	1
3	0	1	0	0	1	0	2
4	0	0	0	0	0	1	1
5	0	0	0	1	0	0	1
6	0	0	1	1	1	0	3
7	0	0	0	1	2	0	3
8	0	0	1	1	1	0	3
9	0	0	1	2	0	0	3
Total	0	2	3	7	5	1	18
	0.00%	11.11%	16.67%	38.89%	27.78%	5.56%	100.00%

(Source: Calculated by author, data collected from IWM, LGED, ACAL)



Map-5.3: Location of primary schools in respect of climate change induced flood

Source: Prepared by author; Data collected from IWM, LGED and ACAL

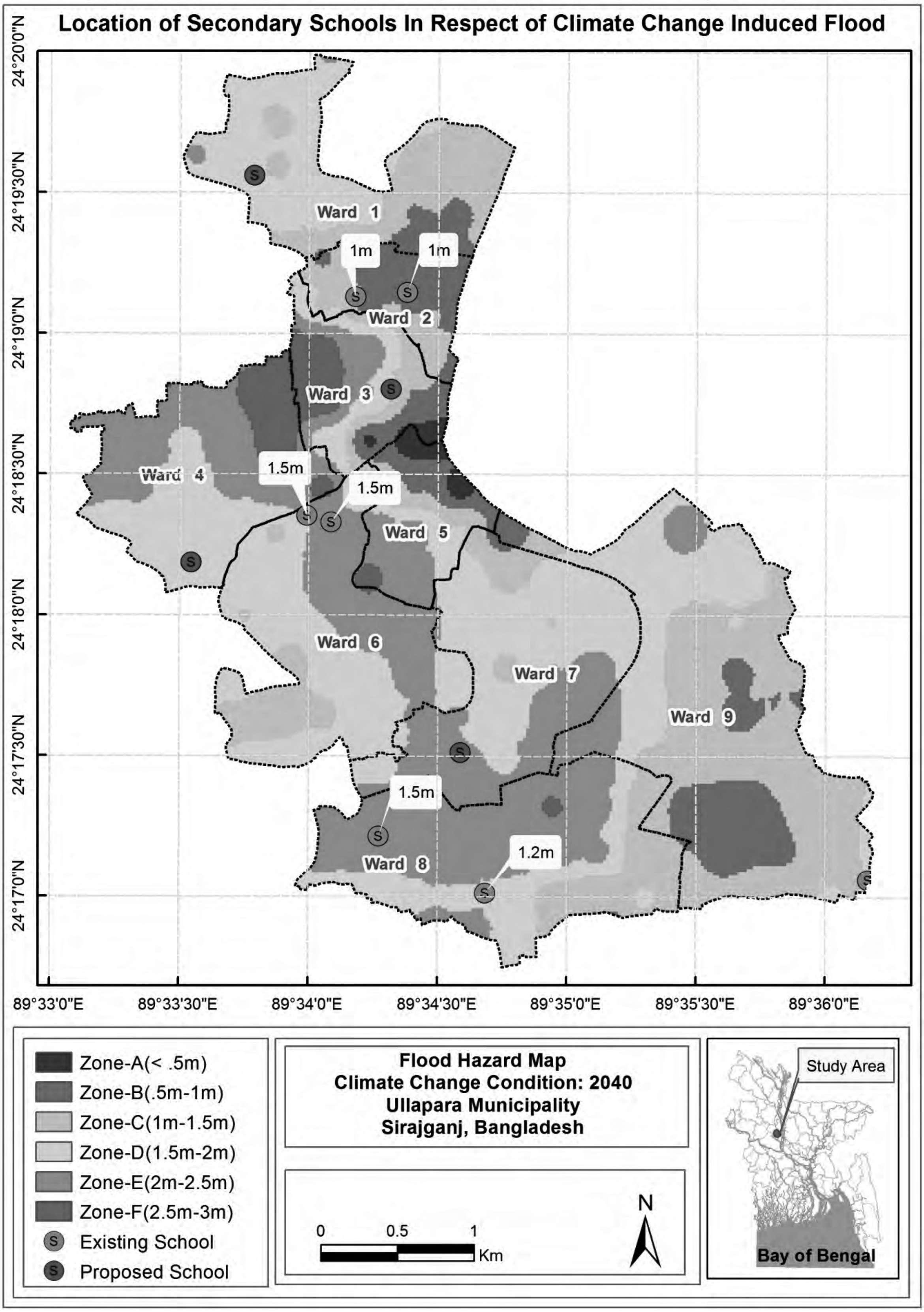
5.4.1.2 Secondary school

According to master plan of Ullapara Pourashava, there will be total 11 secondary schools in the year 2031. The proposed distribution of primary school with respect to future flood inundation scenario has been presented in the Map-5.4 which illustrates how secondary school will be inundated in future climate change scenario in the study area. The Table-5.9 shows that 9.09%, 54.55% and 36.36% secondary school will be exposed to 1.0m to 1.5m, 1.5m to 2.0m and 2.0 to 2.5m inundation depth due to climate change induced flood. The Table-5.9 also indicates that level of flood exposure of secondary school in ward-2 and ward-6 are higher compared to other wards. In these wards, total 3 secondary schools will be exposed to flood in each.

Table-5.9: Number of high school to be exposed by climate change induced flood

Ward	Flood Inundation depth						Total
	<0.5m	**.5-1.0m**	**1.0-1.5m**	**1.5m-2.0m**	**2.0-2.5m**	**2.5-3.0m**	
1	0	0	0	1	0	0	1
2	0	0	1	1	0	0	2
3	0	0	0	1	0	0	1
4	0	0	0	1	0	0	1
5	0	0	0	0	0	0	0
6	0	0	0	0	2	0	2
7	0	0	0	0	1	0	1
8	0	0	0	1	1	0	2
9	0	0	0	1	0	0	1
Total	0	0	1	6	4	0	11
	0.00%	0.00%	9.09%	54.55%	36.36%	0.00%	100.00%

(Source: Calculated by author, data collected from IWM, LGED, ACAL)



Map-5.4: Location of secondary schools in respect of climate change induced flood

Source: Prepared by author; Data collected from IWM, LGED and ACAL

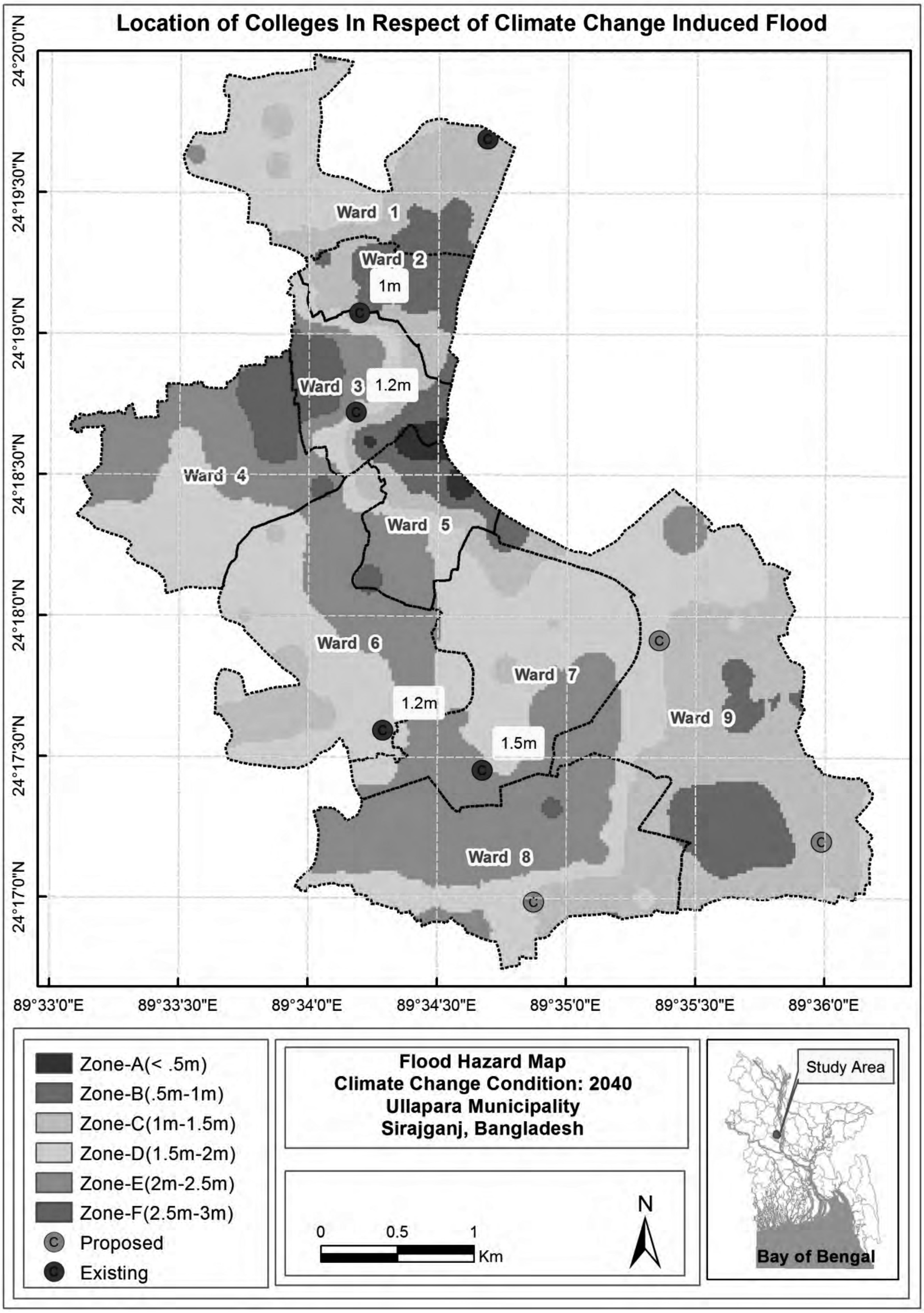
5.4.1.3 College

As per proposed master plan of Ullapara Pourashava, there will be total eight colleges in the year 2031. The proposed distribution of colleges with respect to future flood inundation scenario has been presented in the Map-5.5 which illustrates how college will be inundated in future climate change scenario in the study area. The Table 5.10 shows that three colleges will be exposed to 1.0m to 1.5m inundation depth, four will be exposed to 1.5m to 2.0m inundation and only one college will be exposed to more than 2m inundation. The Table-5.10 indicates most of the college will be exposed to 1.5m-2.0m inundation depth due to climate change induced flood in Ullapara Pourashava.

Table-5.10: Number of college to be exposed by climate change induced flood

	Flood Inundation depth						**Total**
	<0.5m	**.5-1.0m**	**1.0-1.5m**	**1.5m-2.0m**	**2.0-2.5m**	**2.5-3.0m**	
1	0	0	1	0	0	0	1
2	0	0	1	0	0	0	1
3	0	0	0	1	0	0	1
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	1	0	0	1
7	0	0	0	0	1	0	1
8	0	0	0	1	0	0	1
9	0	0	1	1	0	0	2
Total	0	0	3	4	1	0	8

(Source: Calculated by author, data collected from IWM, LGED, ACAL)



Map-5.5: Location of college in respect of climate change induced flood

Source: Prepared by author; Data collected from IWM, LGED and ACAL

5.4.2 Flood exposure scenario of educational institution

The Figure 5.2 illustrates the different types of educational infrastructures that are supposed to be exposed to climate change induced flood in the study area. From the figure it is seen that most of the educational infrastructure in the study area will be exposed to future flood. The figure depicts that in Ullapara Municipality about 68.75% Primary School and 72.72% Secondary School will be exposed to more than 2m inundation; 87.50% College will be exposed to 1-2m inundation. Overall 91.43% educational institution will be exposed to more than 1m inundation due to climate change induced flood.

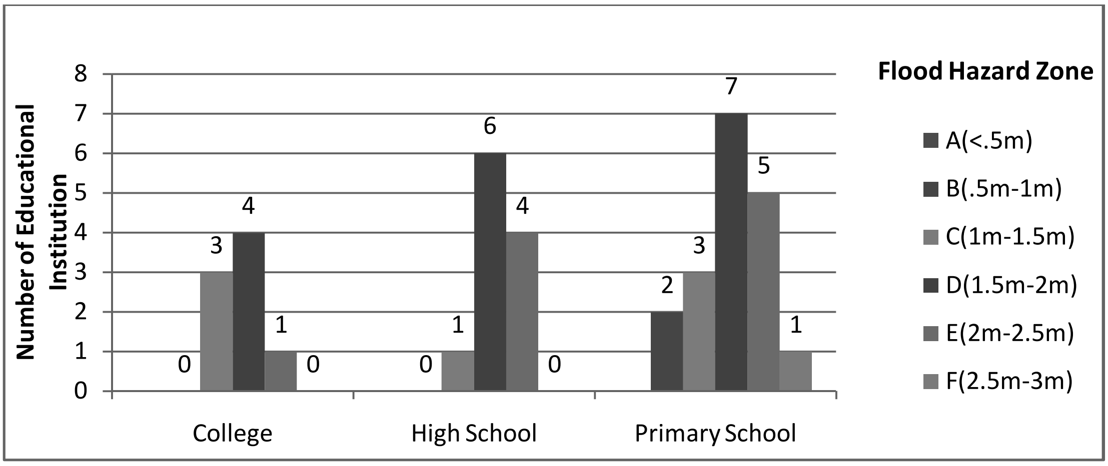


Figure 5.2: Flood inundation level of educational institution in Ullapara Municipality

(Source: Prepared by author, data collected from IWM, LGED, ACAL)

5.4.3 Past experience of flood

5.4.3.1 Inundation depth and duration

It was found from the face to face discussion with the local teachers of educational institutions that in 2007 flood, all educational institutions were inundated in the flood with varying inundation depth from 1 foot to 2.5 feet. But in 2014 flood all institutions were not inundated. Ten out of 15 primary schools, five out of seven secondary schools and three out of five colleges were inundated during the 2014 flood. The duration of the school inundation was up to 1.5 months in 2007 flood and up to 0.5 month in 2014 (Table-5.7, Table-5.8 and Table-5.9).

Table 5.11: Inundation scenario of primary school at Ullapara Pourashava

SL No	Name	No. of Students (2014)	Year of flood inundated	Depth of Inundation (ft)		Duration of Inundation (month)		Closing period (month)		Material Type	Floor
				2007	2014	2007	2014	2007	2014		
1	Nayanganj Govt primary School, Ward-8	643	1998, 2004, 2007, 2014	2.5	1.5	1.5	0.5	2.5	1	Semipucca	1
2	Kaoak Non-govt. Primary School, Ward-6	425	1998, 2004, 2007, 2014	2.5	1.5	1.5	0.5	2.5	1	Katcha	1
3	Jhikrabond Model Govt. Primary School, Ward-3	725	1998, 2004, 2007, 2014	2.5	1.5	1.5	0.5	2.5	1	Pucca/Katcha	2/1
4	Enaetpur Govt. Primary School, Ward-7	357	1998, 2004, 2007, 2014	2.5	1.5	1.5	0.5	2.5	1	Pucca/Katcha	1
5	Shibpur Non-govt. Primary School, Ward-7	415	1998, 2004, 2007, 2014	2	1	1.5	0.5	2.5	1	Katcha	1
6	Purbopara Govt. Primary school, Ward-5	589	1998, 2004, 2007, 2014	2	1	1.5	0.5	2.5	1	Katcha	1
7	Sree kola Govt. Primary School, Ward-1	482	1998, 2004, 2007, 2014	2	1	1.5	0.5	2.5	1	Pucca/Katcha	1
8	Ghatina Govt Primary School	429	1998, 2004, 2007, 2014	2	1	1.5	0.5	2.5	1	Katcha	1
9	Charghatina Non-govt. Primary School, Ward-9	323	1998, 2004, 2007, 2014	2	1	1.5	0.5	2.5	1	Katcha	1
10	Neoar gacha Notun para Non-Govt Prmary School, Ward-8	395	1998, 2004, 2007, 2014	2	1	1.5	0.5	2.5	1	Pucca/Katcha	1

SL No	Name	No. of Students	Year of flood	Depth of Inundation (ft)		Duration of Inundation (month)		Closing period (month)		Material Type	Floor
11	Char Neoar Gacha Non-govt primary school, Ward-8	415	1998, 2004, 2007	2	-	1.5	-	2.5	1	Katcha	1
12	Vottokawak Non Govt. Primary School, Ward-6	410	1998, 2004, 2007	1.5	-	1	-	2	1	Katcha	1
13	Upazila Parishad Jhikira Govt. Primary School, Ward-2	940	1998, 2004, 2007	1.5	-	1	-	2	1	Pucca/Katcha	2/1
14	Rimjhim Non Govt. Primary School, Ward-3	376	2004, 2007	1.5	-	1	-	2	1	Katcha	1
15	Enaetpur Gucchogram Reg. Non-govt. Primary School, Ward-9	266	2007	1.5	-	1	-	2	1	Semipucca	1

(Source: Ullapara Pourashava, 2014)

Table 5.12: Inundation scenario of Secondary school at Ullapara Pourashava

SL No	Name	No. of Students (2014)	Year of flood inundated	Depth of Inundation (ft)		Duration of Inundation (month)		Closing period (month)		Material Type	Floor
				2007	2014	2007	2014	2007	2014		
1	Zahura Mahiuddin Khan Girls High School, Ward-8	786	1998, 2004, 2007, 2014	2	1	1.5	0.5	2.5	1	Katcha	1
2	Khondokar A. Majid High School, Ward-8	658	1998, 2004, 2007, 2014	2.5	1.5	1.5	0.5	2.5	1	Pucca/Katcha	1/1
3	Ullapara Adorsho High School , Ward-6	621	1998, 2004, 2007, 2014	2.5	1.5	1.5	0.5	2.5	1	Semipucca	1
4	Rafia High School, Ward-6	489	1998, 2004, 2007, 2014	2.5	1.5	1.5	0.5	2.5	1	Katcha	1
5	Ghatina Bohumukhi Secondary School, Ward-9	526	1998, 2004, 2007, 2014	2	1	1.5	0.5	2.5	1	Katcha	1
6	Hira Pre-Cadet High School, Ward-2	610	1998, 2004, 2007	2	-	1.5	-	2.5	1	Katcha	1
7	Mamun Haq Momena Ali Science School, Ward-2	482	1998, 2004, 2007	2	-	1.5	-	2.5	1	Katcha	1

(Source: Ullapara Pourashava, 2014)

Table 5.13: Inundation scenario of college at Ullapara Pourashava

SL No	Name	No. of Students (2014)	Year of flood inundated	Depth of Inundation (ft)		Duration of Inundation (month)		Closing period (month)		Material Type	Floor
				2007	2014	2007	2014	2007	2014		
1	Ullapara Degree College, Ward-7	630	1998, 2004, 2007, 2014	2	1	1	0.5	2	1	Pucca	1
2	Jhikrabond Degree college, Ward-3	745	1998, 2004, 2007, 2014	2	1	1	0.5	2	1	Pucca	1
3	Hamida Pilot Girls College , Ward-3	1873	1998, 2004, 2007, 2014	2	1	1	0.5	2	1	Semipucca	1
4	Ullapara Science College Building, Ward-2	1118	1998, 2004, 2007	2	-	1	-	2	1	Pucca/Tinshed	2/1
5	Ullapara Merchant Pilot Tecnical College, Ward-2	1523	1998, 2004, 2007	2	-	1.5	-	2.5	1	Pucca/Katcha	1

(Source: Ullapara Pourashava, 2014)

5.4.3.2 Damage and loss

While discussing with the teachers of different educational institutions, they informed that due to the inundation they had to close the institutions for longer period up to 2.5 month in the 2007 flood. Although in 2014, all the schools were not inundated but they had to close the school due to inundation of road and unavailability of means of communications. A teacher of Nayanganj Govt primary School in Ward-8 reported that some children from poor family do not attend school after flood due to the discontinuation of class. As a result, they could not complete the syllabus on time. Thus flooding has adversely affected education in this area. It was found that about 7,190 primary school students, about 4,172 secondary school students and about 5,889 college students were deprived from attending school during this period. They told that this situation happens almost every year with varying inundation duration. Normally each year flood inundates for about 15-20 days. However the situation was more sever in 1988, 1998, 2004 and 2007. The teachers told that they could not restart schools immediately after flood due to siltation in the classroom and destruction of school furniture due to inundation for longer period. About two weeks were required to clean the silt and repair the school furniture. It was also reported by the teachers that they had to spend a significant amount of money to clean the silt and repair the furniture almost every year. It was found from the discussion with the local teachers that about 11.15 Lakh Tk for 10 primary schools (Please see Table-14), 7.1 Lakh Tk for five secondary schools (Please see Table-15) and 7.0 Lakh Tk for three Colleges (Please see Table-16) was spent to clean silt and to repair furniture that was destroyed in the 2014 food. A summary of such cost is presented in the Table 5-14, Table 5-15 and Table 5-16. Sometimes this money comes from government through various post-flood recovery and emergency assistance programmes and sometimes they had to pay from their own school fund.

