Use of Modern Technology in Cyclone Management Practice:
A case study of Dacope Zilla

The Thesis Submitted to the Department of Urban and Regional Planning, Khulna University of Engineering & Technology (KUET), in Partial Fulfilment of the Requirement for the Degree of

Bachelor of Urban and Regional Planning.

Session: 2019 – 2020

Submitted By

Anim Saha (1617040)

Department of Urban and Regional Planning
Khulna University of Engineering & Technology

July, 2022

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Anim Saha (1617040)
Undergraduate student
Department of Urban and Regional Planning,
Khulna University of Engineering & Technology.

Thesis Supervisor

Dr. Md. Mustafa Saroar
Professor and Head
Department of Urban and Regional Planning,
Khulna University of Engineering & Technology.

Examiner

Palash Chandra Das
Assistant Professor
Department of Urban and Regional Planning,
Khulna University of Engineering & Technology.

Head of the Department

Dr. Md. Mustafa Saroar
Professor and Head
Department of Urban and Regional Planning,
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_____

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Abstract

Bangladesh is geographically located in a cyclone-prone area, and has a long history of being hit by cyclones. There are hefty cyclone prone areas where live and asset loss is high, whereas incorporation of technology can reduce the vulnerability as well as the life loss or asset damage. Recent days the urbanized countries are practicing latest technological application in all phases of cyclone management. Being a developing country puts us in a position where we hardly take steps to invest huge amount of money to procure those modern technologies in cyclone management practice where other disasters are recurrently occurring.

Based on the previous statistical data, vulnerability, live losses, social and asset losses etc. the study area of four vulnerable Union of Dacope Upazila, Khulna is selected and as well as theoretical framework was conducted. Reconnaissance field survey was done to prepare questionnaires for the field survey is conducted. After gathering necessary information from the field survey the data was analyzed as well as interpreted.

This research is to observe the current practicing activities of cyclone management phases both governmental and non-governmental organizations. It conducts a comparative analysis on regional, national and international level cyclone management activities.

Disasters are the situations that necessitate the mobilization of local capabilities and capacities. Local determination of needs is essential due to the context-specific nature of adaptation and the difficulty of defining standardized policies for successful adaptation. That's why in this research we tried to figure out the local context and tend to provide compatible technological solution for our selected study area.

This research also explores the technological aspects in current cyclone management practice. It discusses about new available technology which is practiced globally and suggest apposite technology on the respect of availability, adaptability, excess ability etc. for Bangladesh. This research also focusses on human behavior on technological site as well as provide recommendations based on it.

Acknowledgement

First and foremost, all praises belong to the one above all of us, the omnipresent almighty God, the most merciful, benevolent to man and His action. I would never have been able to finish my dissertation without the guidance of my supervisor and examiner, help from friends, and support from my family. I would like to express my deepest gratitude to my supervisor for his excellent guidance, caring, encouragement, patience, support and providing me with an excellent atmosphere from the preliminary to the concluding level enabled me to develop an understanding of the research. This dissertation would not have been possible without the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

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Last but not the least, my family for their continuous supports to carry out the research with the due time. Lastly, I offer my regards to all of those who supported me in any respect during the completion of the research.

Table of Contents

List of Tables

List of Figures

List of Acronyms and Abbreviations

CRI	Climate Risk Index (CRI)
PPP	Purchasing Power Parity
GIS	Geographic Information System
GDP	Gross Domestic Product
BBS	Bangladesh Bureau of Statistics
BDT	Bangladesh Taka
ISDR	International Strategy for Disaster Reduction
CBDM	Community-Based Disaster Management
CPP	Cyclone Preparedness Program
DRR	Disaster Risk Reduction
BDRCS	Bangladesh Red Crescent Society
FSCD	Fire Service and Civil Defense
NAWG	Need Assessment Working Group
EOC	Emergency Operations Center
BMD	Bangladesh Meteorological Department
TCs	Tropical Cyclones
PRA	Participatory Rural Appraisal
RRA	Registered Records Administrator
DMIC	Disaster Management Information Centre
NGO	Non-governmental Organization