Table 5.14: Approximate cost of silt cleaning and furniture repairing of inundated primary school for the year 2014

SL No	Name	Cost (Tk)
1	Nayanganj Govt primary School, Ward-8	110000
2	Kaoak Non-govt. Primary School, Ward-6	90000
3	Jhikrabond Model Govt. Primary School, Ward-3	130000
4	Enaetpur Govt. Primary School, Ward-7	120000
5	Shibpur Non-govt. Primary School, Ward-7	115000
6	Purbopara Govt. Primary school, Ward-5	100000
7	Sree kola Govt. Primary School, Ward-1	120000
8	Ghatina Govt Primary School	115000
9	Charghatina Non-govt. Primary School, Ward-9	120000
10	Neoar gacha Notun para Non-Govt Prmary School, Ward-8	95000
Total		11,15,000

(Source: Ullapara Pourashava, 2014)

Table 5.15: Approximate cost of silt cleaning and furniture repairing of inundated secondary school for the year 2014

SL No	Name	Cost (Tk)
1	Zahura Mahiuddin Khan Girls High School, Ward-8	165000
2	Khondokar A. Majid High School, Ward-8	125000
3	Ullapara Adorsho High School , Ward-6	150000
4	Rafia High School, Ward-6	130000
5	Ghatina Bohumukhi Secondary School, Ward-9	140000
Total		710000

(Source: Ullapara Pourashava, 2014)

Table 5.16: Approximate cost of sediment cleaning and furniture repairing of inundated college for the year 2014

SL No	Name	Cost (Tk)
1	Ullapara Degree College, Ward-7	180000
2	Jhikrabond Degree college, Ward-3	190000
3	Hamida Pilot Girls College , Ward-3	230000
Total		700000

(Source: Ullapara Pourashava, 2014)

5.4.4 Evaluation of educational infrastructure

Access to education has long been considered as an important vehicle for poverty alleviation. Educational facility is thought as one of the important facilities and it plays a vital role to increase the literacy rate in any area (Habibullah & Williams, 2006). It is observed that there exists strong relationship between access to educational facilities, education level and poverty. The area with higher educational facilities generally characterized with high degree of education level. Education empowers a person and it helps them to become more proactive, gain control over their lives, and to broaden the range of available options (UNESCO, 1997). Education is recognized as a basic human right and it is closely linked to virtually all dimensions of development - economic, social, and human. It is also a key factor in improving the quality of governance that has a significant impact on national income (Habibullah & Williams, 2006). Robert Lucas, in his ‘endogenous’ growth model used education as the critical variable that generates technical progress in an economy (Lucas, 1988). So it is clear that education is a leading driver for promoting economic growth and development. For this, access to educational institution and facilities is very important. Keeping in mind, a plan has been made to provide educational infrastructure and facilities in the study area under “Ullapara Pourashava Master Plan (2011-2031)”.

This flood exposure analysis of educational infrastructure has already been conducted and discussed in section 5.4.1. This analysis shows that the number of different educational infrastructure to be exposed in different inundation level in future climate change induced flood. The damage and loss due to inundation of educational infrastructure in 2007 and 2014 flood was discussed in the section 5.4.3.2 which makes it clear that the total educational system was severely hampered during 2007 flood. It is expected that the severity will be increased in future climate changed induced flood. In the Ullapara Pourashava master plan, educational facilities has been planned only based on future population without considering climate change induced flood. In Bangladesh flood normally occurs during the monsoon season from June to September and stay normally 3 to 5 weeks. Due to climate change the inundation scenario will be increased in this period. As a result, educational institution will remain closed during floods due to high level of inundation. This will create a gap in the delivery of educational services and children will not be able to perform well in subsequent exams and they lose interest in study and are reluctant to attend schools. So it is obvious that access to educational infrastructure will be severely affected during these three months of monsoon flooding. And student will not be able to attend the school due to flooding. The findings of the flood exposure analysis of educational infrastructure suggest that the majority of the students in the study area will be severely affected in climate change induced intensified flood in future. The normal functioning of the inundated schools will be affected severely resulting in dropouts and lowering the quality of education. The flood inundation of educational infrastructure for longer period along high flood water flow may also lead to destruction or damage of the infrastructure which may require replacement or reconstruction infrastructure. In such cases the delay in replacement or reconstruction of the infrastructure also may lead to increased dropout rate. The above discussion makes it clear that in changing climate the proposed plan for educational facilities in Ullapara Pourashava will not work properly rather it will create difficulties to access the educational facilities. These difficulties will affect education level of the locality. Education rate is linked with income generation and country GDP, as discussed earlier. So the inundation scenario will affect income and socio-economic development in long term. From the above discussion it can be said that the education infrastructure planning in Ullapara Pourashava should be revised in order to cope with the climate change situation.

5.5 Health infrastructure

5.5.1 Flood exposure analysis

A health system consists of all organizations, people and actions whose primary intent is to promote, restore or maintain health. Health sector is one of the important sectors vulnerable to climate change. In climate change induced flood it will be a great challenge to maintain the health services during flood because health infrastructures are supposed to be exposed in climate change induced flood. So it is necessary to study how health infrastructure will be exposed to climate change induced flood. At present there are five (5) hospitals/clinic in Ullapara Pourashava. According to Ullapara Pourashava Master plan (2011-2031), there will be total 13 community clinics including one Upazila health complex. The proposed distribution of community clinic with respect to future flood inundation scenario has been presented in the Map-5.6 which illustrates how community clinic will be inundated in future climate change scenario in the study area. The Map indicates that health infrastructure in ward 3, 4, 6 and 8 will be most vulnerable due to climate change induced flood. The following Table 5.17 and Figure 5.3 shows the health facilities that are supposed to be exposed to climate change induced flood in Ullapara Pourashava.

Table-5.17: Number of clinics to be exposed by climate change induced flood

Ward	Health Facilities by Flood Inundation depth						Total
	<0.5m	**.5-1.0m**	**1.0-1.5m**	**1.5m-2.0m**	**2.0-2.5m**	**2.5-3.0m**	
1	0	0	1	1	0	0	2
2	0	0	1	0	0	0	1
3	0	1	0	0	0	1	2
4	0	0	0	1	0	2	3
5	0	0	0	0	0	0	0
6	0	0	0	2	0	0	2
7	0	0	0	0	1	0	1
8	0	0	0	0	1	0	1
9	0	1	0	0	0	0	1
Total	0	2	2	4	2	3	13

(Source: Calculated by author, data collected from IWM, LGED, ACAL)

The Table 5.17 shows that level of flood exposure of Health Infrastructure in ward-3 and ward-4 are higher compared to other wards. In these wards 1 and 2 clinics will be highly exposed falling under Zone-F (2.5m to 3.0m inundation) to climate change induced flood respectively. In Ward 7 and ward 8 there is one clinic in each and these clinics fall under Zone-E which is characterized by 2.0 to 2.5m inundation depth. The Table-5.17 indicates that most of the health facilities in Ullapara Pourashava will be highly exposed to future climate change induced flood. This is more vivid from illustration of the figure 5.3 and Map 5.6. The figure 5.3 shows that total 15.38% Health Infrastructure will be exposed to Zone-B (0.5m to 1.0m inundation), Zone-C (1.0m to 1.5m) inundation and Zone-F (2.5 to 3.0m inundation). About 30.77% and 28.08% will be exposed to Zone-D (1.5m to 2.0m inundation) and Zone-E (2.0m to 2.5m inundation) respectively due to climate change induced flood in Ullapara Pourashava. The inundation scenario indicates that at least 84.77% of the total health facilities in Ullapara Pourashava are supposed to be exposed by future climate change induced flood. This inundation scenario indicates that it will be a great challenge for Bangladesh to meet the increasing health care facilities that would be required due to increases of both vector borne and water borne diseases to be caused by global warming under climate change scenario.

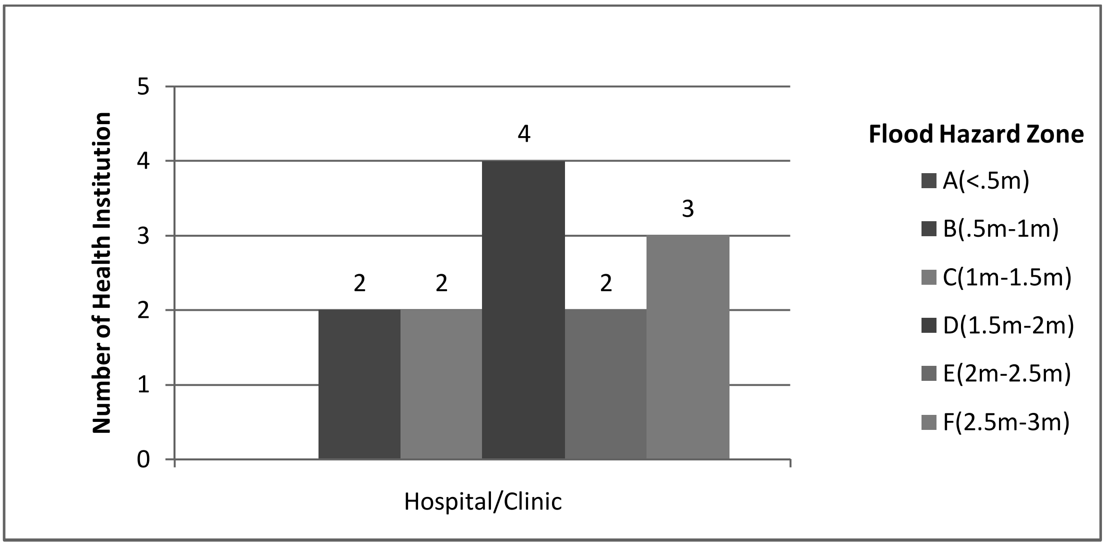


Figure 5.3: Flood inundation level of health infrastructure in Ullapara Municipality

(Source: Prepared by author, data collected from IWM, LGED, ACAL)

5.5.2 Past experience of flood

5.5.2.1 Inundation depth and duration

It has been found from the discussion with the Officials of different hospitals that all the clinics and hospitals were inundated in 2007 flood. On the other hand in 2014 flood no clinics/ hospital was inundated because the health facilities are constructed in relatively high land and the depth flood 2014 was lower than that of 2007. However, in 2007 flood, inundation depths of those health facilities were about 2 to 2.5 feet and duration of inundation was about 1.5 month. Derail of Inundation depth and duration has been presented in Table-5.18.

5.5.2.2 Damage and loss

It was found from the discussion with the health officials that siltation was occurred inside the hospitals/clinics, many furniture and apparatus was damaged due to inundation for long period in 2007 flood. It has been estimated from the discussion that about 10.25 Lakh Tk (Please see Table-19) was required to clean the silt and repair the furniture and apparatus.

Table 5.18: Inundation scenario of health infrastructure at Ullapara Pourashava

SL No	Name	Bed Number	Average number of patient (daily)	Year of flood inundated	Depth of Inundation (ft)	Duration of Inundation (month)	Structure Type	Floor
					2007	2007		
1	Upazilla Health Complex, Ward-6	50	200	1998, 2004, 2007	2	1.5	Pucca	3
2	Bengal Community Hospital, Ward-4	30	125	1998, 2004, 2007	2.5	1.5	Pucca	2
3	Ullapara Eye and General Hospital, Ward-4	30	120	1998, 2004, 2007	2	1.5	Pucca	3
4	Seba Generel Hospital Ward-3	15	70	1998, 2004, 2007	2.5	1.5	Pucca	3
5	Doctors Diagnostic Center,Ward-6	15	75	1998, 2004, 2007	2	1.5	Pucca	3

(Source: Ullapara Pourashava, 2014)

Table 19: Approximate cost of silt cleaning, equipment transfer and furniture repairing of inundated hospitals for the year 2007

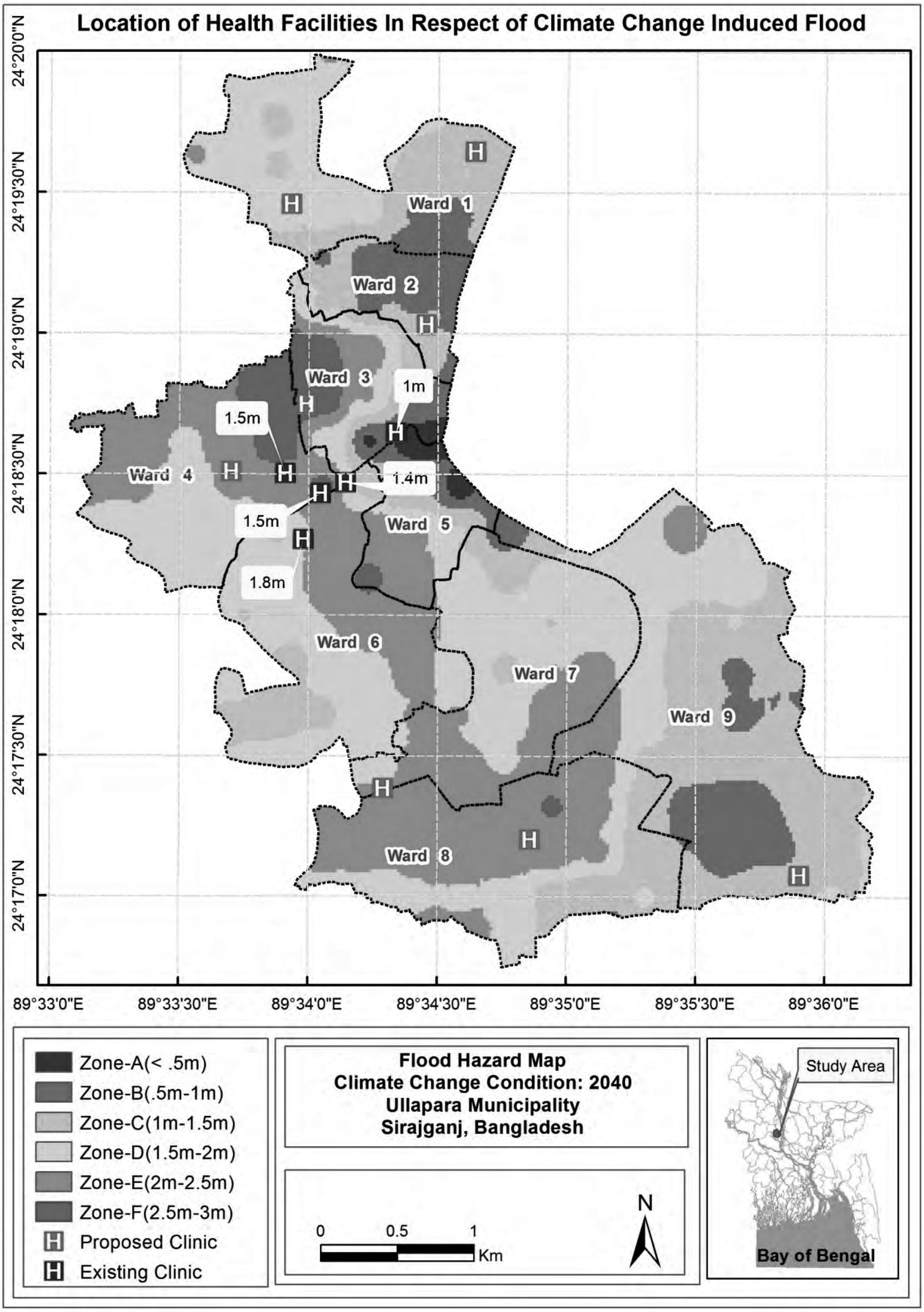
SL No	Name	Cost (Tk)
1	Upazilla Health Complex, Ward-6	265000
2	Bengal Community Hospital, Ward-4	185000
3	Ullapara Eye and General Hospital, Ward-4	210000
4	Seba Generel Hospital Ward-3	190000
5	Doctors Diagnostic Center,Ward-6	175000
Total		1025000

(Source: Ullapara Pourashava, 2014)

According to one officials of Ullapara health complex, during 2007 flood it was very critical to manage the large number of patients. It can be mentioned that structure of all health facilities in Ullapara Pourashava are pucca and multistoried. So during the flood, patients, some important equipments and medicine were brought in the first floor of the hospital. This made congestion in the upper floor causing difficulty in proper treatment of large number of patients within squeezed space. He also reported that the number of patients increases during flood. During 2007 flood they could not provide bed and sufficient medicine to the increased number of patient due to inundation of ground floor. Sometimes medicine could not reach timely. They observed that the number of patients having water-borne diseases is more compared to other types of patients during flood seasons. He also told that due to communication problem doctors and nurse could not attend in the hospital regularly. Thus increase in the number of patients, limited seating capacity, insufficient medicine along with irregularity of doctors and nurse make it more complicated for the treatment and to manage the situation during flood season. They face this problem almost each year. Moreover some furniture and materials are destroyed during flood. While discussing with the officials of different hospitals, five major problems were identified during flood including a) severe difficulty in management of equipments, medicine, other treatment facilities and patients located in ground floor; b) upper floors become congested due to placement of some ground floor equipments and facilities; c) increased number of patients during and after flood period; d) limited medicine compared to increased number of patients during and after flood and e) irregularity of Doctors and nurse due to inundation of roads . They also told that surrounding medicine shops are inundated during flood so patients could not avail required medicine in due time. The patient has to go to sirajganj sadar to buy medicine. Even sometimes they could not reach sirajganj sadar on time due to the inundation of roads and unavailability of boat services. About 590 patients are daily consulted by existing five hospitals ((Please see Table-18). The number increases during flood. Thus during flood more than 26,550 patients remain in health risk in Ullapara Pourashava during flood. Thus the total health system gets severe form of complexity during and after flood in Ullapara Pourashava.

5.5.3 Evaluation of health infrastructure

Bangladesh is vulnerable to outbreaks of infectious, waterborne and other types of diseases (WHO, 2002). Records show that the incidence of malaria increased from 1556 cases in 1971 to 15 375 in 1981, and from 30282 cases in 1991 to 42012 in 2004 (WHO, 2010). Other diseases such as diarrhoea and dysentery, etc. are also on the rise especially during the summer months. It has been predicted that due to climate change the combination of higher temperatures and potential increase in summer precipitation and increase in flood may cause the spread of many infectious and waterborne diseases (BCAS and NIPSOM 2007). A study conducted by DoE indicates that water borne diseases remained a major public health problem in Bangladesh due to climate change induced flood. And the scenario of such waterborne diseases will be severe in more flood prone areas of Bangladesh (DoE, 2009). According to IPCC (2001a), global warming would cause increase of vector borne and water borne diseases in the tropics (IPCC, 2001b).Climate change will also bring about additional stresses like dehydration, malnutrition and heat-related morbidity especially among children and the elderly. Several studies have been conducted in home and abroad to relate the effects of climate change on human health and those studies recommended specific activities, programs, measures to be taken to address health impact due to climate change. (DoE, 2009; WHO, 2003; IPCC, 2001a, IPCC, 2007b; Githeko, 2003). Among others protection of health infrastructure from climate change induced flood has been identified as key element of policies and programmes (WHO, 2008; Campbell-Lendrum, 2007). Many researchers argued that if health infrastructures are damaged or functionally disrupted by flood events it will affect the access to and quality of health care and any breakdown of health services will a situation of double jeopardy. They also add that as health infrastructure such as hospital, clinic etc are the center of health services and all the health related programs are based on health infrastructures so if these infrastructures are damaged or functionally disrupted then the climate related health programs will not be successful (Menne, 1999; PAHO, 2001; Milsten, 2000; Orellana, 2002).



Map-5.6: Location of health facilities in respect of climate change induced flood

Source: Prepared by author; Data collected from IWM, LGED and ACAL

According to this plan there will be about 13 clinics including 1 Upazila Health complex in Ullapara Pourashava. However, this plan did not consider climate change induced flood for the planning of health infrastructure. At the end of the section 5.5.1 it was discussed the impact of inundation during 2007. In future the inundation scenario would be increased. The flood exposure analysis indicates that at least 84.77% of the total health facilities in Ullapara Pourashava would be exposed by future climate change induced flood. If these health infrastructures are inundated during flood, people will face difficulty to access to health facilities. During this time access to healthcare facilities will be severely hampered. Thus from the above discussion it is clear that the proposed health infrastructure planning, as prepared in Ullapara Pourashava Master Plan, will not work during climate change induced flood and will not be able to face the challenge of climate change scenario.

5.6 Urban facilities

The urban facilities that are now being built in small urban area of Bangladesh are particularly vulnerable to flood damage. Recent floods are examples of catastrophic floods that cause a new type of damage infrastructures in urban areas. The vulnerability of urban facilities is expected to increase due to climate change induced flood. Flood exposure of some important urban facilities is discussed in this section and the status of flood exposure level has been presented in the Table 5.20 and Map-5.7. The Table and Map indicate to what extent these urban facilities will be exposed in future climate change induced flood in Ullapara Pourashava.

Table 5.20: Flood inundation scenario of urban facilities in Ullapara Pourashava

Urban Facilities	Flood Hazard Zone	Inundation Depth (m)	Location
Community Center	E	2.0-2.50	Ward-6
Waste Disposal Site	E	2.0-2.50	Ward-1
Fire Service	E	2.0-2.50	Ward-8
Police Station	B	0.5-1.0	Ward-3

(Source: Calculated by author, data collected from IWM, LGED, ACAL)

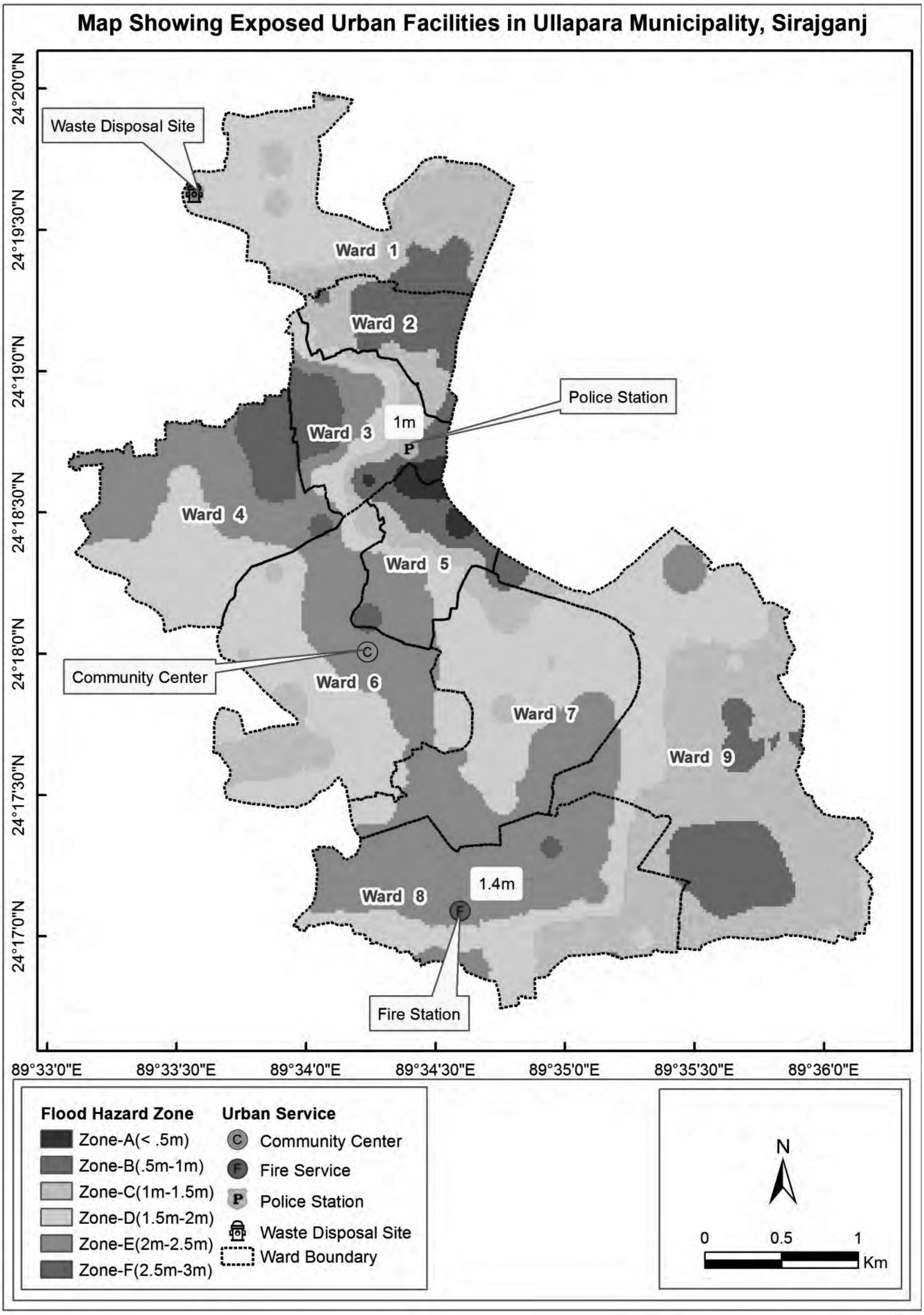
5.6.1 Community center

5.6.1.1 Flood exposure analysis

Community centers are public locations where members of a community tend to gather for group activities, social support, public information, and other purposes. It performs many functions in its community and is an important part of social life. At present there is no community center in Ullapara Pourashava. However, based on the projected population and planning standard one community center has been proposed in Ullapara Pourashava Master Plan. This Community center has been proposed in ward-6. Table-5.20 shows the flood exposure level of various urban facilities in Ullapara Pourashava. From the Table-5.20, it is seen that if proposed community center is built without any height enhancement, then it would be highly exposed to climate change induced flood for about 2.0-2.50m inundation depth. This inundation for long time during flood and even in post flood period will hamper the services.

5.6.1.2 Evaluation

Community centers are public locations where members of a community tend to gather for group activities, social support, public information, and other purposes. It is the place for all-community celebrations at various occasions and traditions; place for public meetings of the citizens on various issues; place where politicians or other official leaders come to meet the citizens and ask for their opinions; place where community members meet each other socially, place that community members (and sometimes others), can rent cheaply when a private family function or party is too big for their own home. So community center is very much important for any community. From the flood exposure analysis it is seen that the proposed community center in Ullapara Pourashava is supposed to be exposed to climate change induced flood for about 2.0-2.50m. If this facility is inundated for long period it will not be able to serve the purpose. Even it will not be functional after immediate flood while cleanup and repairs will be undertaken after flood.



Map-5.7: Location of urban facilities in respect of climate change induced

Source: Prepared by author; Data collected from IWM, LGED and ACAL

5.6.2 Fire station

5.6.2.1 Exposure analysis

A fire department or fire brigade (also known as a fire and rescue service or simply fire service) is a public organization that provides predominantly emergency firefighting and rescue services for a certain jurisdiction, which typically is a municipality, county, or fire protection district. A fire department usually contains one or more fire stations within its boundaries, and may be staffed by career firefighters, volunteer firefighters, or a combination thereof referred to as a combination department. At present there is one fire station in Ullapara Pourashava which serves the whole Upazila. This fire station is located in Ward-8. This is two storied building. In new master plan there is no proposal of additional fire station. However, there is recommendation of increasing the area in addition to existing land.

5.6.2.2 Past experience of flood

The station officer of Ullapara Fire Brigade told that it was inundated about 1m in 2007 flood for about one month. The inundation of ground floor created many problems to them. Much silt was deposited in the ground floor which required cleaning after flood. In the ground floor there was a small workshop. In the workshop they would keep machineries and various valuable apparatus. They had to shift the machineries and apparatus in the upper floor but they could not shift all the machineries and apparatus. This is why some apparatus and firefighting equipments were damaged due to inundation. The officials estimated that this damage cost was more than 4 lakh. The big problem was to manage the firefighting Truck. There was no alternative place to keep the truck; those vehicles were inundated for about one month. Due to the inundation and damage of road it was not possible to move the truck in another place. Even one firefighting was completely dysfunctional after flood. However the flood exposure analysis shows that the existing fire station is supposed to be exposed to about 2m-2.50m inundation in future climate change induced flood. So it can be assumed that in future the damage will be more due to high level of inundation.

5.6.2.3 Evaluation

A fire station is a critical facility. It is a structure or other area set aside for storage of firefighting apparatus such as fire engines and related vehicles, personal protective equipment, fire hoses and other specialized equipment. It may also have dormitory living facilities and work areas for the use of fire fighters. Major fire station functional areas include the following:

- Apparatus bay(s): This is where the fire fighting and emergency response vehicles are stored.
- Apparatus bay support and vehicle maintenance: These industrial spaces are where the vehicles and other firefighting equipment are cleaned, maintained, and stored.
- Administrative and training areas: These include offices, dispatch facilities, and training and conference rooms.
- Residential areas: These include the dorm rooms, day room/kitchen, and residential support areas such as bathrooms and fitness spaces.

A fire station, by its nature and function, is a critical facility and need to function continuously. Fire service is essential for the delivery of vital services and for the protection of the community. Fire services can be considered more vulnerable than others because of their importance to disaster relief, recovery; search and rescue operation. Fire service, because of its function, size, service area, or uniqueness, have the potential to cause serious bodily harm, extensive property damage, or disruption of vital socioeconomic activities if they are destroyed, damaged, or if their functionality is impaired. The adverse effects of impaired fire station can extend far beyond direct physical damage. This facility may be isolated by the flood, requiring additional resources to maintain its operations and thus should be located in flood free areas. The flood exposure analysis shows that the existing fire station is supposed to be exposed to about 2.0-2.50m inundation in future climate change induced flood. The station officer of Ullapara Fire Brigade reported that at present there are three Fire Fighting trucks, three Fire Fighting water tenders, two Towing Vehicles, four Portable Pumps, one rescue vehicle, two foam tender, two chemical tender, two cold cuts (cobra), 20 fire extinguishers and other valuable apparatus in the Ullapara Fire Brigade. The station officer estimated that the price of the existing firefighting vehicles and equipments is more than 10 crore Tk. If the station is inundated then the total system of fire station will collapse; it will be difficult to move its heavy and bulky apparatus, those valuable vehicles, apparatus worth of more than 10 crore Tk will be at risk and even they may be damaged or destroyed. The inundation of apparatus may lead to dysfunction. The building may be damaged due to inundation for longer time. Damage may result in a total loss, or may require substantial cleaning and restoration efforts. Floods water can produce large quantities of debris and silt that can be time consuming and expensive to remove. Thus the total system will be un-operational during and even in post flood period. Regardless of the nature and severity of damage, flooded fire station typically is not functional while cleanup and repairs are undertaken after flood. As fire service is an emergency service its full functionality is very much important in search and rescue operation during and after fire hazard. If fire station or fire service is not fully functional or is impaired due to flood inundation then it will create enormous losses to lives and properties. In Ullapara Pourashava Master Plan there is no consideration of climate change induced flood. That is why this inconsiderateness will cause flood inundation of fire station making it un-operational and which will further lead to severe losses of lives and properties.

5.6.3 Police station

5.6.3.1 Exposure analysis

Police Department is the law enforcement division of any City. The department is responsible for the enforcement of State law, as well as local ordinances. The department serves and protects all persons and property within the city limits. At present, in Ullapara Pourashava there is one Police station which serves the whole Upazila. This Police station is located in ward-3. In new master plan there is no proposal of additional Police station. However, there is recommendation of increasing of area in addition to existing land. The structure of the Police station is Pucca and two storied. The first floor is completely used for official purpose. Along with official room there was residential room and garage in the ground floor. The residential room was used for night stay of police and other staff. The flood exposure analysis shows that the existing Police station is supposed to be exposed to about .05m-1.0m inundation in future climate change induced flood. So it is expected that in future climate change the scenario would be more severe due to increased flood inundation depth. In the proposed plan there is only proposal of increasing land area but no consideration for future climate change induced flood.

5.6.3.2 Past experience of flood

It was found from the discussion with the staff of the Police station that the garage would contain about two pickups, 30 motorcycles, 10 bicycles. Moreover more valuable goods are kept in the ground floor. The staff told that in 2007 flood the ground floor of the Police station was inundated to about 0.5m depth for about one month. Due to inundation it was very difficult to manage the valuable goods in the ground floor specially the vehicle. Some motorcycles were shifted to first floor. He also added that many other valuable goods were inundated in the ground floor because there was no place in the upper floor to keep the goods and valuable material located in the ground floor. Thus many resources were damaged during flood. During flood silt was deposited in the ground floor that created another problem in post flood period. According to his estimate it cost more 3 lakh Taka to buy new goods that was destroyed to repair the furniture and to clean the silt in the ground floor. Thus overall function of Thana was hampered during the flood.

5.6.3.3 Evaluation

A police station is a building which serves to accommodate police officers and other members of staff. These buildings often contain offices and accommodation for personnel and vehicles, along with locker rooms, temporary holding cells and interview/interrogation rooms. A police station of a locality is the basic unit that looks after the law and order situation of that area. It looks after the safety of the neighborhood and prevents crime by patrolling the area; protects the vehicles and property from theft by having police booths at crowded places and parking lots. In case of a crime, it investigates the matter and brings the criminals to justice. It assists the people of the locality in case of any accident or natural calamity; ensures that traffic rules are respected so that accidents are reduced to a minimum. It also provides supports in emergency situation during disaster and flood relief. It Co-ordinates the emergency services in a major flood incident and help with evacuation of people from their homes where it is necessary. Thus, the police station is a symbol of safety and security to the people of a locality and responsible for the maintenance of public order, prevention and detection of crimes in the state. Hence, the role of the police has become more important than before. So it should be ensured that police station is disrupted by any means and continuous service of police station is essential for maintaining law and order situation in a locality and without the police, there would be chaos in the society. In case of Ullapara Pourashava it is seen that the police station is supposed to be exposed to 0.5-1.0m inundation in future climate change induced flood. If the police station is inundated for long time during flood, what would be the situation at that time? They themselves will be at risk due to inundation in flood and will be busy to save themselves. When they will be at risk how will they be able to serve the people? When this critical facility is located in flood-prone space, valuable records may be lost. If left in flood-prone areas, police cars and other vehicles may require replacement or cleaning to be serviceable and may not be functional and available for service immediately after a flood. Ultimately the law and order situation will be deteriorated and they will not be able to take part in search and rescue operation and relief work if needed. So it is clear that the role of the local police during flooding is paramount and without the ability to carry out the invaluable works that local police undertake in a flood situation, the general public of Ullapara would be put at immense risk. But unfortunately in Ullapara Pourashava Master Plan there is no consideration of climate change induced flood. That is why this inconsiderateness will cause flood inundation of police station making it un-operational and this may lead to worsen the law and order situation in Ullapara Pourashava.

5.6.4 Solid waste disposal site

5.6.4.1 Exposure analysis

Municipal Solid Waste—more commonly known as trash or garbage—consists of everyday items we use and then throw away, such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. This comes from our homes, schools, hospitals, and businesses. For proper management of Municipal solid waste it requires the solid waste disposal site where collected municipal waste can be dumped. Solid waste disposal site is a place where rubbish is dumped, flattened, covered with sand, and left to decompose or break down and rots away. At present in Ullapara Pourashava there is no designated solid waste disposal site. In the newly prepared master plan of Ullapara Pourashava one solid waste disposal site has been proposed in ward -1. The flood exposure analysis shows that if the proposed site is built without any height enhancement then it would to be exposed to about 2.0m-2.5m inundation due to climate change induced flood. This inundation will pose risk to environment and human health.

5.6.4.2 Evaluation

Municipal solid waste consists of various organic and inorganic matters. Some of these may be hazardous and thus harmful to environment and health. So solid waste management is an important health issue. It needs to be addressed due to several reasons ranging from its impact on health and the environment. Improper management of solid waste have negative impact on environment; pollute the local environment (such as contamination of groundwater and/or aquifers by leakage or sinkholes and residual soil contamination during landfill usage, as well as after landfill closure); off gassing of methane generated by decaying organic wastes (methane is a greenhouse gas many times more potent than carbon dioxide, and can itself be a danger to inhabitants of an area); harboring of disease vectors such as rats and flies. The negative impact of solid waste may be triggered if it is inundated by flood water. From the flood exposure analysis it is seen that the proposed solid waste disposal site in Ullapara Pourashava would be inundated up to 2.0m-2.5m inundation due to climate change induced flood. Even the site has been proposed in northern side of the Pourashava. Executive Engineer of Ullapara Pourashava told that flood water flows north to south direction in this area. He thinks that it was not wise to propose waste disposal site in such low land and even in north side. According to Executive Engineer of Ullapara Pourashava if the proposed waste disposal site is constructed in such potential flood zones then it whole Pourashava population of about 54860 people will be at health risk of polluting of surrounding areas and surface/groundwater bodies due to leaching, waste emissions and subsequent pollution. He also added that the social impact of pollution in this area would be worse if the flood waters transport waste to residential areas. The flood waters could collect and transport chemical pollutants and waste to Ullapara Pourashava and its adjoining area. Inundation of waste disposal site will lead to increased leaching of pollutants into the groundwater and methane generation to the atmosphere. This could cause serious damage to the locality, both physically and socially. In Ullapara Pourashava master plan there is no consideration of future climate change induced flood. Even there is no proposal for protective or adaptive measures regarding waste disposal site in response to flood. But from the analysis it found that the proposed waste disposal site is located in Zone-E which is characterized with 2.0m-2.50m flood inundation and, in turn, this will cause environmental risk to Ullapara Pourashava. Thus the proposed waste disposal site without considering protective or adaptive measures in response to climate change induced flood is not justified.

Chapter 6: Adaptation strategies

6.1 Introduction

The second objective of the study is to suggest adaptation strategies regarding infrastructure proposed in Ullapara Pourashava Master Plan. The Fourth Assessment Report of the IPCC defines adaptation as "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007a). Adaptation thus includes both anticipatory and reactive actions in order to reduce vulnerability or enhance resilience in response to already observed and expected changes in climate. Adaptation practices can be differentiated along several dimensions, including the spatial scale, sector, action or actor (IPCC, 2007c).

This chapter elaborately discusses the adaptation strategies in the face of climate change induced flood. These adaptation strategies are based on the flood exposure analysis, local level discussion with the Pourashava Engineers and Councilors, teachers of different educational institutions, health officials, and other peoples. The researcher also reviewed various national and international studies in this regard. Expert opinions were also taken from various Government, Autonomous, Semi-government, NGO and Private organizations including IWM, BWDB, WARPO, IWFM (BUET), BRAC, LGED and DoE. Finally the researcher applied his own judgment to find suitable adaptation strategies. A list of local level peoples and experts consulted has been presented in Appendix-A and Appendix-B.

Early adaptation research and practice was primarily concerned with identifying technical solutions. Research and practice gradually shifted to concerns with the institutional context of adaptation. More recently, the emphasis has been placed on governance and the coordination of knowledge, actions and how knowledge among diverse actors influence decisions and interactions (Adger et al., 2009; Winsvold et al., 2009; Ziervogel et al., 2009). It is argued that climate change adaptation can only be adequately addressed if action is taken at all levels of government: international, national, regional, and local (Corfee-Morlot, 2011). In relation to climate change, it is widely assumed that the response to the impacts of climate extremes such as floods, raise complex development issues that are best addressed at the local level with substantive community involvement. It is however also recognized that local and city level actors require firm linkage and support from higher levels of government (Bicknell et al., 2009). Thus adaptation to climate-related disaster risks is a concern of multiple actors, working across scales from international, national, and sub-national and community levels, and often in partnership, to ultimately help individuals, households, communities, and societies to reduce their risks (Twigg, 2004; Schipper, 2009; Wisner et al., 2004). Recent studies on climate change adaptation strategies underscore the need for attention to multilevel governance, i.e. governance across all levels of government and active engagement with stakeholders within a particular level for successful adaptation with climate extremes (corfee-morlt et al., 2011; Vidal et al., 2010; Brondizio et al., 2009; Milbert, 2006; Jordan, 2000; Cash et al.,2006). It is now understood that climate change adaptation can be best addressed under multilevel governance framework each having different level of contribution and coordination. It has already been mentioned that expert opinions were taken to find the suitable adaptation strategies. They also suggest multilevel governance approach for climate change adaptation. So the adaptation strategies have been discussed from local, regional and national level context.

6.2 The local level

Local authorities are in a unique position to develop tailored responses to the impacts of climate change. They have first-hand knowledge of local conditions and can develop proactive strategies in response to climate change, experimenting with local solutions and committing to ambitious targets. Local authorities can work together with voluntary efforts such as city networks, the private sector and community organizations to develop new institutional models for local adaptation (Piorr et al., 2011). There are many adaptation strategies at local level. Many studies suggest that spatial planning or structural measures should be considered as indispensible part and be given as utmost priority to adapt with climate change induced flood (UNISDR, 2009e, 2011; UNISDR, 2009a; Cardona, 2001, 2010; Cardona, 2011; Mercer et al., 2010; Metzger et al., 2006; McLeman & Smit, 2006). Among others, this study focuses mainly on spatial planning and/or structural measures as adaptation strategies in response to climate change induced flood in Ullapara Pourashava. The following sections elaborately discuss adaptation strategies for selected infrastructures in Ullapara Pourashava in climate change induced flood scenario.