CHAPTER 1: INTRODUCTION

1.1 Background of the Study

Bangladesh is typically implicited as a land of natural disasters as a result of it's terribly vulnerable once it involves floods, stream erosion and cyclones. Nearly 75% of Bangladesh sits below sea level and faces annual floods and we are known as "ground zero for climate change." (Giovetti, 2021). Between 1980 and 2019, the country faced 252 weather- and climate-related disasters, resulting in 163,758 deaths and affecting nearly 60 million lives (EM-DAT). The Climate Risk Index, which evaluates long-term exposure and vulnerability to extreme weather events, estimates a loss of US$ 1,686 million (consumer price parity) attributable to natural disasters between 1999 and 2018. (Eckstein D., 2020)

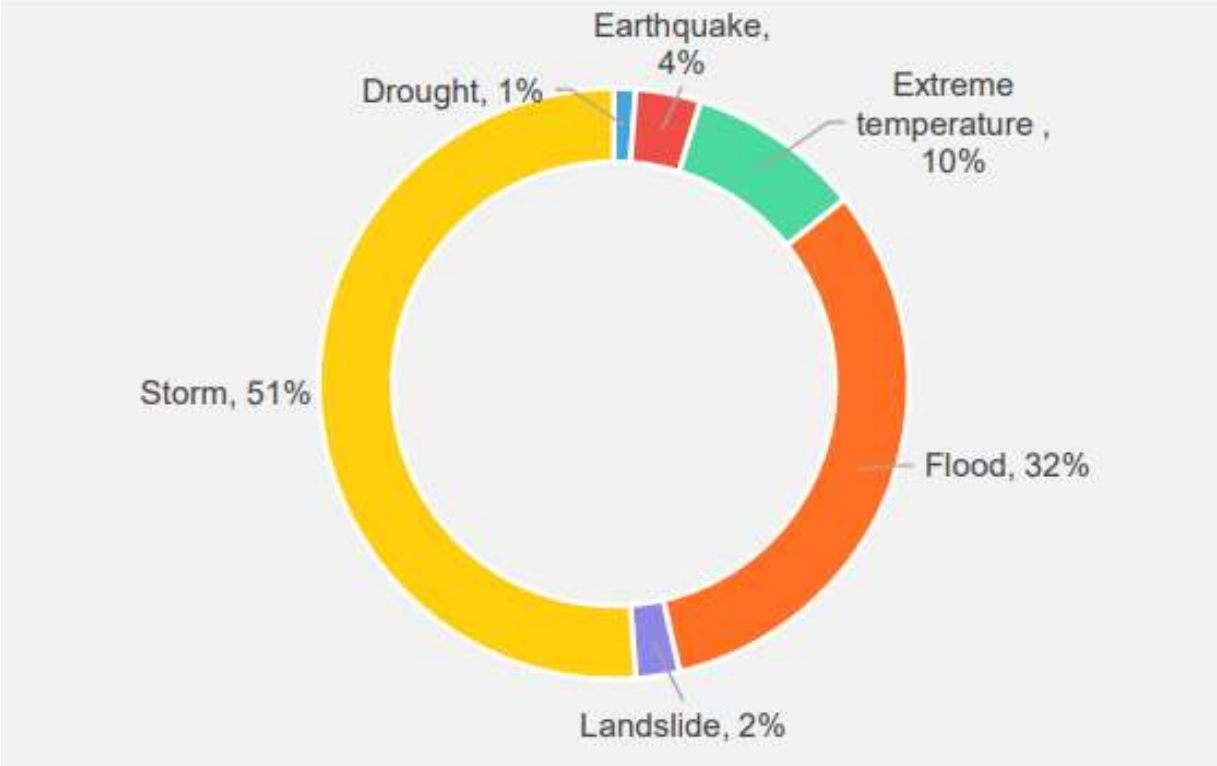


Figure 1.1: Type of disasters that have occurred in Bangladesh (1980–2019)

Source: EM-DAT, accessed 10 March 2020.