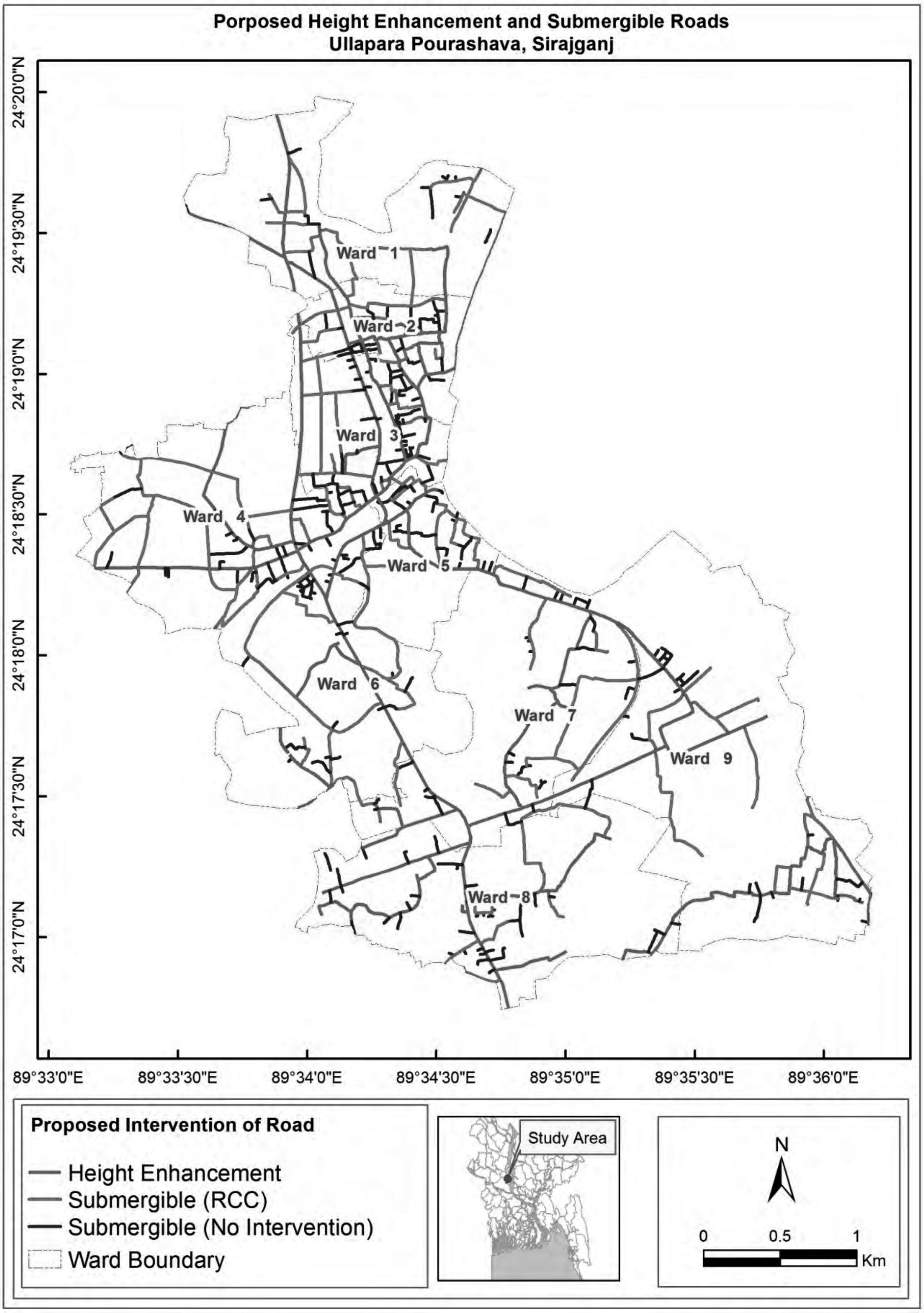
6.2.1 Transportation and communication infrastructure

6.2.1.1 Road

Climate change could have significant implications for transportation and communication infrastructure. As infrastructure assets have long operational lifetimes they are sensitive not only to the existing climate at the time of their construction, but also to climate variations over the decades of their use. A study shows that in Bangladesh road damages accounted for 15% of the total damages or about 0.7% of GDP during the 1998 flood (Tanner et al., 2007). To increase the resilience of both new and existing infrastructure, we must be prepared to plan ahead and manage the impacts of climate change. The flood exposure analysis of road infrastructure and it associated consequence have been discussed under the Section 5.3.1 of chapter 5. The discussion portrays that inundation of road not only damage itself, rather it has significant impact on socioeconomic life. Inundation of road severely hampers education, health, business and peoples involved in transport sector and other urban services. The study findings show that about 45.7km road (pucca and katcha) was partially or severely damaged during 2007 flood due to inundation. To rehabilitate and repair those roads about 8.41 crore was spent. Based on flood exposure analysis it is evident that existing and proposed road infrastructure will fail to serve the functions properly during the flood period. Under this circumstance we have to search for planning solutions and adaptation strategies. This section describes the adaptation strategies and planning solutions for road infrastructure that may be undertaken to adapt with climate change scenario. Based on the findings of the study, discussion with the Pourashava Engineers, local peoples, experts and other relevant studies, three type adaptation strategies can be undertaken to adapt with climate change induced flood. These are a) road heightening, b) construction of appropriate culvert in size and location, and c) using climate proofing material for road construction. These are discussed below.

a) *Elevated road:*

A number of international studies including studies conducted in Asian countries suggest that raising road elevation or height above the anticipated highest flood level may be one of the strategies to adapt with climate change (JICA, 2002; Douven, 2009; ADB, 1993; ADPC, 2008). International literature provides ample guidance on planning and design of roads in climate change scenario. For example in Cambodia and Vietnam it is recommended that the crest level for National roads and (major) Provincial roads should be based preferably on a flood frequency for example 100 year plus an additional 0.5 meters. For (major) regional roads the crest level should correspond with a minimum height of the water level of floods with a recurrence of 10 years plus 0.25 meters (Douven, 2009). JICA has developed planning and design standard for such freeboard based on discharge of flood water. According to this standard the minimum freeboard should be at least 0.6m if the flood discharge is $200m^3/S$ or more (JICA, 2002). In Bangladesh, there is no such study regarding climate proofing infrastructure planning. But in recent past it is observed that some organization is considering climate change induced flood as one of important planning and design consideration. For example, Bangladesh water Development Board (BWDB) inevitably considers climate change induced flood in designing embankment and polder in coastal area of Bangladesh. They consider 0.5-1.0m freeboard in designing polders. Recently in 2014, LGED has completed a project titled “Coastal Climate Resilient Infrastructure Project (CCRIP)” in coastal area of Bangladesh with financial assistance from Asian Development Bank (ADB) and International Fund for Agricultural Development (IFAD) to adapt with climate change induced flood. This project considers 0.5m freeboard above the anticipated climate change induced flood in designing roads in coastal areas of Bangladesh. However, it is clear that raising crest level of road may be one of the adaptation strategies. Pourashava engineer and experts from IWM, LGED have suggested to raise the road keeping 0.5m freeboard above design flood level due to climate change. However it is neither possible nor feasible to raise all the roads. Because it will involve huge cost on the other hand it will restrict to free flow of water. So most important road should be raised. The Pourashava engineer also suggested to raise most important roads. However the major Pucca roads having connectivity to various facilities such as educational facilities, health facilities, hat/bazaars, urban facilities and to other surrounding locality should be given utmost priority. Priority should be given to those roads that benefit the highest number of people and connect village markets with each other and growth centers. Such major roads include Sirajganj-Pabna road, Ullapara-Bogra road, Ullapara-Bera road, Ullapara-Sirajganj Road, Pourashava Road, Goshganti-Enayetpur Road etc. Other less important roads may be allowed to be inundated for free flow of water. The Map 6.1 shows the submergible roads and the roads that should be raised along with their corresponding additional height enhancement. To raise all those roads about 13.44 crore Tk would be required (Please see Table-4 of Appendix-D for detail calculation). Although the cost seems to be higher compared to damage cost nevertheless the road can be raised because this would onetime cost where damage occur more or less almost every year. Moreover road is the main component of communication system. If roads are inundated people would not be able to access many facilities, on the other hand if roads are not inundated people would be able to access the facilities. The Table-4 of Appendix- D shows the detail list those roads along with additional height requirements and corresponding cost of height enhancement. The Table 6.1 shows the summary of height enhancement in Ullapara Pourashava in response to climate change induced flood. The Table 6.1 shows that a total of about 36.44 km out of 91.93 km road should be raised in Ullapara Pourashava. Out of which highest percentage (23.74%) of road should be raised up to 0.7m. About 18.00%, 16.68% and 16.20% road should be raised up to 1.0m, 1.3m and 1.5m respectively. However a total of 25.15 km (69.03%) road should be raised more than 1m in Ullapara Pourashava.



Map 6.1: Height enhancement and subsidence of roads

(Source: Prepared by author; Data collected from IWM, LGED and ACAL)

Table 6.1: Summary of road height enhancement in Ullapara Pourashava

Additional Height (m)	Length (Km)	Percentage
0.2	0.23	0.63%
0.6	2.16	5.93%
0.7	8.65	23.74%
0.9	0.24	0.67%
1.0	6.56	18.00%
1.1	4.28	11.75%
1.2	0.85	2.33%
1.3	6.08	16.68%
1.5	5.90	16.20%
1.6	1.48	4.07%
Total	36.44	100.00%

(Source: Prepared by author, data collected from IWM, LGED, ACAL)

b) Construction of Culvert:

A culvert is a closed conduit used for the conveyance of surface drainage water under a roadway, railroad, and canal. Climate resilient design requires higher and wider road shoulders, additional culverts in the road infrastructure to cope with higher discharge volumes (IFAD, 2012). Several studies suggest that construction of culvert along the road may be one option to protect road infrastructure that may be vulnerable due to heavy load and pressure to be incurred by extreme flow of water due to climate change induced flood (JICA, 2002; Douven et al 2009; ADB, 1993; IFAD, 2012). Pourashava Engineer told that several roads were broken due to heavy load of flood water. He also added that in Ullapara Pourashava there is no sufficient number of culverts along the roads. As a result, the flood water overtopped the broad and caused destruction to the roads. Pourashava engineer and expert from IWM and LGED and RHD suggested to construct sufficient number of culverts along different roads to allow free flow of water. Pourashava engineer recommends to construct 12 culverts along Sirajganj-Pabna road, Ullapara-Bogra road, Ullapara-Bera road, Ullapara-Sirajganj Road, Pourashava Road, Goshganti-Enayetpur Road, Bhatta Kauak-Jhikra Road, Bhatta Kauak-Enayetpur Road to allow free flow of water. So the culvert should be constructed along those roads. Design specifications of culverts should be such that water flows in canals, small rivers and heavily flooded area are not obstructed. To quantify the location, size and number of culverts a hydrological study is required. It will assess the number, location and width of culverts needed.

c) *Construction Material*

It has already been discussed that there will be some submergible roads in Ullapara Pourashava that will be inundated during flood. However, the period of inundation by floodwater affects the load bearing capacity and strength of pavement layers significantly. According to Alam and Zakaria (2002) in case of inundation for 30-days, the stability of road materials reduces by 26 percent. The figure implies that the longer the period of inundation, the more severe will be the deterioration of road infrastructure. As flood is a perennial problem for Bangladesh and measures to prevent flood is not economically feasible, strategies to cope with flood may prove to be economically more justified. So climate change induced flood should be considered as a design parameter for designing roads. JICA (2002), Douven (2009), IFAD (2012) and other studies suggest that selection of material for construction of road is one of the design considerations for climate proofing infrastructure. There is no much study in Bangladesh regarding climate proofing construction material. However, a recent project by LGED with financial assistance from IFAD suggests that Reinforced Concrete Cement (RCC) can be used as surface material instead of Bituminous Carpet (BC) (IFAD, 2012). The experts from LGED, RHD and IWM told that the BC road is less durable and requires a higher maintenance than RCC roads. They also added that the advantage of RCC roads is that they are durable and resilient to flood and tidal surges, while they require very little maintenance as compared to other road types. So in case of Ullapara Pourashava RCC may be used as surface material of some important submergible roads to adapt with climate change induced flood. Other less important submergible roads may not require any intervention. The Map 6.1 shows the submergible roads where RCC may be used. Appendix- D shows in detail the list submergible roads with and without RCC. The Table-5 of Appendix- D shows the list of roads where RCC pavement may be used instead of BC pavement for about 37.50 km which will cost about 13.97 crore Tk.

6.2.1.2 Terminal facilities:

From the previous discussion (section 5.3.2 in Chapter 5) it is clear that the proposed terminal facilities in Ullapara Pourashava will be exposed to high level of inundation and it will hamper the total transport and communication system in Ullapara Pourashava and its adjoining areas. So we should rethink about proposing the terminal facilities' in Ullapara Pourashava.

The travel characteristics in and around the Pourashava suggests that there is no need for terminal facilities within the Pourashava at all. The terminal location should be in a locality where routes should logically connect or terminate. If the station is used as an intermediate stopping point on routes passing through, it should be conveniently located for passengers joining or leaving vehicles. There are several types of vehicle that are used in Ullapara Pourashava. These are bus, truck, pickup van, auto rickshaw motor-cycle, rickshaw, bi-cycle and van etc. The recent study by AQUA (2012) shows that the modal share in Ullapara Pourashava for Bus, truck, Car, auto-rickshaw, rickshaw and van are 31%, 4%, 6%, 31% and 11% respectively. Of them bus and truck serve as inter-Upazila and inter-district services. And other modes serve as local services. In Ullapara Pourashava one truck terminal has been proposed but it account for only 4% of total share and even they serve either inter-Upazila or inter-district services. So in no way for this small portion of transports a terminal can be proposed within Ullapara Pourashava. Although bus accounts for a major share (about 31%) but these bus are not also local transport. They also serve inter-Upazila or inter-district services and pass the Pourashava. For example a major share of such traffics follows the route along Dhaka-Pabna, Sirajganj-Pabna, Ullapara-Bogra, Ullapara-Bera etc. And neither origin nor destination of these buses is within the Pourashava. So these are not local traffics and no bus terminal is justified for these traffics. So it can be concluded that no bus or truck terminal is needed for Ullapara Pourashava; however, bus stop, tempo stops and rickshaw stand etc can be proposed in the Pourashava which also require detail transport study and the designated place should be kept in roadside and should be elevated above the maximum flood level. From the flood exposure analysis it is found that Tempo/Rickshaw stands are supposed to be exposed by 2.0-2.5m inundation. So Tempo/Rickshaw stands constructed having height above 2.5m to avoid climate change induced flood.

6.2.2 Educational infrastructure

The flood exposure analysis in section 5.4 of Chapter 5 made it clear that the educational infrastructure in Ullapara Pourashava will be highly exposed to climate change induced flood and this will compel it to un-operational during and post flood period limiting the access to education. Under this circumstance we have to rethink regarding the educational infrastructure of Ullapara Pourashava so that climate change induced flood do not hamper it operation during and post flood period. The teacher of educational institutions told that flood is a regular phenomenon in this area and this cannot be avoided. Almost every year they had to close the school during and beyond the flood period. Under this situation they suggests four options including a) construction of two storied building, b) raising the plinth level of existing structure above the anticipated highest flood level c) ensuring boat services during flood period and d) construction of new structure in high land. Several studies have been conducted on "climate change and education" especially in developing countries and these studies suggests several structural and non-structural adaptations measures for education in response to climate change induced flood (DFID, 2010; FEMA, 2004; FEMA, 2007; UNICEF, 2011; ZVAC, 2007). However, three types of alternative structural solutions can be devised from these studies to face the challenge of climate change induced flood. These are Relocation, Height Enhancement and Floodwall Construction. These are discussed bellow with reference to Climate change induced flood in Ullapara Pourashava.

6.2.2.1 Relocation

Relocation of educational infrastructure from flooded area to flood free area may be a solution to protect educational infrastructure from climate change induced flood inundation. But the flood inundation Map of Ullapara Pourashava shows that there is hardly flood free area in Ullapara Pourashava. It has been discussed with the

Pourashava Engineer, Local teachers and peoples regarding new schools as proposed in Master plan. They told that they do not want the new school in low lying area rather they suggested to relocate the new school in relatively high area within the scope of population and communication facilities. In this regard the researcher presented his proposal for relocation of new school with height enhancement. The local people visualized it and agreed with the relocation as proposed by researcher. So, new educational infrastructure may be constructed in less flood prone zone of Ullapara Pourashava if other criteria permit. In Ullapara Pourashava, additional 3 primary school, 4 secondary School and 3 colleges are proposed in highly flood prone area in Zone-D, Zone-E and Zone-F (see Map-5.3, Map-5.4 and Map-5.5). So the location of proposed educational infrastructure can be revised in less flood prone zone. The revised locations of the educational infrastructure have been presented in Map-6.2, Map-6.3 and Map-6.4.

6.2.2.2 Height enhancement

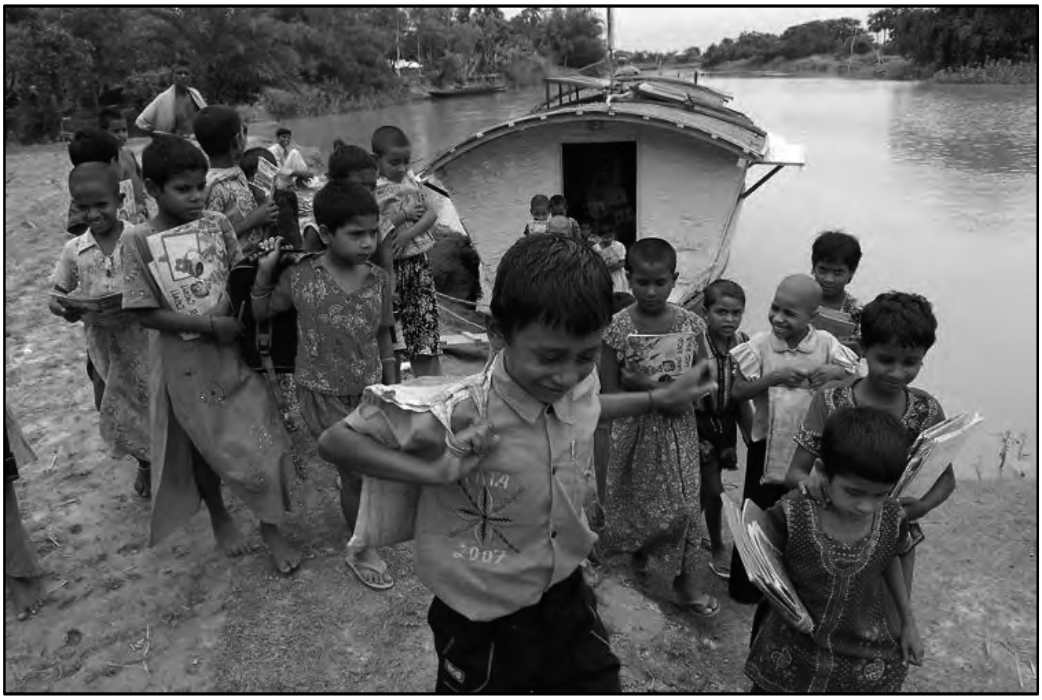
Another option for educational infrastructure to protect from climate change induced flood may be to elevate its base height above design flood level. The height enhancement can take two forms: either reconstructing the educational infrastructure on the same land making it elevated beyond the design flood level by earthwork (Figure 6.2) or the educational infrastructure can be constructed upon elevated column (Figure 6.3). The selection of the appropriate method of elevating an educational infrastructure in a flood hazard area depends on many factors, including cost, desired level of safety and property protection, and the nature of the flood hazard area. The freeboard of educational infrastructure may be 1m. That is the base height should be 1m above highest flood level. The local teachers told that almost every year they had to spend money to clean silt and repairing furniture. Instead if the structures were raised above flood level then they would not have to spend the money at the same time they could run the school even in flood. But they could not do this because of unavailability of school fund. In 2014 flood about a total of 25.25 Lakh Tk was required to clean silt and repairing furniture for ten primary schools, five secondary schools and three colleges (Please see Table-5.14, Table-5.15 and

Table-5.16 of Chapter-5). If the existing primary and secondary schools (katcha) are raised then the total cost for ten primary schools, five secondary schools would be about 60.06 Lakh tk (please see Table-1 and Table-2 of Appendix-D for detail calculation). Although it is seen that raising of structures of those institutions cost about four times than cleaning and repairing cost but it should be noted that cleaning and repairing cost incur almost every year. On the other hand raising cost would be for one time, this would not incur for every year. Another important aspect is that if the structures are raised then they can run the school during flood and 17,251 students can attend the school. However, for the katcha structure this options can adopted. The minimum heights of different types of educational infrastructure of Ullapara Pourashava in different locations are presented in the Map-6.2, Map-6.3 and Map-6.4. This height is based on freeboard and the maximum flood height in different location.

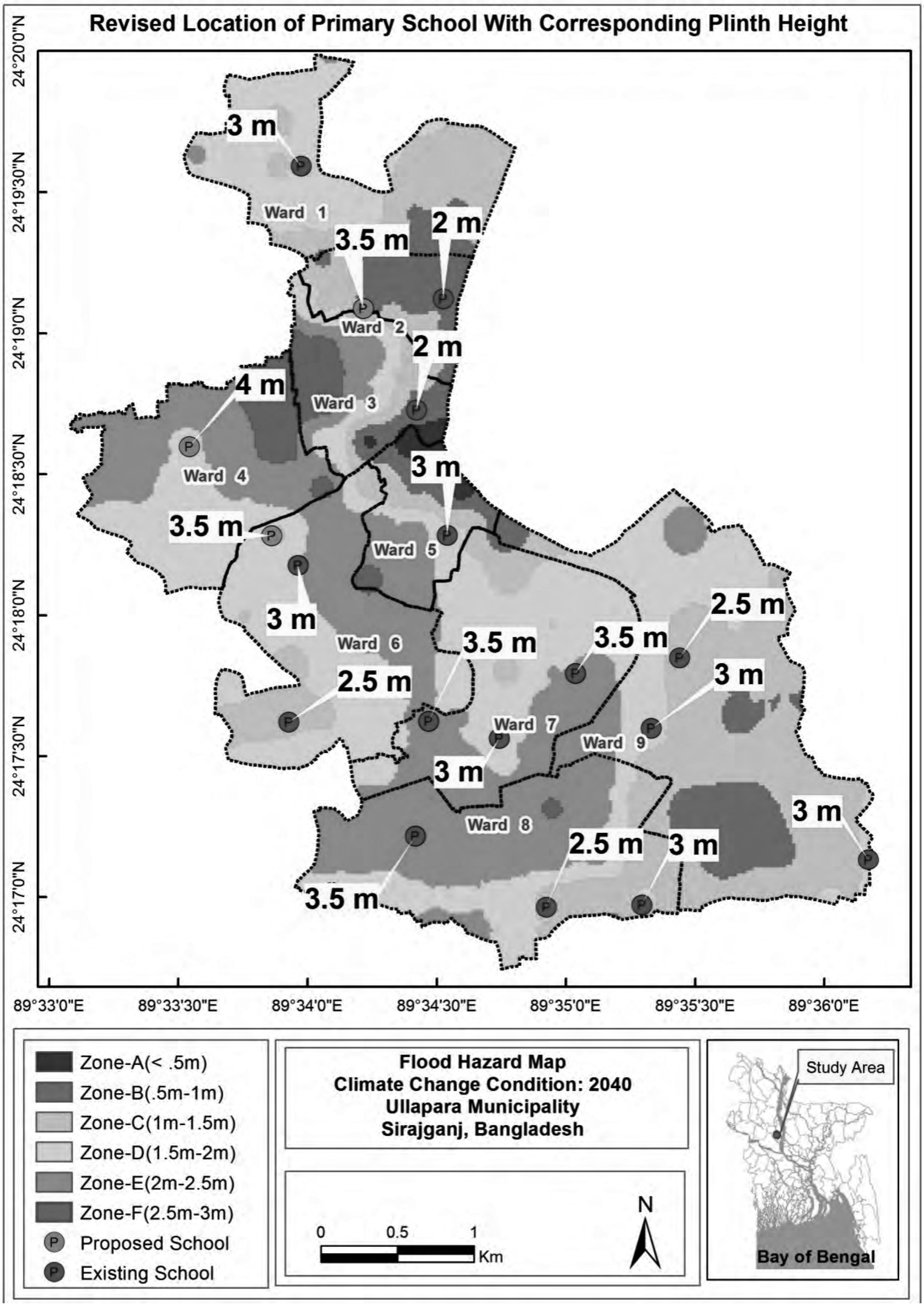
6.2.2.3 Boat services

Most of the teachers emphasized on ensuring boat services during flood because in floods some schools are not inundated but the students could not attend the school due to unavailability of communications facilities. Most of the roads are inundated during flood. Under this circumstances if boat services are ensured then the student could attend the school. It can be mentioned that boat services during flood has already been started in a few areas of Bangladesh. For example Hatibandha, a northwest area of Bangladesh, is accessible only by boat during the rainy season. Here schools often close for prolonged periods of time when floods occur, disrupting their education. In this area "Plan Bangladesh", an international, has started boat services that can take teachers and students to and from school during rainy season (Plan Bangladesh, 2014). An NGO named "Shidhulai Swanirvar Sangstha" has also started floating school and boat services in some flood prone areas of Bangladesh. Among others Boat schools in Chalanbeel is mentionable (Daily Amar Desh, 2008; Daily Shamokal, 2008).

Photograph 6.1: School students are going to school by boat supported by Shidhulai Swanirvar Sangstha *(Sources: http://www.fastcodesign.com/1671401/floating-schools-designed-to-fight-floods-in-bangladesh#9)*

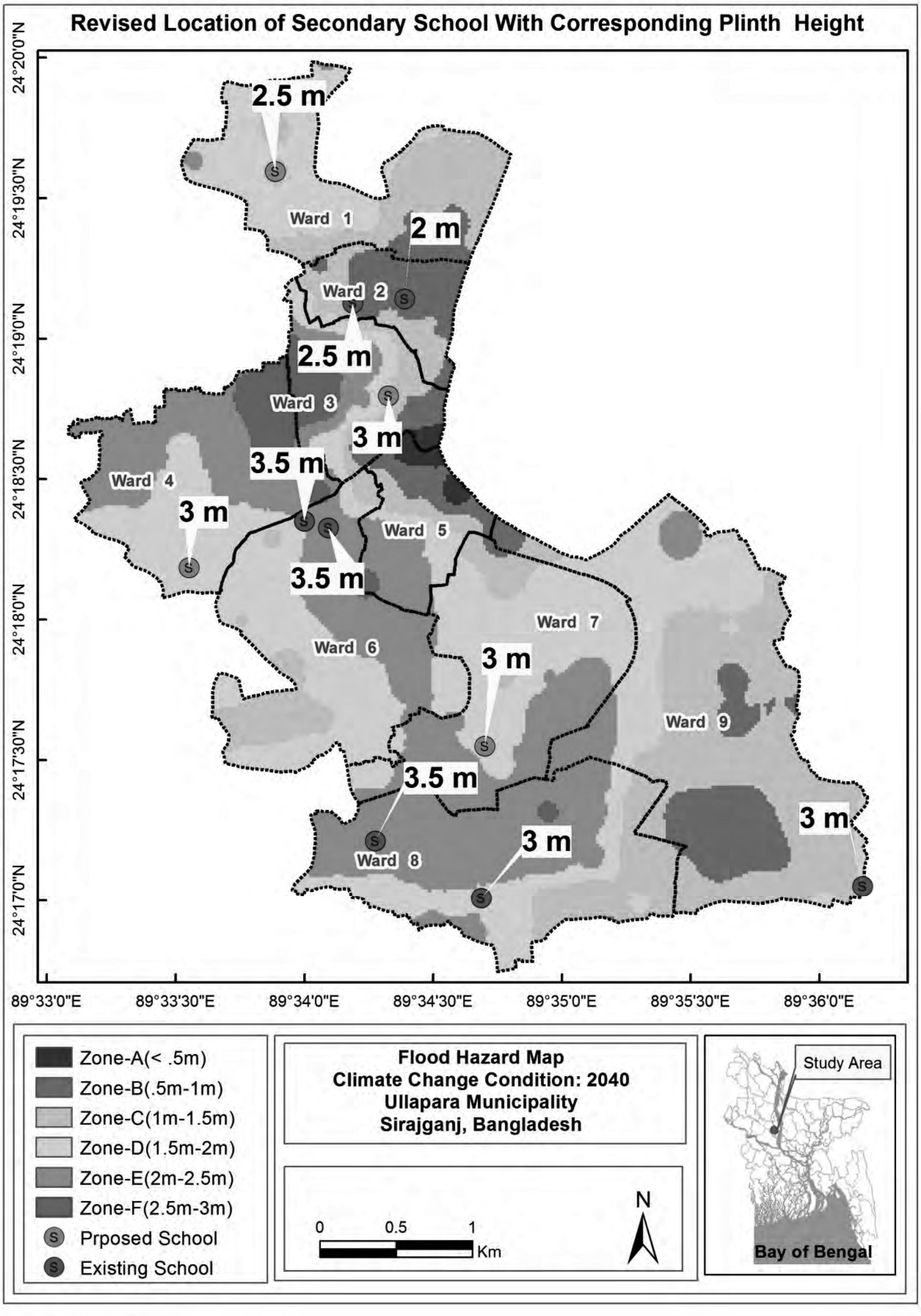


Photograph 6.2: School students are going to school by boat supported by Shidhulai Swanirvar Sangstha *(Sources: http://www.fastcodesign.com/1671401/floating-schools-designed-to-fight-floods-in-bangladesh#9)*



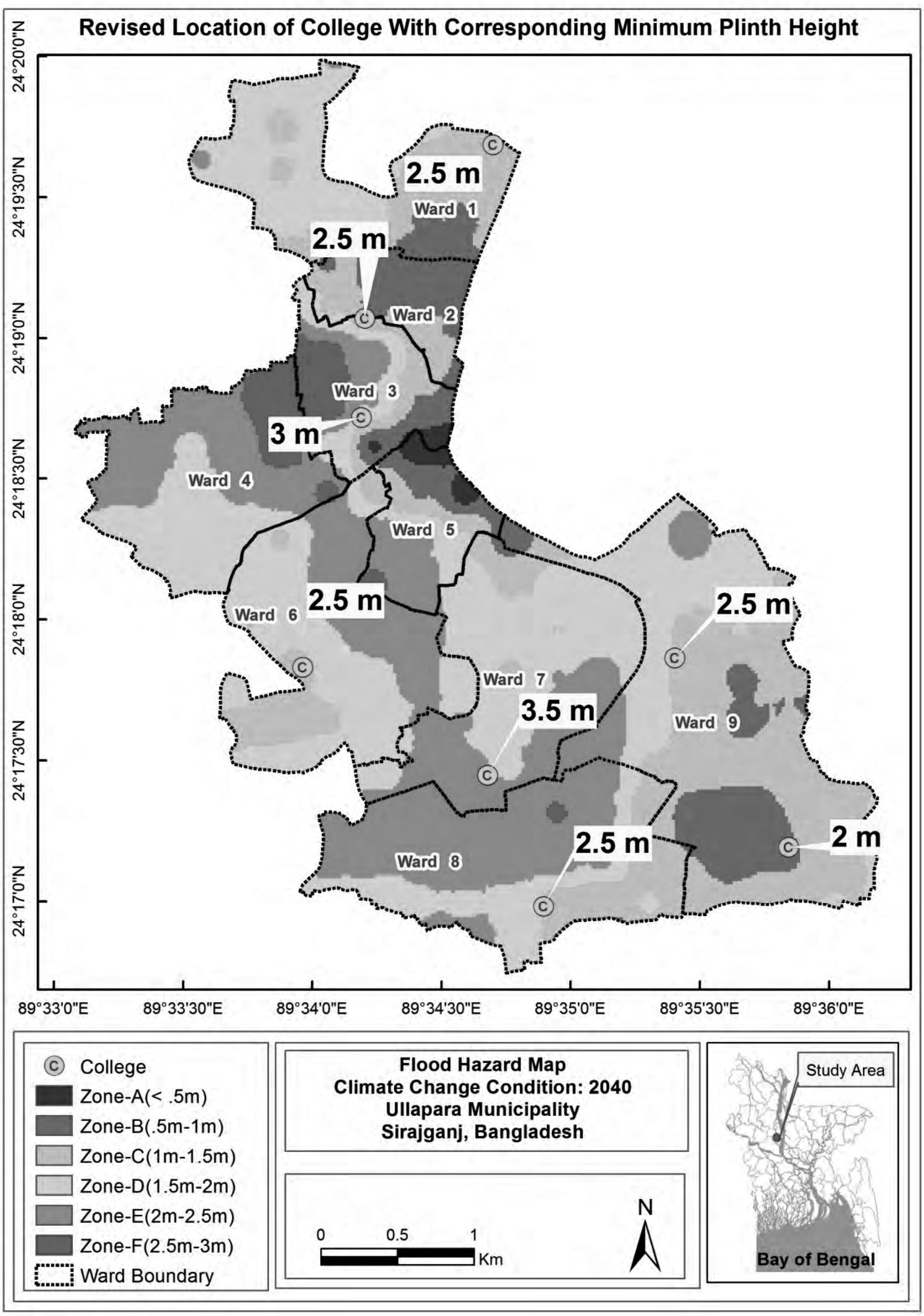
Map 6.2: Revised location of primary school with corresponding plinth height

Source: Prepared by author; Data collected from IWM, LGED and ACAL



Map 6.3: Revised location of secondary school with corresponding plinth height

Source: Prepared by author; Data collected from IWM, LGED and ACAL



Map 6.4: Revised location of college with corresponding minimum plinth height

Source: Prepared by author; Data collected from IWM, LGED and ACAL

Figure 6.2: Building on elevated earth

(Source: FEMA, 2004)

Figure 6.3: School constructed on elevated column to protect from flood

(Source: FEMA, 2004)

6.2.2.4 Floodwall:

Floodwall is another option to protect from flood. A floodwall is a primarily vertical artificial barrier designed to protect an area from flood water which may rise to unusual levels during seasonal or extreme weather events (Figure 6.4). Floodwalls are freestanding, permanent engineered structures that are designed to prevent encroachment of floodwaters. Typically, a floodwall is located some distance from a building, so that structural modification of the existing building is not required. Flood walls are mainly used on locations where space is scarce, such as cities or where building levees or dikes (dykes) would interfere with other interests, such as existing buildings, historical architecture or commercial use of embankments. A floodwall is a significant structure that is designed to hold back water of a certain depth based on the design flood for the site. Generally, due to design factors, floodwalls are most effective in areas with relatively shallow flooding and minimal wave action. So floodwall can be used to protect educational infrastructure from climate change induced flood in Ullapara Pourashava. This strategy can be adopted for pucca structure that cannot be elevated. For example existing colleges are pucca and they cannot be elevated. So flood wall can be constructed around existing Colleges. The total cost of constructing flood wall around existing three colleges may be of about 46.74 Lakh tk (please see Table-4 of Appendix-D).

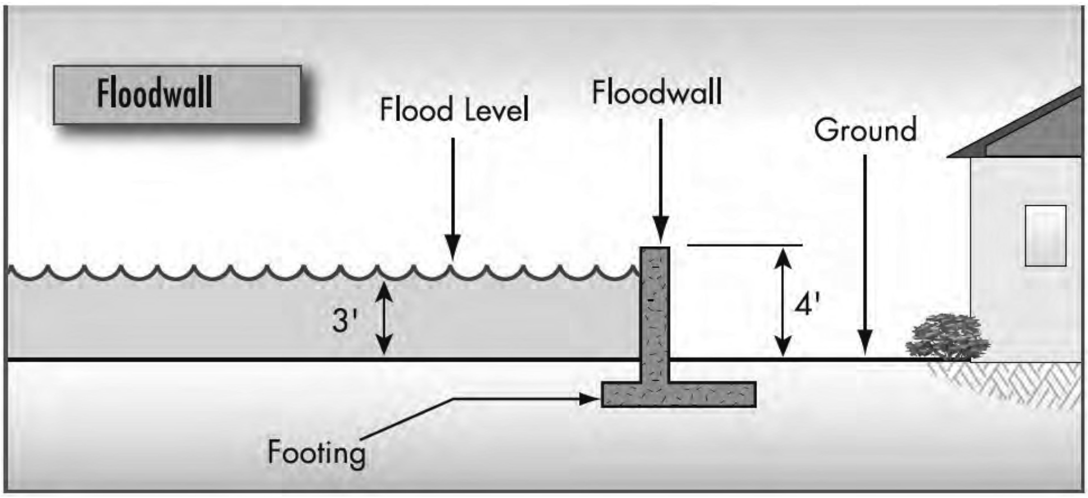


Figure 6.4: A typical floodwall to protect structure from flood

(Source: FEMA, 2007)

Figure 6.5: Structure surrounded by flood wall to protect from flood

(Source: FEMA, 2007)

However, adaptation measures should include hazard specific school design and construction, retrofitting the existing schools to withstand further hazards, flexible school calendar and test schedule, provision of emergency pool of teachers and educational materials, food, water and medicine storage for children in schools, include climate change in curriculum for both teachers and students, community awareness about continuing education during hazards. The following Table-6.2 shows the summary of suggestion for educational infrastructure.

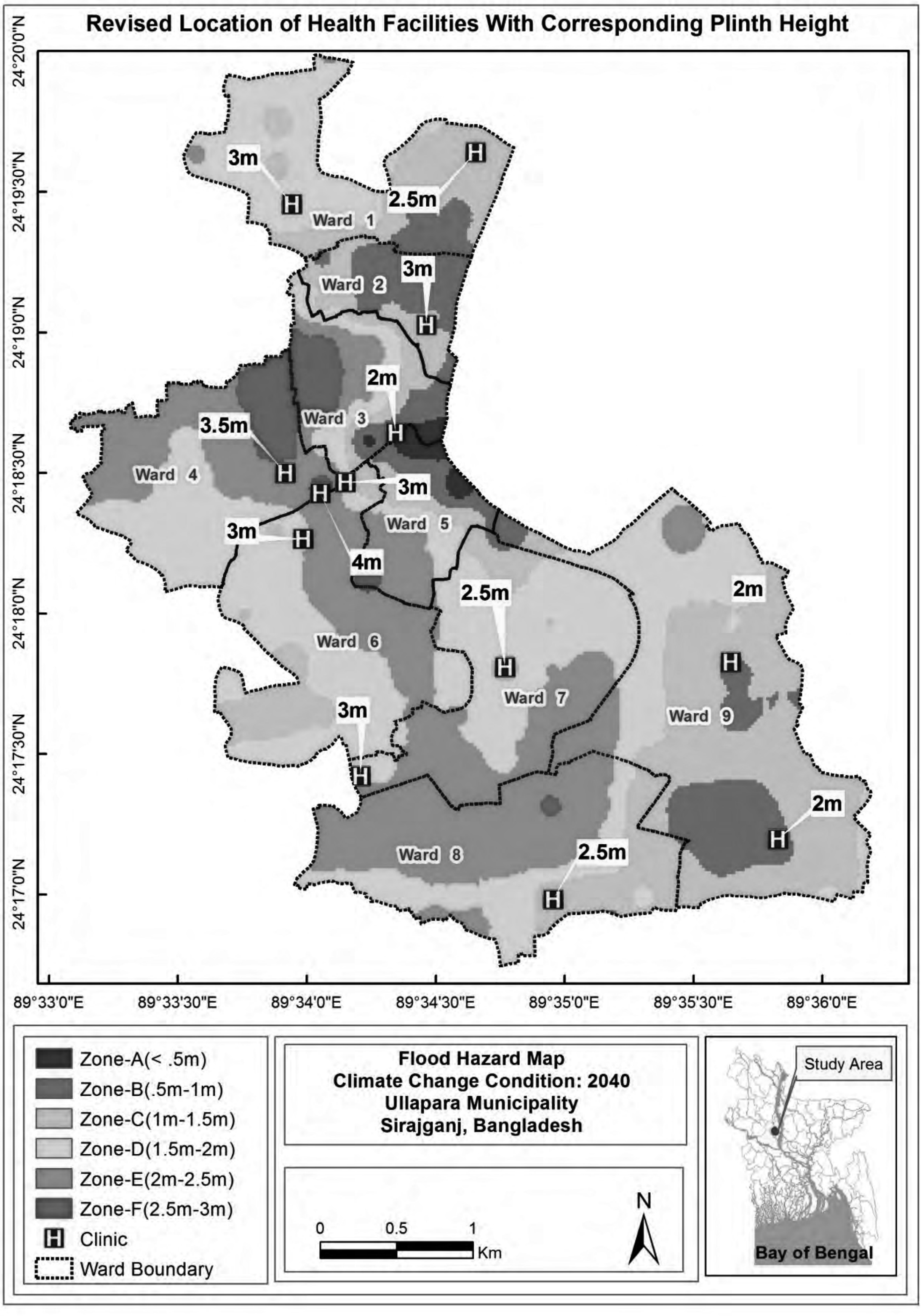
Table 6.2: Summary of suggestion for educational institution

Institution	Status	Suggestion
Primary School	Existing	Height Enhancement
	Proposed	• Relocation and Height Enhancement (Proposed school in Ward 4 and 6) • Height Enhancement (Proposed school in Ward 7)
Secondary School	Existing	Height Enhancement
	Proposed	• Relocation and Height Enhancement (Proposed school in Ward No 1 and7) • Height Enhancement (Proposed school in Ward No 3 and 4)
College	Existing	Flood wall construction
	Proposed	Height Enhancement

NB: For detail please see the Table-1, Table-2 and Table-3 of Appendix-D

6.2.3 Health infrastructure

The impact of climate change on human health has already been discussed in section 5.5 of Chapter 5. It has been also discussed how climate change induced flood will affect access to health care services in Ullapara Pourashava. It is evident from the discussion of section 5.5 of Chapter 5 that total hospital facilities was severely disrupted during and post flood period. In future this situation will be aggravated due to climate change induced flood. Thus, the planning, design and construction of health infrastructure needs to take into account the likely physical threat from flood events. Anticipated disruption in access to health care infrastructure during flood in Ullapara Pourashava emphasize the need for guidelines to ensure as far as possible that health care infrastructure is built outside flood zones or designed to function effectively in a flooded environment. At present there are 6 clinics in the Pourashava and new 7 health facilities have been proposed. But flood exposure study shows that most of the health facilities would be highly exposed to climate change induced flood in Ullapara Pourashava. This inundation scenario leads to rethinking in the plan. Based on the findings of this study along with other international studies, discussion with the health officials and local people three options may be taken to adapt with climate change induced flood. Firstly, flood wall construction around the health infrastructure; secondly height enhancement of infrastructure and thirdly relocation in a less flooded zone. Floodwall may be used for existing infrastructure because relocation or reconstruction may be much costly. If flood walls are constructed around existing five health facilities about 36.40 Lakh Tk (Please Table-7 of Appendix-D) would be required. For newly proposed health facilities height enhancement that is construction of infrastructure above the design flood level may be appropriate option. The Map 6.5 shows revised health infrastructures locations with minimum height for each health infrastructure to avoid flood. The minimum height should be 1 meter more than design flood level. In this revised location, new health infrastructure has been proposed in less flooded zone.