According to the Global Climate Risk Index (CRI) of 2021, Bangladesh seems to be the seventh most vulnerable nation to climate change. This study evaluated four indicators, including the number of total deaths, the number of deaths per 100,000 inhabitants, the total losses in purchasing power parity (PPP), and the losses per unit of gross domestic product. (Eckstein D., 2020)

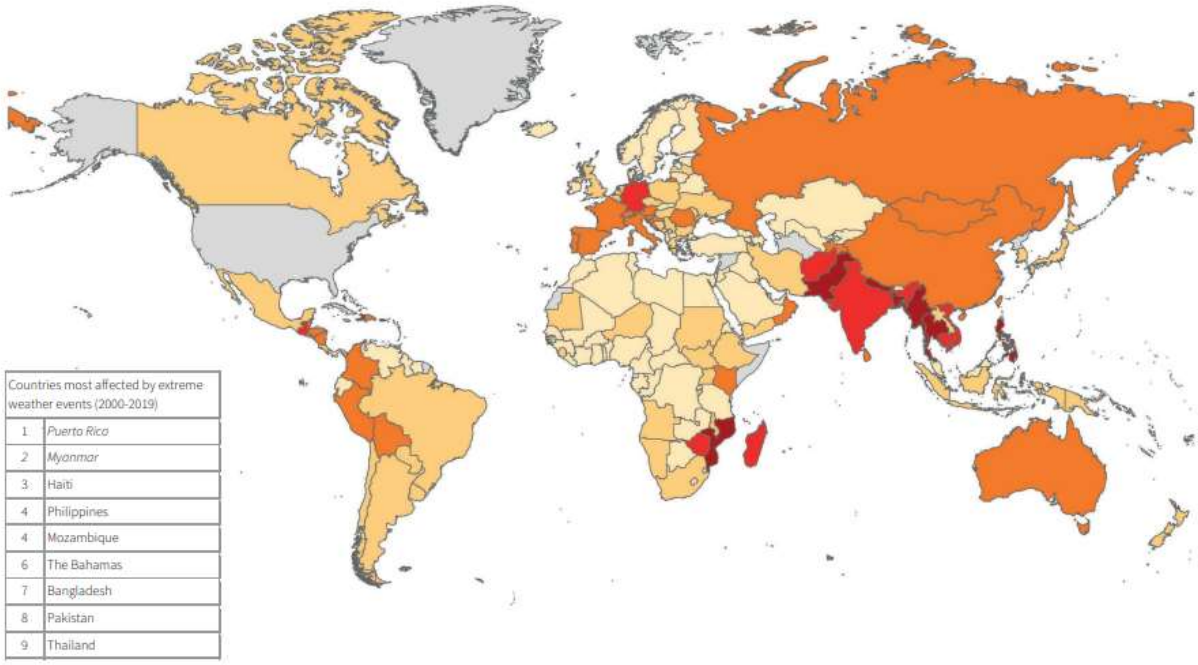


Figure 1.2: World Map of the Global Climate Risk Index 2000 – 2019

(Eckstein D., 2020)

As a result of being funnel form of Bangladesh, it often became the landing ground of cyclone in Bay of geographical region. The low flat of land, over concentration of population, poor engineering house, livestock, assets are affected by the cyclonic storms. A low-lying deltaic country formed by the Ganga, the Brahmaputra, and the Meghna rivers, demographically Bangladesh is one of the most vulnerables in face of earth's forces. That's why the country is in an exceedingly permanent state of danger. The natural components have caused the death of uncountable individuals and are threatening a hundred and sixty million populations that are presently living in Bangladesh.