Map 6.5: Revised location of health facilities with corresponding plinth height

Source: Prepared by author; Data collected from IWM, LGED and ACAL

6.2.4 Urban facilities

6.2.4.1 Community facilities

From the previous analysis in section 5.6.1 of Chapter 5, it is seen that the proposed community center in Ullapara Pourashava is supposed to be exposed to climate change induced flood for about 2m-2.5m falling Zone-E and this inundation will disrupt to serve the purpose during and after flood. So we have to rethink regarding the community center planning in Ullapara Pourashava. There may be several options for community services to adapt with climate change induced flood in Ullapara Pourashava. These are relocation and elevation consideration. From the Map 5.7 it is seen that proposed community facility is at Zone-E which is highly flood prone area having 2.5m possible flood inundation. So the community center can be proposed in nearby Zone-C which is comparatively less flood prone area having maximum flood inundation of about 1.5m. If community center is proposed in Zone-C then minimum height of the plinth should be at least 2m considering 0.5m freeboard to make it flood free. Proposed area of community center is about 1000m2. Unit cost of earthwork is about 400Tk/m2. Thus it will take about 8.00 lakh taka for the earthwork. Revised location of community center with minimum height has been presented in Map-6.6.

6.2.4.2 Fire Station

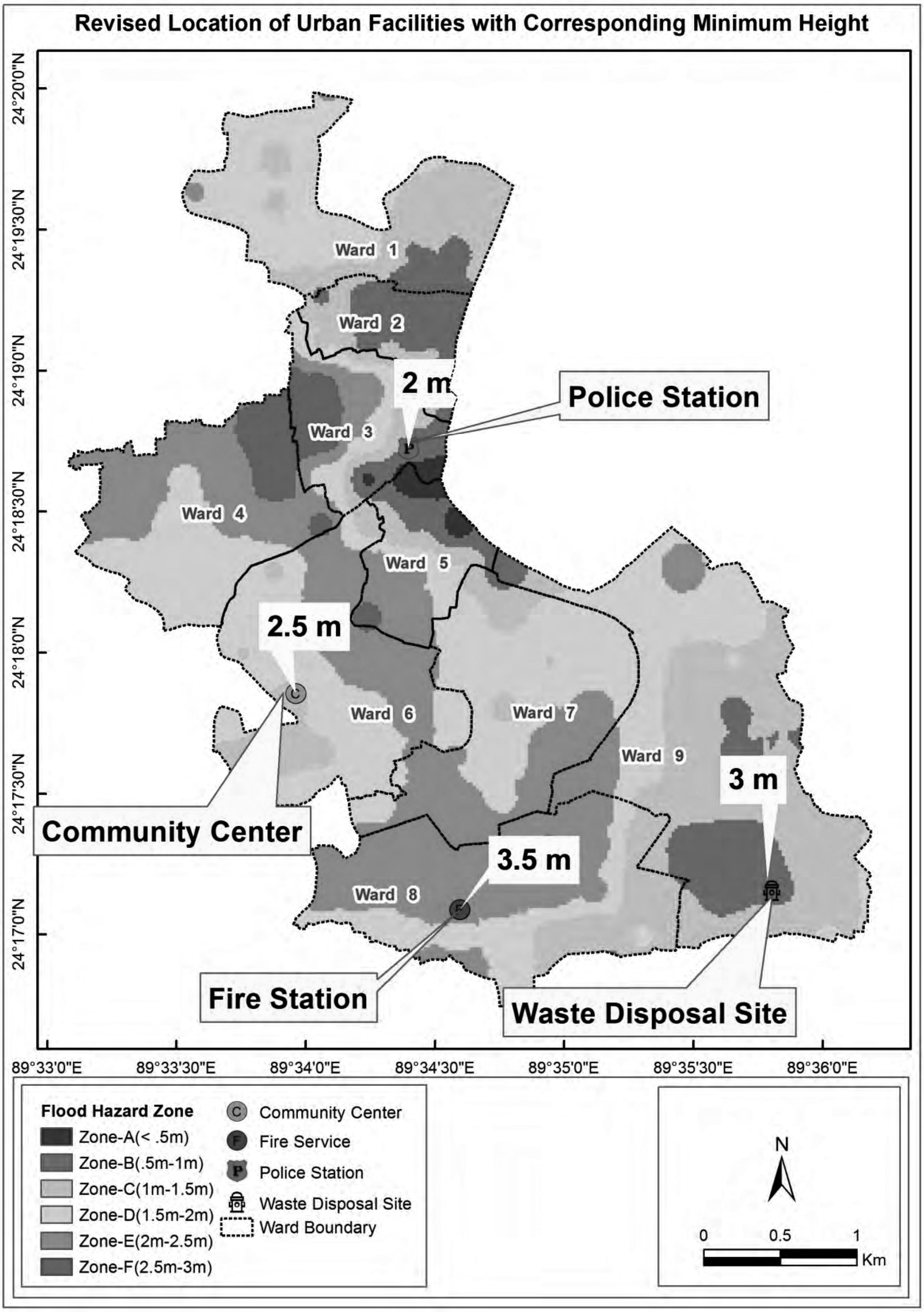
The flood exposure analysis and discussion in section 5.6.2 made it clear that the existing fire station in Ullapara Pourashava will be exposed to climate change induced flood for about 2.0m-2.50m inundation depth due to climate change induced flood and this will compel it to un-operational during and post flood period and which will further lead to severe losses of lives and properties. Under this circumstance we have to rethink regarding the fire station of Ullapara Pourashava so that climate change induced flood do not hamper it operation during and post flood period. Ideally, the emergency response facilities should not be located in a floodplain or a site exposed to other types of hazards. However, emergency response facilities, especially fire station and police stations, must contend with geographic limitations pertaining to size and adequate coverage of their service areas that frequently place them in hazardous locations. One option to avoid flood is relocating fire station in flood free zone or in less flood prone zone. But in Ullapara Pourashava there is hardly flood free zone. One the other hand relocation of fire station in less flood prone zone may not be wise because it will require acquisition of new land which will incur addition cost and at the same time it is very difficult. In this case, two alternative solutions can be devised to face the challenge of climate change induced flood for fire station in Ullapara Pourashava. These are height enhancement and construction of floodwall. These two options are already discussed in section 6.3.2 and 6.3.3. However, the existing fire station is supposed to be exposed about 2.50m. Existing height of the structure is 1.4m. So the height of the flood wall should be 2.6m considering 0.5m freeboard and 1m base under earth. The perimeter of the flood wall would be approximately 100m and total area the flood wall would be 260m2. Thus the total cost would be approximately about 7.8 Lakh considering the unit cost is 3000/m2 cost.

6.2.4.3 Police Station

For police station, similar adaptation strategies can be taken like fire station. However, the existing police station is located in Zone-B having 1m inundation. Existing height of the structure is 1m. So height of the flood wall may be only one meter above plinth level. So the total height of the flood wall should be 2m considering 1m base under earth. The perimeter of the flood wall would be approximately 120m and total area would be 240m^2. Thus total cost of constructing flood wall around the station would be about Tk. 6.00 Lakh considering unit cost is 3000Tk/m2.

6.2.4.4 Solid waste disposal site

Waste generation increases with population expansion and economic development. Improperly managed solid waste poses a risk to human health and the environment. Uncontrolled dumping and improper waste handling causes a variety of problems, including contaminating water, attracting insects and rodents. Improper waste management also increases greenhouse gas (GHG) emissions, which contribute to climate change. Solid waste disposal site is an important part of whole waste management system. So the selection of waste disposal site is crucial. One criterion locating waste disposal site is that it should not be located in flood-prone areas. That is flood prone area has to be avoided first in locating waste disposal site due to its negative impact as discussed earlier. However, if waste disposal site has to be located in flood prone areas due to unavoidable situation then special care and adaptive measures has to be taken. From the flood exposure analysis it is found that the proposed waste disposal site is supposed to be exposed to 2.0m-2.50m inundation due to climate change induced flood. If the proposed waste disposal site is located in such potential flood zones then it will pose a threat to surrounding areas and surface/groundwater bodies of Ullapara Pourashava due to waste emissions and subsequent pollution. Even the site has been proposed in northern side of the Pourashava. Executive Engineer of Ullapara Pourashava told that flood water flows north to south direction in this area. He thinks that it was not wise to propose waste disposal site in such low land and even in north side. So the proposed site may be shifted in Zone-A of Ward-9 and only 1m earthwork is needed to make it flood free. Proposed area of dumping site is about 1600m2. Unit cost of earthwork is about 400Tk/m2. Thus it will take about 6.4 lakh taka for the earthwork up to 1m height. Revised location and minimum height of dumping site is presented in Map-6.6.



Map 6.6: Revised location of urban facilities with corresponding minimum plinth height

Source: Prepared by author; Data collected from IWM, LGED and ACAL

6.2.5 Expert opinion for local level action

Most of the experts emphasized on local level action planning in response to climate change. They argued that local authorities experience the actual scenario and adverse impact due to flooding. They will better understand what may be the adaptation strategies; what will work and what will not work in the local condition. So they should come first to take action regarding climate resilient planning. According to the experts following may be the local level adaptation strategies that local authorities can adopt.

6.2.5.1 Flood hazard mapping

Most of the experts (IWM, IWFM, DoE, and BRAC) suggest that flood hazard mapping is the first step in the process of adaptation strategies. They explained that hazard mapping will help better understand and communicate flood extent and flood characteristics such as water depths and velocity. Multiple stakeholders such as city managers, urban planners, emergency responders and the community at risk can use hazard maps in planning long term flood risk mitigation measures and the appropriate actions to be taken in an emergency.

6.2.5.2 Storm water storage pond and improved drainage system:

According to experts (IWM, BRAC, IWFM) climate change will cause excess rainfall and this will lead to sudden raifed flood and water logging in urban area. This is supported by many studies as mentioned in section 2.4.2 of Chapter 2 that monsoon rainfall may increase by 10-15% by the year 2030 and by 15-20% by the year 2050 (Warrick et al., 1996); 11% and 28% increases over Bangladesh by the year 2030 and 2075, respectively (Alam et al.,1999). To tackle this type of rainfed flood and water-logging experts advocate to concentrate on storm water retention pond and improved drainage system in urban area. Drainage system should be facilitated with adequate culvert to allow free flow of water. This recommendation is also justified by various researches (WB, 2012; Catherine et al, 2007; CIRIA, 2000; Morgan, 2007). They argued that storage pond and improved drainage system will manage storm water runoff to prevent sudden flooding in urban area that may be caused by heavy rainfall due to climate change. They also recommend that the depth and design of pond, drainage system and culvert should be based on specific hydrological characteristics of the locality.

6.2.5.3 Climate sensitive infrastructure planning and design

Experts (IWM, IWFM, LGED, AQUA) also focus on careful design of buildings and infrastructure that can reduce the vulnerability and risk to flood damage. Infrastructure can be planned and designed considering future climate change induced flood. To avoid inundation from flooding infrastructure can be constructed on elevated ground or should be raised beyond the expected flood level. Important infrastructure may be protected from flood by constructing floodwall. Construction material should be so chosen that it can withstand with flood water without destroying. Infrastructure should be constructed in relatively less flood prone zone. Flood hazard mapping should be used as reference for the purpose.

6.2.5.4 Risk sensitive land use planning

Risk Sensitive Land Use Planning (RSLUP) contributes both to mitigation of and adaptation to urban floods. Land use planning and the regulation of new development is a key aspect of integrated urban flood risk management. Urban floods are also caused by the effects of deficient or improper land use planning. Experts also suggest that Risk-based land use planning should be adopted. Risk-based land use planning identifies the safest areas in order to prioritize immediate investments in urban development and infrastructure projects. Land use plans should influence the location, type, design, quality, and timing of development. Mainstreaming risk-based land use planning in infrastructure projects may reduce risk in the rapidly urbanizing centers that are prevalent in hazard-prone areas and exposes where high concentrations of population and economic assets are at risk (IWM, WARPO, and LGED).

6.2.5.5 Land zoning

Land Zoning refers a set of a rules for the settlement of the areas at most risk of flooding, with the aim of minimizing future material damage and loss of human life as a result of major floods. The strict land zoning should be introduced and implemented in the flood plain area allowing rational development of riverside areas.

The regulation of the use of flooding zones should be based on maps marking out areas of different risks (hazard mapping) and on the criteria for occupying them, as well as for the construction aspects. In order for these regulations to be used, for the benefit of the communities, they should be integrated into municipal legislation on housing developments (or subdivisions), buildings and dwellings, so that they can be enforced (LGED, WARPO).

6.2.5.6 Early warning system

Flood early warning system should be effectively introduced at local level. Local level warning system should also include forecasting about intense and/or prolonged rainfall and how this condition may translate into flood hazards. At present there is a Flood Forecasting and Warning Center (FFWC) under BWDB which provides flood forecasting and warning services all over the country to minimize or mitigate loss of life and damage of properties. But there is no integrated system incorporating local level authority such as municipality to disseminate the real time information at local level. The center needs to be strengthened in terms of its capacity and dissemination of real time information at local level so that local people can prepare for the flood hazard. This system should be upgraded and up-to-date and it should be ensured that flood information. Early warning system should be designed and implemented with a clear understanding of local perspectives and requirements; it should target all sections of society including decision makers, educators, professionals, members of the public and individuals living in exposed areas; messages should be designed in a way that can reach the different target audiences on time (BWDB, IWM).

6.3 The regional level:

Local authorities face different obstacles in their efforts to design and implement adaptation policies. Such obstacles to local policy design can be of a variety of natures including jurisdictional and institutional and economic and budgetary (Juhola, 2010; ICLEI, 2011; Pahl-Wostl, 2009). Important limitations of local level authority relate to the scale of intervention. For example, local level authority can raise road elevation to safe road infrastructure from inundation but municipalities cannot solve the problems of climate change induced river flooding of their own; they are not able to operate at the basin level management of river. This requires up-stream interventions of regional approach. (EEA, 2012; Nicholls, 2004). Moreover, the cross-border nature of flooding requires a regional approach in which local measures should embedded. Under changing climate scenario, flood risk management plans should involve a region much larger than the city itself (EEA, 2012). Thus effective climate change adaptation requires consideration of cross-scale management concerns and at the same way any action that crosses jurisdictions from local to regional to national can be best planned using a perspective that takes into account all levels of management (Adger et al., 2005).

It has already been stated that Sirajganj district is located in the bank of Jamuna River which is one of the rivers of GBM basin (Ganges-Brahmmaputra-Meghna) through which the impact of climate change induced flood will be observed across the country (DoE, 2006; DFID, 2007; WB, 2010a; WB, 2010b). So increase in water level in Jamuna River due to climate change will cause flooding in the surrounding area. Solutions to flooding problems under climate change conditions can be achieved by adopting and exercising watershed-scale best management practices that include: floodplain zoning, planned urbanization, restoration of abundant channels and lakes, dredging rivers and streams, efficient storm sewer systems, establishing buffer zones along rivers, and improvement on flood warning/preparedness systems (Khalequzzaman, 1994; Rashid and Paul, 1987; Haque and Zaman, 1993). But Ullapara Pourashava, as a local level authority, is not capable to address river management and even they are not responsible for river basin management. It requires regional approach of river basin management from upper level authority. In Bangladesh, BWDB, RRI and WARPO are responsible for such course of actions. Most importantly, BWDB is responsible to develop and manage water resources in the country. So these organizations can take initiative for flood management strategies in Jamuna River to adapt with climate change induced flood.

6.3.1 Expert opinion for regional level action

Experts from various organizations suggested the following adaptation strategies at regional level in response to climate change induced flood. Their recommendations are summarized below.

a) Dredging of major rivers, tributaries and distributaries for mitigation of flood and erosion and to improve navigability (BWDB).
b) Floodplain policy and act can be formulated. Under this provision floodplain zoning should be introduced to reduce flood plain development; to reserve space for water. Landowners who wish to develop in these areas should require permission from the concerned authority prior to any development. In such case, if permitted, the authority should determine site specific design criteria e.g elevation, drainage etc (WARPO, LGED).
c) Planned urbanization should be ensured; flood risk management should be incorporated in regular urban planning practice that can cope with a changing climate and uncertainties (LGED, IWM).
d) Restoration of abundant channels, lakes and khals to allow free flow of water during flood (BWDB)
e) Construction of embankment with adequate sluice gates for controlled water flow (BWDB, LGED).
f) Controlling flood through structural measures is hardly possible in Bangladesh. As part of non-structural measures, flood forecasting and effective and organized early warning system should be introduced to reduce the flood risks. People-centered early warning systems will empower communities to prepare for and confront the destructive nature of flood (BWDB, IWFM).

6.4 National level:

Another level in climate change adaptation strategies is the National Level. Cities do not act in a vacuum. They are embedded in a legal and institutional context set by national governments (Keskitalo, 2010b). Although regional level authority is significant in climate change adaptation, Regional level authority has limitations in national policy level action in terms of their scope, mandate and institutional backing. The specific role that regional governments can take depends on the dynamics of national structures. (Young, 2002; Haddad, 2005; Keskitalo, 2010a). This leads to need for national level authority to be strongly engaged in climate change adaptation. National governments can provide a strategic framework. They can set the framework by developing national legislation and creating a variety of standards and incentives (Swart et al., 2009). National governments can formulate climate-proof national legislation and policy and mainstream adaptation into different areas whilst ensuring that national policies are also coherent and supportive for local adaptation (Corfee-Morlot et al., 2009). Many countries including Japan, Finland, Denmark, Sweden, Germany and Norway have their own national adaptation strategies and policy in response to climate change (Swart et al. 2009). Thus flood risk management needs to be embedded at a national policy level of Bangladesh. This requires relevant and responsible agencies/departments/institutions to establish policy positions that provide guidance to other arms of government and the community.

Likewise other countries, Bangladesh has also national adaptation strategies and policy in response to climate change. There are mainly two national level strategies and policy exist in Bangladesh namely National Adaptation Programme of Action (NAPA) and Bangladesh Climate Change Strategy and Action Plan (BCCSAP).

6.4.1 National adaptation programme of action

In 2005, Bangladesh developed the National Adaptation Programme of Action (NAPA) after extensive consultation with communities across the country, professional groups; and other member of civil society. NAPA for Bangladesh has been prepared by the Ministry of Environment and Forest (MOEF), Government of the People’s Republic of Bangladesh as a response to the decision of the Seventh Session of the Conference of the Parties (COP7) of the United Nations Framework. The whole preparation process was guided by the a high powered Project Steering Committee headed by the Secretary, Ministry of Environment and Forests and member from other key ministries, department and agencies including Ministry of

Finance and Planning. The basic approach to NAPA preparation was along with the sustainable development goals and objectives of the country where it has recognized necessity of addressing environmental issue and natural resource management with the participation of stakeholders. Policy makers of Government, local representatives of the Government (Union Parishad Chairman and Members), scientific community members of the various research institutes, researchers, academicians, teachers (ranging from primary to tertiary levels), lawyers, doctors, ethnic groups, media, NGO and CBO representatives and indigenous women contributed to the development of the NAPA for Bangladesh. The NAPA of Bangladesh draws upon the understanding gathered through discussion with relevant stakeholders in four sub-national workshops and one national workshop, prior research, background papers prepared by Six Sectoral Working Groups (SWG) i.e. a) Agriculture, Fisheries and Livestock coordinated by Bangladesh Agricultural Research Council (BARC), b) Forestry, Biodiversity and Land-use coordinated by IUCN, Bangladesh, c) Water, Coastal Zone, Natural Disaster and Health coordinated by Water Resources Planning organization (WARPO), d) Livelihood, Gender, Local Governance and Food Security coordinated by Bangladesh Institute for Development Studies (BIDS), e) Industry and Infrastructure coordinated by Department of Environment (DoE), and f) Policies and Institutes coordinated by Bangladesh Centre for Advanced Studies (BCAS), and expert judgments.

6.4.2 Bangladesh climate change strategy and action plan

In 2009, the Ministry of Environment and Forest, government of Bangladesh formulated a policy, the Bangladesh Climate Change Strategy and Action Plan (BCCSAP), as a guideline on priority projects that address the country’s climate change adaptation plan. This document has been prepared as a living document in the development priorities in the country. To this end, the government formed a cabinet review committee under the chairpersonship of the Hon’ble Minister for planning with other members drawn from among the ministers and secretaries of all relevant ministries. The present revised version of the BCCSAP 2009 has followed the guidelines and incorporates the views and thinking of the Cabinet Review Committee. BCCSAP (2009) has identified 44 different programmes within six thematic areas, including: food security, social protection and health; comprehensive disaster management; infrastructure; research and knowledge management; mitigation and low carbon development; and capacity building and institutional development (BCCSAP, 2009).

Now the challenge is to translate the national policy into local level planning and implementation. As the magnitude and long-term nature of the climate change threat is increasingly better understood, it is becoming clear that simply implementing a set of adaptation projects, although useful, is not going to be sufficient. If long-term resilience to climate change impacts is to be built into the economy and society of the country, then climate change adaptation (as well as mitigation) needs to be embedded (or mainstreamed) into regular national development planning and actions. Moreover, mainstreaming climate change into planning needs to be done at every level, not just national plans. Thus sectoral ministries such as local government, water management, agriculture, health and others also need to mainstream climate change into their respective sectoral plans.

6.4.3 Expert opinion for national level action

Experts from various institutions suggest the national level recommendations for infrastructure planning in response to climate change induced flood. Summary of their suggestions are listed below:

a) Climate change adaptation needs to be mainstreamed into national development planning including policy-making, budgeting and implementation processes (DoE, WARPO).

b) Priority activities as outlined in NAPA should be implemented (DoE, LGED). There are four types of activities viz intervention, research, capacity building and Awareness Building. About 15 projects have been identified as priority activities following iterative process. Among them project no 3 and 8 are most important for the current research. These two projects are as follows:

   - *Capacity building for integrating Climate Change in planning, designing of infrastructure, conflict management and land-water* *zoning for water management institutions. Responsible agencies are WARPO, DoE(Climate Cell) CEGIS, IWM and BWDB, LGED,RHD, MoL, MoWR, MoEF, DAE, DoF.(Project No-3)*

- *Enhancing resilience of urban infrastructure and industries to impacts of climate change. Responsible agencies are DoE and LGED, UDD(project No-8)*

c) There should be interdisciplinary co-operation at all level of government for a co-ordination of sectoral policies regarding environmental protection, physical planning, landuse planning, agriculture, transport and urban development, and a co-ordination regarding all phases of risk management: risk assessment, mitigation planning and implementation of measures (WARPO, LGED, BRAC).

d) International cooperation on climate risk adaptation and flood risk management is necessary to strengthen the knowledge and information base as well as financial assistance (BRAC, LGED, IWM).

In case of infrastructure (urban) planning in Bangladesh, concerned ministries are Ministry of Local Government, Rural Development & Cooperatives and Ministry of Housing and Public Works. Different departments including UDD, LGED, Municipalities, City Corporations and Development Authorities (e.g. RAJUK, CDA, KDA, RDA etc) are engaged in urban planning of Bangladesh. These ministries along with Ministry of Environment and Forest can prepare national adaptation policy for urban and/or infrastructure planning. Once adaptation policy is prepared it has to be circulated among concerned departments to be followed while preparing urban plan and thus the adaptation strategies should be mainstreamed and translated into local level planning.

Chapter 7: Recommendation and conclusion

7.1 Introduction

In previous chapter detail adaptation strategies were discussed in response to climate change induced flood in Ullapara Pourashava. Those adaptation strategies were based on flood exposure analysis of infrastructure, literature review and expert opinion. Although those adaptation strategies were devised for Ullapara Pourashava but the adaptation strategies can be applied for any flood prone area in Bangladesh. In this chapter the recommendation has been made regarding adaptation strategies for flood prone area in Bangladesh based on study findings. The recommendation has been summarized in three categories: local, regional and national.

7.2 The local level

The effects of climate change will have direct and indirect implications for local governments (UKCIP, 2003). Local authorities are in a unique position to develop tailored responses to the impacts of climate change because they have first-hand knowledge of local conditions and can develop proactive strategies in response to climate change (Piorr et al., 2011). Local governments may have a role in encouraging adaptation in new buildings and infrastructure through motivating and educating the community, providing incentives and regulation. However, Local government decision-making with regards to planning and development is generally steered by policy and legislation at the state government level (McLeman, R. and B. Smit, 2006). In following sections local level actions are summarized.

7.2.1 Road

a) Road elevation should be raised above the anticipated highest flood level due to climate change. The elevation of the road may be different based on flood inundation level. However, it is not possible neither feasible to elevate all the roads because elevating every roads may create obstacles to free flow of water. So major important Pucca roads having connectivity to various facilities and to other surrounding locality should be considered for height elevation. Other roads may be allowed for inundation.

b) Height enhancement of road may hinder free flow of flood water and sometimes road may be damaged due to heavy flow of flood water. To avoid such difficulty sufficient number of culverts should be constructed along the road. The location, size and number of culverts should be based on hydrological study of the specific area.
c) Climate resilient material should be used for road construction to cope with the climate induced flood. RCC pavement may be used instead of BC pavement in case of submergible roads.
d) For construction of new road, land elevation and flood inundation depth should be considered. It should be tried to be constructed in high elevation area. For this flood zoning map should be used.
e) Higher elevation of road may be applicable to major roads. Submergible roads can be designed and identified which can go under water during flood season. This may be considered to ensure free flow of water.

7.2.2 Educational infrastructure

a) Educational infrastructure may be relocated from flooded area to flood free or less flood free area to avoid flood inundation if other criteria permit. This strategy may be suitable only for site selection of new educational infrastructure. In Ullapara Pourashava, additional 3 primary school, 4 secondary School and 3 colleges are proposed in highly flood prone area in Zone-D, Zone-E and Zone-F (see Map 5.3, Map 5.4 and Map 5.5). So the location of proposed educational infrastructure can be revised in less flood prone zone. The revised locations of the educational infrastructure have been presented in Map 6.2, Map 6.3 and Map 6.4.
b) Base height of educational infrastructure may be elevated above design flood level to protect from climate change induced flood. The height enhancement can take two forms: either reconstructing the educational infrastructure on the same land making it elevated beyond the design flood level by earthwork

(figure 6.2) or the educational infrastructure can be constructed upon elevated column (figure 6.3). The height elevation may be applicable for the educational infrastructure having katcha structures.

c) If relocation and height enhancement are not possible for particular infrastructure, then floodwall around the infrastructure may be constructed to protect from flood (Figure 6.4). Generally, due to design factors, floodwalls are most effective in areas with relatively shallow flooding and minimal wave action. This may be applicable for pucca structure

d) Provision of alternative mode of transport like boat is required to be used for students to attend school during monsoon.

7.2.3 Health infrastructure and urban facilities

Adaptation strategies for health infrastructure and other and urban facilities (community center, fire station, polis station, solid waste disposal site etc) may similar as recommended for educational infrastructure. These may be flood wall construction around the health infrastructure; height enhancement of infrastructure and relocation of infrastructure in a less flooded zone. Floodwall may be used for existing pucca infrastructure because relocation or reconstruction may be much costly. For newly proposed health facilities height enhancement may be appropriate option. Revised locations of health infrastructures and other urban facilities have been illustrated in Map 6.5 and 6.6 of Chapter-6.

7.2.4 Flood hazard mapping

Climate change induced flood hazard mapping should be prepared for all flood prone Pourashavas of Bangladesh to understand and communicate flood extent and this flood zoning map should be strictly followed for infrastructure planning.

7.2.5 Storm water storage pond and improved drainage system:

To tackle the climate change induced rainfed flood storm water retention pond and improved drainage system should be introduced in urban area. Drainage system should be facilitated with adequate culvert to allow free flow of water.

7.2.6 Climate sensitive infrastructure planning and design

Infrastructure represents such a major investment that it is important to build it to cope with future changes. This means that recognition of likely climate change, its impacts and appropriate adaptation measures should occur now. However, most infrastructures should be designed, built and maintained on the premise that the future climate will aggravate the intensity the present risk. Recognition of the risks associated with climate change is a valuable first step towards better planning of new infrastructure investments and mitigating potential damage to existing infrastructure.

7.2.7 Risk sensitive land use planning

Risk Sensitive Land Use Planning (RSLUP) provides better framework to incorporate the climate change adaptation in to the development planning. It would require understanding of processes that shape disaster vulnerability as well as ways to integrate risk reduction into land use planning processes. RSLUP contributes to building disaster resilience of urban areas. It emphasizes land use planning to proactively address risk factors in urban areas and promote sustainable urban development. RSLUP should be adopted at Pourashava level infrastructure planning.

7.2.8 Early warning system

Early warning is a major element of disaster risk reduction. It prevents loss of life and reduces the economic and material impact of disasters. To be effective, early warning systems need to actively involve the communities at risk, facilitate public education and awareness of risks, effectively disseminate messages and warnings and ensure there is constant state of preparedness.

7.3 The regional level

There are some actions in response to climate change induced flood that the local government cannot response. The regional level government should take those actions. In case of Bangladesh, BWDB can dredge of major rivers, tributaries and distributaries for mitigation of flood. It can restore abundant channels, lakes and khals to allow free flow of water during flood. Embankment should be constructed with adequate sluice gates for controlled water flow. WARPO can prepare floodplain policy and act to control flood plain development and to reserve space for water. UDD can take actions to ensure planned urbanization in flood prone area

7.4 National level

Climate change adaptation needs to be mainstreamed into national development planning including policy-making, budgeting and implementation processes. Most importantly priority activities as outlined in NAPA should be implemented. Interdisciplinary co-operation is also necessary at all level of government International cooperation should also be ensured on climate risk adaptation strengthen the knowledge and information base as well as financial assistance. In case of infrastructure (urban) planning in Bangladesh, concerned ministries can prepare national adaptation policy for urban and/or infrastructure planning. Once adaptation policy is prepared it has to be circulated among concerned departments to be followed while preparing urban plan and thus the adaptation strategies should be mainstreamed and translated into local level planning.

7.5 Conclusion

Bangladesh is already vulnerable to many climate change related extreme events and natural disasters. It is expected that climate change will bring changes in characteristics of natural hazards and gradual changes phenomenon of the physical system. Studies and assessments of impacts, vulnerabilities and adaptation to climate change and sea level rise for Bangladesh clearly demonstrates that Bangladesh is one of the most climate vulnerable countries in the world. Many sectors will be affected by climate change in Bangladesh. Infrastructure is one of the most vulnerable sectors to climate change associated with many multiplier effects. This case study is based on infrastructure planning made by LGED and is an attempt to examine how infrastructure will be affected by climate change induced flood in Ullapara Pourashava. This study finds that most of the infrastructure, both existing and proposed, will be exposed to climate change induced flood. In 2007 flood the physical damage of roads, hospitals, Police Station and Fire service was equivalent to about 8.57 crore Tk. The present value of that physical damage is about 9.24 crore considering 7.75% inflation rate[1] from 2007 to 2014. This is only physical damage cost. In addition the inundation of infrastructure severely affected the socio-economic life of the people of Ullapara Pourashava. As discussed in Chapter-5 and Chapter-6, the inundation of infrastructure has negatively affected the education, health, business, income and overall socio-economic life. In future the inundation scenario will be aggravated due to climate change. This exposure will lead to dysfunction of concerned infrastructure and, in turn, undermines the stability of a socio-economic system of Ullapara Pourashava. As the infrastructure plan is not implemented till now so there is a scope for intervention in the plan to incorporate climate change induced flood. Several adaptation strategies for exposed infrastructures were devised in response to climate change induced flood in the study area. These strategies are based on climate change induced flood exposure analysis of various infrastructures, various literature reviews, various national and international study and expert opinions and local level consultation. These adaptation strategies have been presented in chapter-6. The total cost of proposed intervention

[1] http://www.bangladesh-bank.org/econdata/inflation.php;
http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG/countries/BD?display=graph

will be about 29.04 crore Tk (for detail calculation please seen Appendix-D). This study concludes that the Ullapara Master Plan should be revised incorporating climate change induced flood and this type of study can be replicated for other Pourashava located in flood prone area of Bangladesh. They also recommends that climate change should be mainstreamed in national development planning and all levels of government should act jointly to achieve better adaptation strategies in response to climate induced flood in Bangladesh. However, there also exist constraints and challenges to adopt the adaptation strategies due to lack of comprehensive study on climate resilient urban planning in Bangladesh, lack of skilled manpower, lack of fund and lack of intra and inter-ministerial integration and cooperation. So these challenges and constraints certainly extend further scope of research on climate resilient planning more importantly on multi-level governance in climate change adaptation, climate finance, climate sensitive infrastructure design, climate and hydrological events.

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Appendix A: List of people consulted at local level

Location: Ullapara Pourashava area

SL No	Name	Designation	Organization
1	Md. Shahadat Hossain	Executive Engineer	Ullapara Pourashava
2	Md. Abdul Malek	Assistant Engineer	Ullapara Pourashava
3	Md. Jahurul Islam	Sub-Assistant Engr	Ullapara Pourashava
4	Md. Ariful Haque	Assistant Teacher	Nayanganj Govt primary School
5	Md. Kabirul Islam	Assistant Teacher	Kaoak Non-govt. Primary School
6	Golam Rabbani	Assistant Teacher	Jhikrabond Model Govt. Primary School
7	Nazmul Alom	Assistant Teacher	Enaetpur Govt. Primary School
8	Md. Shahid Uddin	Assistant Teacher	Shibpur Non-govt. Primary School
9	Md. Kabir	Assistant Teacher	Purbopara Govt. Primary school
10	Md. Azizur Rahman	Assistant Teacher	Sree kola Govt. Primary School
11	Md. Jamal uddin	Assistant Teacher	Ghatina Govt Primary School
12	Md. Moshiour Rahman	Assistant Teacher	Charghatina Non-govt. Primary School
13	Md. Alim Uddin	Assistant Teacher	Neoar gacha Non-Govt Prmary School
14	Md. Rubel	Assistant Teacher	Char Neoar Gacha Non-govt primary school
15	Md. Razu Ahmed	Assistant Teacher	Vottokawak Non Govt. Primary School
16	Md. Liakat Ali	Assistant Teacher	Upazila Parishad Jhikira Govt. Primary School
17	Md. Zakir Hossain	Assistant Teacher	Rimjhim Non Govt. Primary School
18	Md. Raihan	Assistant Teacher	Enaetpur Gucchogram Reg. Primary School
19	Md. Akbar Ali	Assistant Teacher	Zahura Mahiuddin Khan Girls High School
20	Md. Kawsar	Assistant Teacher	Khondokar A. Majid High School
21	Md. Nurul Islam	Assistant Teacher	Ullapara Adorsho High School
22	Md. Atikul Islam	Assistant Teacher	Rafia High School
23	Md, Ranju	Assistant Teacher	Ghatina Bohumukhi Secondary School
24	Md. Taposh	Assistant Teacher	Hira Pre-Cadet High School
25	Md. Mahbubur Rahman	Assistant Teacher	Mamun Haq Momena Ali Science School
26	Md. Mahfuzur Rahman	Lecturer	Ullapara Degree College
27	Md. Helal Uddin	Lecturer	Jhikrabond Degree college
28	Md. Khaleq	Lecturer	Hamida Pilot Girls College
29	Md. Sabur	Lecturer	Ullapara Science College Building
30	Md. Tazul islam	Lecturer	Ullapara Merchant Pilot Tecnical College
31	Md. Afsar Ali	Station Officer	Ullapara Fire Station
32	Md. Rakib	Gaurd	Ullapara Police station
33	Md. Shah alom	Health official	Upazilla Health Complex
34	Md. Touhidur Rahman	Health official	Bengal Community Hospital
35	Md. Shahin	Health official	Ullapara Eye and General Hospital
36	Md. Akbar Ali	Health official	Seba Generel Hospital
37	Md. Shajahan Ali	Health official	Doctors Diagnostic Center
38	Md. Mukul	Business man	Local people
39	Md. Jahangir Kabir	Business man	Local people
40	Md. Kader Ali	Rickshaw driver	Local people
41	Md. Ziaur Rahman	Auto driver	Local people
42	Md. Md. Shahin	Auto driver	Local people

Appendix B: List of experts consulted for this study

Sl No	Name	Designation	Organization
1	Md. Zahirul Haque Khan	Director	IWM
2	Mr. Trun Kanti Mazumdar	Senior Flood Management Specialist	IWM
3	Md. Taneem Sarwar	Design Engineer	IWM
4	Md. Bablu Miah	Assistant Engineer	LGED
5	Md. Saifur Rahman	Urban Planner	UTIDP, LGED
6	Md. Jubaer Hassan	Executive Engineer	BWDB
7	Md. Masud Alom	Senior Scientific Officer	WARPO
8	Md. Tajminur Rahman	Assistant Director	DoE
9	Manik Kumar Shaha	Development Professional	BRAC
10	Md. Atiqulla Bhuian	Assistant Engineer	RHD
11	Sonia Binte Murshed	Assistant Professor	IWFM, BUET
12	Md. Kawsar-ul-alom	Executive Engineer	BWDB
13	Md. Asadul Kabir	Flood Management Specialist	IWM

Appendix C: Methodology of flood exposure analysis developed by ADPC

ADPC conducted many studies on flood exposure analysis in Asian countries. They developed methodology of GIS based flood exposure analysis. This method can be found in MoHA (2009), ADPC (2011) and in many other studies. The four step simplified methodology is described below.

Step 1: Flood hazard assessment

Flood hazard assessment is essential and first step of exposure analysis. Hazard assessment is mainly characterized by inundation extent, depth and duration. There are several ways by which, hazard assessment can be performed, which largely depends upon availability of data and scientific tools like modeling software platform, analysis of satellite imageries, field reconnaissance, geophysical and hydrological studies etc. The flood map is developed in raster formate. The flood hazard is generally associated with time, either in terms of return period or in terms of particular year. For example a flood may be 10 year or 25 year or 50 year return period flood; or sometimes flood may be predicted for particular year in future based on previous flood level data, existing hydrological condition and expected climatic changes. [*In this study flood level data has been collected from secondary sources which has been predicted for the year 2040 and this is a 10-year return period flood*]

Step 2: Classification of hazard zone

Flood Hazard assessment commonly shows zones of different intensity or inundation depth. The flood hazard maps show the flood inundation and flood water depth with respect to specific return period scenario. The different inundation depths are classified as zone. The interval of classification depends on specific context. For example inundation classifications for Nepal were <0.3m, 0.3-1m, 1-2m and >2m. [*In this study 0.5m interval was used for inundation classification as 0-.5m, 0.5-1m, 1-1.5m, 1.5-2m and 2-2.5m and 2.5-3m inundation depth. This classification was based on World Bank (2010b) study in Bangladesh*]

Step 3: Identifying elements at risk

The next step is to identify different elements that have potential risk to flood. In Nepal study ADPC identified different infrastructure including, health infrastructure, educational infrastructure, transport infrastructure, irrigation infrastructure, power infrastructure, telecommunication infrastructure, tourism infrastructure, mining infrastructure, trade and financial institution etc. The collected all these data from secondary sources in the form of shapefile to be used in ArcGIS environment. [*In this study infrastructure includes transport and communication infrastructure, educational infrastructure, health infrastructure, and other community facilities*]

Step 4: Quantification of exposed infrastructure

The next step is to quantify the exposed elements. For this, the infrastructure maps are overlaid on flood hazard map to quantify the exposed elements in different inundation depth (Figure-1). The exposed elements are quantified in terms of number (for point feature e.g educational infrastructure), length (for linear feature e.g road) and area (for area feature e.g land). Then the quantified infrastructures are presented in the form of tables, figures etc.

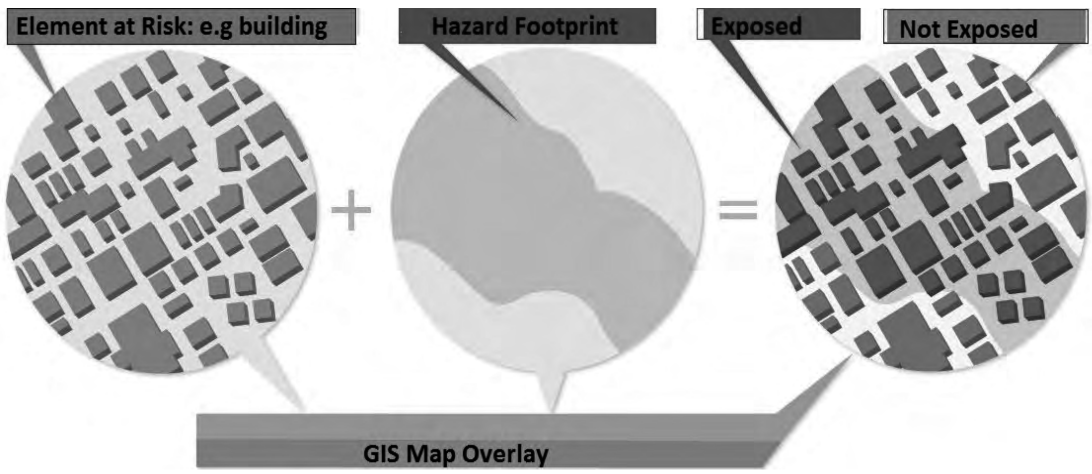

Figure 1: Quantifying exposed elements through overlay operation in ArcGIS environment

Appendix D: Cost of Proposed intervention

Table 1: Approximate Cost of additional height enhancement of inundated Primary school at Ullapara Pourashava

SL No	Name	Area (Sqm)	Height Enhancement (m)	[2]Unit Earthwork Cost (Tk/m3)	Total Earthwork Cost (Lakh Tk)	[3]Other cost (Lakh Tk)	Total Cost (Lakh Tk)
1	Nayanganj Govt primary School, Ward-8	600	1.5	400	3.6	1.00	4.60
2	Kaoak Non-govt. Primary School, Ward-6	300	1.5	400	1.8	1.00	2.80
3	Jhikrabond Model Govt. Primary School, Ward-3	700	1.8	400	5.04	1.00	6.04
4	Enaetpur Govt. Primary School, Ward-7	200	1.6	400	1.28	1.00	2.28
5	Shibpur Non-govt. Primary School, Ward-7	200	1.2	400	0.96	1.00	1.96
6	Purbopara Govt. Primary school, Ward-5	600	1.4	400	3.36	1.00	4.36
7	Sree kola Govt. Primary School, Ward-1	500	1.5	400	3	1.00	4.00
8	Ghatina Govt Primary School	300	1.5	400	1.8	1.00	2.80
9	Charghatina Non-govt. Primary School, Ward-9	200	1	400	0.8	1.00	1.80
10	Neoar gacha Notun para Non-Govt Prmary School, Ward-8	200	1.3	400	1.04	1.00	2.04
Total					22.68	10.00	32.68

[2] Unit Earthwork Cost for school varies from 350-450Tk/m3. It has been decided in consultation with the Assistant Engineer of LGED, Assistant Engineer of RHD and Design Engineer of IWM. Average cost is considered in this study.