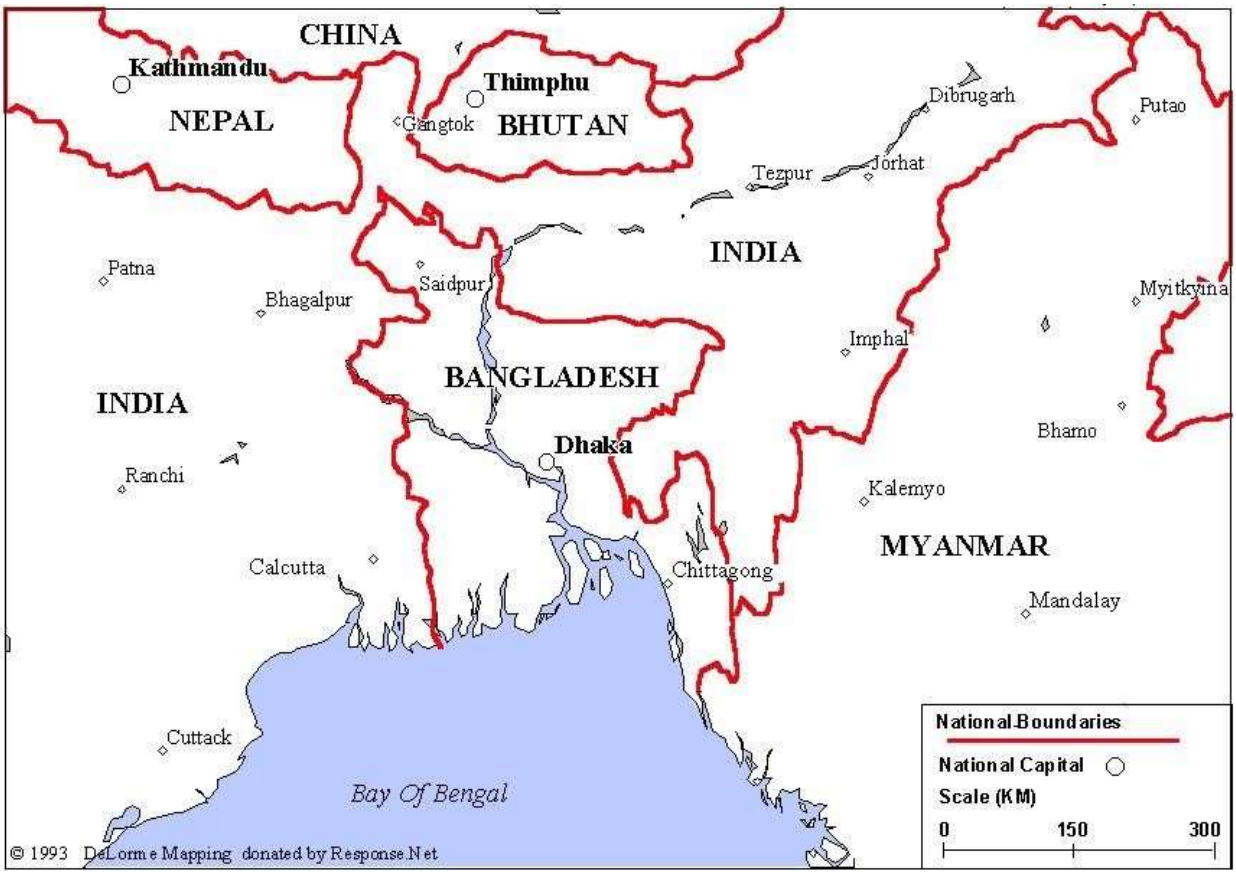


Figure 1.3: Map showing funnel shaped coast of Bangladesh

Source: (Islam, 2011)

The coastal zone of Bangladesh is highly disaster prone, especially tropical cyclone. Several deadly cyclones go by on Bangladesh in the last fifty years, one was 1970 then 20 years letter in 1991. And in the last century it faced two important cyclones and they are Sidr (11 November 2007) and Aila (26 may 2009).