[3] Other cost includes Carpenter's charge and material cost including wood, tin etc. This average cost has been fixed in consultation with the local Primary School teachers

Table 2: Approximate Cost of additional height enhancement of inundated Secondary school at Ullapara Pourashava

SL No	Name	Area (Sqm)	Height enhancement (m)	Unit Cost (Tk/m3)	Total Earthwork Cost (Lakh Tk)	[4]Other cost (Lakh Tk)	Total Cost (Lakh Tk)
1	Zahura Mahiuddin Khan Girls High School, Ward-8	500	1.3	400	2.6	1.5	4.1
2	Khondokar A. Majid High School, Ward-8	1300	1.5	400	7.8	1.5	9.3
3	Ullapara Adorsho High School , Ward-6	600	1.5	400	3.6	1.5	5.1
4	Rafia High School, Ward-6	500	1.5	400	3	1.5	4.5
5	Ghatina Bohumukhi Secondary School, Ward-9	600	1.2	400	2.88	1.5	4.38
Total					19.88	7.5	27.38

[4] Other cost includes Carpenter's charge and material cost including wood, tin etc. This average cost has been fixed in consultation with the local Secondary School teachers

Table 3: Approximate Cost of constructing flood wall around the inundated College at Ullapara Pourashava

SL No	Name	Flood Wall Perimeter (m)	Height of Flood Wall (m) including 1m base	[5]Unit Cost (Tk/m2)	Cost (Lakh Tk)
1	Ullapara Degree College, Ward-7	200	2.5	3000	15
2	Jhikrabond Degree college, Ward-3	220	2.3	3000	15.18
3	Hamida Pilot Girls College , Ward-3	240	2.3	3000	16.56
Total					**46.74**

[5] Unit cost for constructing flood wall with concrete normally varies from 3000-4000Tk/m2. It has been decided in consultation with the Assistant Engineer of LGED, Assistant Engineer of RHD and Design Engineer of IWM. Lowest cost has been considered for calculation in this study.

Table 4: List of important roads to be raised and corresponding cost of additional height enhancement

RD_ID	Type	Length (m)	Additional Height Enhancement (m)	Width (m)	[6]Unit Earthwork Cost (Tk/m3)	Cost (Lakh Tk)
R_1	Regional Highway	6355.951	1.0	10	500	317.80
R_6	Union road	244.783	0.9	5.5	500	6.06
R_8	Union road	1360.221	0.7	5.5	500	26.18
R_12	Union road	499.249	1.2	5.5	500	16.48
R_20	Union road	767.99	1.5	5.5	500	31.68
R_26	Union road	899.97	0.7	5.5	500	17.32
R_35	Union road	292.833	1.5	5.5	500	12.08
R_37	Union road	73.307	1.5	5.5	500	3.02
R_42	Union road	564.219	0.7	5.5	500	10.86
R_51	Union road	563.097	1.5	5.5	500	23.23
R_53	Union road	255.252	1.5	5.5	500	10.53
R_54	Union road	766.27	1.5	5.5	500	31.61
R_57	Union road	674.787	1.5	5.5	500	27.83
R_65	Union road	223.944	1.5	5.5	500	9.24
R_75	Union road	688.649	1.5	5.5	500	28.41
R_79	Union road	241.281	1.5	5.5	500	9.95
R_87	Union road	867.521	1.1	5.5	500	26.24
R_116	Union road	209.471	1.1	5.5	500	6.34
R_123	Union road	776.843	1.3	5.5	500	27.77
R_198	Union road	1483.425	1.6	5.5	500	65.27

[6] Unit Earthwork Cost for road normally varies from 400-600Tk/m2. It has been decided in consultation with the Assistant Engineer of LGED, Assistant Engineer of RHD and Design Engineer of IWM. Average cost is considered in this study.

RD_ID	Type	Length (m)	Additional Height Enhancement (m)	Width (m)	[6]Unit Earthwork Cost (Tk/m3)	Cost (Lakh Tk)
R_234	Union road	431.558	0.7	5.5	500	8.31
R_248	Union road	350.429	1.2	5.5	500	11.56
R_302	Union road	573.181	0.7	5.5	500	11.03
R_313	Union road	709.645	0.7	5.5	500	13.66
R_314	Union road	380.996	0.7	5.5	500	7.33
R_354	Union road	201.41	1.0	5.5	500	5.54
R_363	Union road	200.495	0.7	5.5	500	3.86
R_366	Union road	365.396	0.7	5.5	500	7.03
R_367	Union road	203.53	1.1	5.5	500	6.16
R_368	Union road	326.611	1.1	5.5	500	9.88
R_369	Union road	154.883	0.7	5.5	500	2.98
R_370	Union road	0.632	0.7	5.5	500	0.01
R_371	Union road	196.978	0.7	5.5	500	3.79
R_372	Union road	69.002	0.7	5.5	500	1.33
R_373	Union road	101.902	0.2	5.5	500	0.56
R_374	Union road	36.477	0.2	5.5	500	0.20
R_375	Union road	90.022	0.2	5.5	500	0.50
R_376	Union road	142.842	0.6	5.5	500	2.36
R_377	Union road	181.185	0.6	5.5	500	2.99
R_378	Union road	211.758	1.5	5.5	500	8.74
R_379	Union road	252.532	1.5	5.5	500	10.42
R_380	Union road	31.521	1.5	5.5	500	1.30
R_80	Upazaila Road	1399.672	0.7	7.3	500	35.76
R_177	Upazaila Road	1342.524	0.7	7.3	500	34.30
R_219	Upazaila Road	3614.2	1.3	7.3	500	171.49

RD_ID	Type	Length (m)	Additional Height Enhancement (m)	Width (m)	[6]Unit Earthwork Cost (Tk/m3)	Cost (Lakh Tk)
R_230	Upazaila Road	1754.498	1.1	7.3	500	70.44
R_312	Upazaila Road	918.356	1.1	7.3	500	36.87
R_329	Upazaila Road	1838.165	0.6	7.3	500	40.26
R_330	Upazaila Road	1686.729	1.3	7.3	500	80.04
R_331	Upazaila Road	860.082	1.5	7.3	500	47.09
Total		**36436.3**				**1343.69**

Table 5: List of submergible roads to selected for RCC Pavement instead of BC pavement and corresponding cost

RD_ID	Type	Length (m)	Width (m)	[7]Additional Unit Cost (Tk/m2)	Cost (Lakh Tk)
R_100	Union road	417.75	5.5	700	16.08
R_101	Union road	218.31	5.5	700	8.40
R_109	Union road	440.90	5.5	700	16.97
R_131	Union road	759.51	5.5	700	29.24
R_144	Union road	1206.86	5.5	700	46.46
R_146	Union road	212.84	5.5	700	8.19
R_17	Union road	249.87	5.5	700	9.62
R_174	Union road	344.27	5.5	700	13.25

[7] Additional unit Cost means additional cost for RCC road compared to Bituminous Road (BC). Average cost for RCC pavement varies from 1700-2000Tk/m2 and where for BC varies from 1200-1500Tk/m2 This cost has been decided in consultation with the Assistant Engineer of LGED, Assistant Engineer of RHD and Design Engineer of IWM

RD_ID	Type	Length (m)	Width (m)	[7]Additional Unit Cost (Tk/m2)	Cost (Lakh Tk)
R_175	Union road	238.35	5.5	700	9.18
R_179	Union road	477.94	5.5	700	18.40
R_18	Union road	311.13	5.5	700	11.98
R_182	Union road	498.28	5.5	700	19.18
R_193	Union road	220.85	5.5	700	8.50
R_197	Union road	221.08	5.5	700	8.51
R_199	Union road	215.45	5.5	700	8.29
R_210	Union road	282.73	5.5	700	10.89
R_213	Union road	215.80	5.5	700	8.31
R_221	Union road	251.56	5.5	700	9.68
R_228	Union road	342.38	5.5	700	13.18
R_229	Union road	681.23	5.5	700	26.23
R_241	Union road	303.75	5.5	700	11.69
R_245	Union road	373.95	5.5	700	14.40
R_252	Union road	250.79	5.5	700	9.66
R_268	Union road	215.24	5.5	700	8.29
R_31	Union road	216.32	5.5	700	8.33
R_310	Union road	231.91	5.5	700	8.93
R_316	Union road	1116.57	5.5	700	42.99
R_317	Union road	463.64	5.5	700	17.85
R_318	Union road	292.18	5.5	700	11.25
R_319	Union road	399.49	5.5	700	15.38

RD_ID	Type	Length (m)	Width (m)	[7]Additional Unit Cost (Tk/m2)	Cost (Lakh Tk)
R_322	Union road	303.79	5.5	700	11.70
R_332	Union road	242.92	5.5	700	9.35
R_335	Union road	764.64	5.5	700	29.44
R_336	Union road	389.35	5.5	700	14.99
R_338	Union road	305.27	5.5	700	11.75
R_339	Union road	301.51	5.5	700	11.61
R_362	Union road	444.77	5.5	700	17.12
R_364	Union road	366.30	5.5	700	14.10
R_381	Union road	251.17	5.5	700	9.67
R_383	Union road	985.16	5.5	700	37.93
R_386	Union road	1311.53	5.5	700	50.49
R_388	Union road	394.21	5.5	700	15.18
R_390	Union road	1512.19	5.5	700	58.22
R_393	Union road	1099.16	5.5	700	42.32
R_394	Union road	1855.82	5.5	700	71.45
R_399	Union road	309.13	5.5	700	11.90
R_4	Union road	272.60	5.5	700	10.50
R_40	Union road	386.42	5.5	700	14.88
R_401	Union road	226.87	5.5	700	8.73
R_405	Union road	291.19	5.5	700	11.21
R_411	Union road	375.75	5.5	700	14.47
R_413	Union road	307.50	5.5	700	11.84

RD_ID	Type	Length (m)	Width (m)	[7]Additional Unit Cost (Tk/m2)	Cost (Lakh Tk)
R_416	Union road	476.03	5.5	700	18.33
R_418	Union road	290.53	5.5	700	11.19
R_76	Union road	277.67	5.5	700	10.69
R_77	Union road	1261.59	5.5	700	48.57
R_85	Union road	221.44	5.5	700	8.53
R_93	Union road	772.72	5.5	700	29.75
R_97	Union road	307.46	5.5	700	11.84
R_111	Village road	323.82	4.8	700	10.88
R_118	Village road	557.69	4.8	700	18.74
R_119	Village road	331.37	4.8	700	11.13
R_120	Village road	318.71	4.8	700	10.71
R_145	Village road	663.35	4.8	700	22.29
R_152	Village road	499.16	4.8	700	16.77
R_154	Village road	589.76	4.8	700	19.82
R_243	Village road	334.71	4.8	700	11.25
R_262	Village road	597.64	4.8	700	20.08
R_278	Village road	199.88	4.8	700	6.72
R_290	Village road	211.52	4.8	700	7.11
R_334	Village road	319.37	4.8	700	10.73
R_341	Village road	528.42	4.8	700	17.75
R_365	Village road	327.91	4.8	700	11.02
R_397	Village road	631.25	4.8	700	21.21

RD_ID	Type	Length (m)	Width (m)	[7]Additional Unit Cost (Tk/m2)	Cost (Lakh Tk)
R_415	Village road	203.45	4.8	700	6.84
R_44	Village road	267.65	4.8	700	8.99
R_56	Village road	323.02	4.8	700	10.85
R_67	Village road	260.52	4.8	700	8.75
R_71	Village road	579.89	4.8	700	19.48
R_72	Village road	325.42	4.8	700	10.93
R_81	Village road	526.69	4.8	700	17.70
R_86	Village road	333.08	4.8	700	11.19
R_90	Village road	265.05	4.8	700	8.91
Total					**1396.91**

Table 6: List of submergible roads with no intervention

RD_ID	Type	Length (m)
R_2	Village road	57.831
R_3	Village road	38.268
R_5	Village road	157.512
R_7	Village road	89.248
R_9	Village road	33.744
R_10	Village road	33.812
R_11	Village road	146.326
R_13	Village road	53.252
R_14	Village road	29.589
R_15	Village road	32.921
R_16	Village road	79.579
R_19	Village road	117.332
R_21	Village road	87.578
R_22	Village road	174.143
R_23	Village road	70.842
R_24	Village road	96.241
R_25	Village road	106.61
R_27	Village road	54.137
R_28	Village road	45.374
R_29	Village road	175.504
R_30	Village road	50.473

RD_ID	Type	Length (m)
R_32	Village road	31.431
R_33	Village road	29.207
R_34	Village road	15.613
R_36	Village road	20.709
R_38	Village road	13.562
R_39	Village road	51.545
R_41	Village road	10.33
R_43	Village road	158.917
R_45	Village road	14.569
R_46	Village road	33.084
R_47	Village road	29.926
R_48	Village road	34.485
R_49	Village road	34.924
R_50	Village road	57.034
R_52	Village road	83.228
R_55	Village road	39.81
R_58	Village road	77.967
R_59	Village road	78.957
R_60	Village road	73.557
R_61	Village road	115.745
R_62	Village road	57.814
R_63	Village road	85.012
R_64	Village road	196.229

RD_ID	Type	Length (m)
R_66	Village road	114.511
R_68	Village road	28.668
R_69	Village road	159.552
R_70	Village road	71.097
R_73	Village road	111.928
R_74	Village road	87.995
R_78	Village road	30.672
R_82	Village road	131.323
R_83	Village road	162.262
R_84	Village road	21.337
R_88	Village road	50.381
R_89	Village road	59.371
R_91	Village road	78.761
R_92	Village road	23.933
R_94	Village road	16.73
R_95	Village road	195.898
R_96	Village road	128.876
R_98	Village road	69.255
R_99	Village road	85.013
R_102	Village road	44.502
R_103	Village road	107.097
R_104	Village road	28.947
R_105	Village road	30.909

RD_ID	Type	Length (m)
R_106	Village road	62.523
R_107	Village road	39.982
R_108	Village road	159.005
R_110	Village road	138.876
R_112	Village road	71.092
R_113	Village road	66.706
R_114	Village road	41.913
R_115	Village road	38.818
R_117	Village road	103.014
R_121	Village road	43.562
R_122	Village road	121.16
R_124	Village road	112.71
R_125	Village road	46.121
R_126	Village road	72.143
R_127	Village road	74.211
R_128	Village road	103.642
R_129	Village road	30.364
R_130	Village road	156.72
R_132	Village road	87.094
R_133	Village road	49.528
R_134	Village road	87.096
R_135	Village road	39.772
R_136	Village road	55.535
R_137	Village road	25.641
R_138	Village road	133.27
R_139	Village road	177.585
R_140	Village road	17.459
R_141	Village road	25.79

RD_ID	Type	Length (m)
R_142	Village road	24.916
R_143	Village road	35.58
R_147	Village road	95.567
R_148	Village road	68.612
R_149	Village road	139.127
R_150	Village road	61.478
R_151	Village road	69.374
R_153	Village road	114.535
R_155	Village road	26.39
R_156	Village road	3.498
R_157	Village road	18.923
R_158	Village road	5.969
R_159	Village road	91.808
R_160	Village road	98.633
R_161	Village road	33.017
R_162	Village road	101.668
R_163	Village road	29.866
R_164	Village road	97.137
R_165	Village road	138.397
R_166	Village road	60.174
R_167	Village road	79.942
R_168	Village road	17.992
R_169	Village road	21.368
R_170	Village road	197.151
R_171	Village road	73.056
R_172	Village road	80.472
R_173	Village road	58.484
R_176	Village road	39.082

RD_ID	Type	Length (m)
R_178	Village road	146.321
R_180	Village road	47.213
R_181	Village road	59.153
R_183	Village road	88.384
R_184	Village road	37.275
R_185	Village road	69.786
R_186	Village road	27.551
R_187	Village road	51.229
R_188	Village road	75.385
R_189	Village road	47.884
R_190	Village road	88.202
R_191	Village road	107.277
R_192	Village road	45.518
R_194	Village road	81.177
R_195	Village road	65.247
R_196	Village road	69.814
R_200	Village road	72.054
R_201	Village road	34.994
R_202	Village road	163.621
R_203	Village road	41.533
R_204	Village road	116.158
R_205	Village road	73.481
R_206	Village road	98.517
R_207	Village road	58.671
R_208	Village road	161.392
R_209	Village road	77.081
R_211	Village road	17.284
R_212	Village road	27.47

RD_ID	Type	Length (m)
R_214	Village road	35.204
R_215	Village road	35.018
R_216	Village road	52.366
R_217	Village road	81.514
R_218	Village road	156.209
R_220	Village road	104.317
R_222	Village road	82.931
R_223	Village road	29.922
R_224	Village road	186.63
R_225	Village road	157.374
R_226	Village road	20.834
R_227	Village road	70.538
R_231	Village road	84.89
R_232	Village road	188.365
R_233	Village road	38.724
R_235	Village road	26.988
R_236	Village road	82.248
R_237	Village road	45.844
R_238	Village road	78.412
R_239	Village road	12.064
R_240	Village road	77.49
R_242	Village road	168.244
R_244	Village road	28.619
R_246	Village road	135.484
R_247	Village road	89.106
R_249	Village road	142.481
R_250	Village road	76.499
R_251	Village road	185.151

RD_ID	Type	Length (m)
R_253	Village road	182.795
R_254	Village road	82.334
R_255	Village road	54.673
R_256	Village road	26.7
R_257	Village road	91.983
R_258	Village road	15.499
R_259	Village road	41.463
R_260	Village road	19.361
R_261	Village road	59.919
R_263	Village road	102.891
R_264	Village road	27.698
R_265	Village road	32.778
R_266	Village road	41.628
R_267	Village road	170.676
R_269	Village road	12.268
R_270	Village road	6.612
R_271	Village road	25.685
R_272	Village road	18.033
R_273	Village road	26.553
R_274	Village road	92.422
R_275	Village road	24.195
R_276	Village road	68.059
R_277	Village road	143.265
R_279	Village road	55.173
R_280	Village road	19.395
R_281	Village road	164.797
R_282	Village road	87.565
R_283	Village road	93.723

RD_ID	Type	Length (m)
R_284	Village road	40.271
R_285	Village road	37.189
R_286	Village road	67.82
R_287	Village road	130.072
R_288	Village road	27.813
R_289	Village road	38.457
R_291	Village road	130.655
R_292	Village road	56.287
R_293	Village road	39.01
R_294	Village road	94.906
R_295	Village road	84.741
R_296	Village road	60.635
R_297	Village road	100.756
R_298	Village road	115.657
R_299	Village road	73.246
R_300	Village road	13.847
R_301	Village road	77.67
R_303	Village road	126.112
R_304	Village road	56.81
R_305	Village road	95.273
R_306	Village road	56.167
R_307	Village road	46.443
R_308	Village road	65.907
R_309	Village road	91.174
R_311	Village road	56.814
R_315	Village road	92.476
R_320	Village road	38.23
R_321	Village road	49.58

RD_ID	Type	Length (m)
R_323	Village road	67.103
R_324	Village road	38.569
R_325	Village road	40.866
R_326	Village road	29.173
R_327	Village road	33.261
R_328	Village road	82.879
R_333	Village road	15.832
R_337	Village road	169.626
R_340	Village road	186.477
R_342	Village road	40.497
R_343	Village road	51.384
R_344	Village road	169.482
R_345	Village road	64.936
R_346	Village road	67.593
R_347	Village road	106.743
R_348	Village road	157.374
R_349	Village road	98.14

RD_ID	Type	Length (m)
R_350	Village road	47.862
R_351	Village road	49.159
R_352	Village road	116.261
R_353	Village road	51.394
R_355	Village road	26.053
R_356	Village road	52.304
R_357	Village road	99.934
R_358	Village road	178.893
R_359	Village road	54.644
R_360	Village road	74.962
R_361	Village road	114.384
R_382	Village road	0.805
R_384	Village road	0.562
R_385	Village road	67.318
R_387	Village road	45.541
R_389	Village road	7.066
R_391	Village road	61.105

RD_ID	Type	Length (m)
R_392	Village road	157.039
R_395	Village road	0.698
R_396	Village road	70.406
R_398	Village road	180.838
R_400	Village road	185.716
R_402	Village road	0.101
R_403	Village road	99.911
R_404	Village road	0.872
R_406	Village road	30.472
R_407	Village road	76.112
R_408	Village road	0.967
R_409	Village road	63.871
R_410	Village road	1.186
R_412	Village road	195.575
R_414	Village road	179.787
R_417	Village road	23.734
Total		20987.303

Table 7: Approximate Cost of constructing flood wall around the existing hospital at Ullapara Pourashava

SL No	Name	Flood Wall Perimeter (m)	Height of Flood Wall (m) including 1m base	Unit Cost (Tk/m2)	Cost (Lakh Tk)
1	Upazilla Health Complex, Ward-6	180	2.2	3000	11.88
2	Bengal Community Hospital, Ward-4	100	2.3	3000	6.9
3	Ullapara Eye and General Hospital, Ward-4	120	2.5	3000	9
4	Seba Generel Hospital Ward-3	56	2.5	3000	4.2
5	Doctors Diagnostic Center,Ward-6	64	2.3	3000	4.416
Total					**36.396**