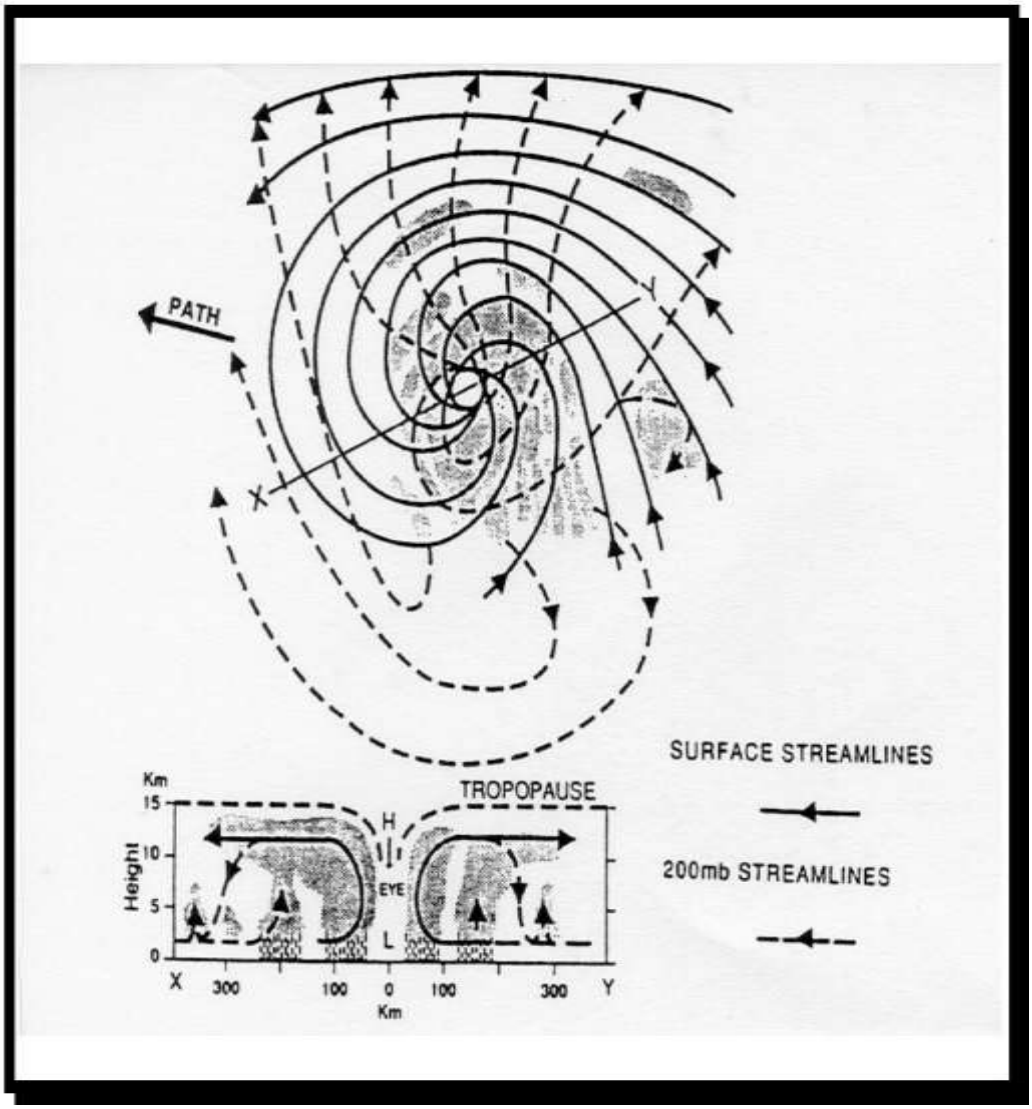


Figure 1.4: A model of the aerial and vertical structure of a tropical cyclone

Source: (Islam, 2011)

In 2007, Cyclone Sidr hit the south-west part of Bangladesh with winds up to 240 kilometers per hour. Using tidal wave, the cyclone changed into accompanied as five meters high with a surge up to sis meters in a few regions, breaching coastal and river embankments, flooding low mendacity areas and instigating vast physical obliteration. The houses, roads, bridges and several infrastructures are damaged due to high wind and floods additional with the cyclone. The roads and waterways have become obstructed as well as the electricity and communication system had been crushed. The source of drinking water as well as agricultural land, ponds, farms etc. was inundated with saline water and the sanitation infrastructure was completely collapse. (Government of Bangladesh, , 2008)

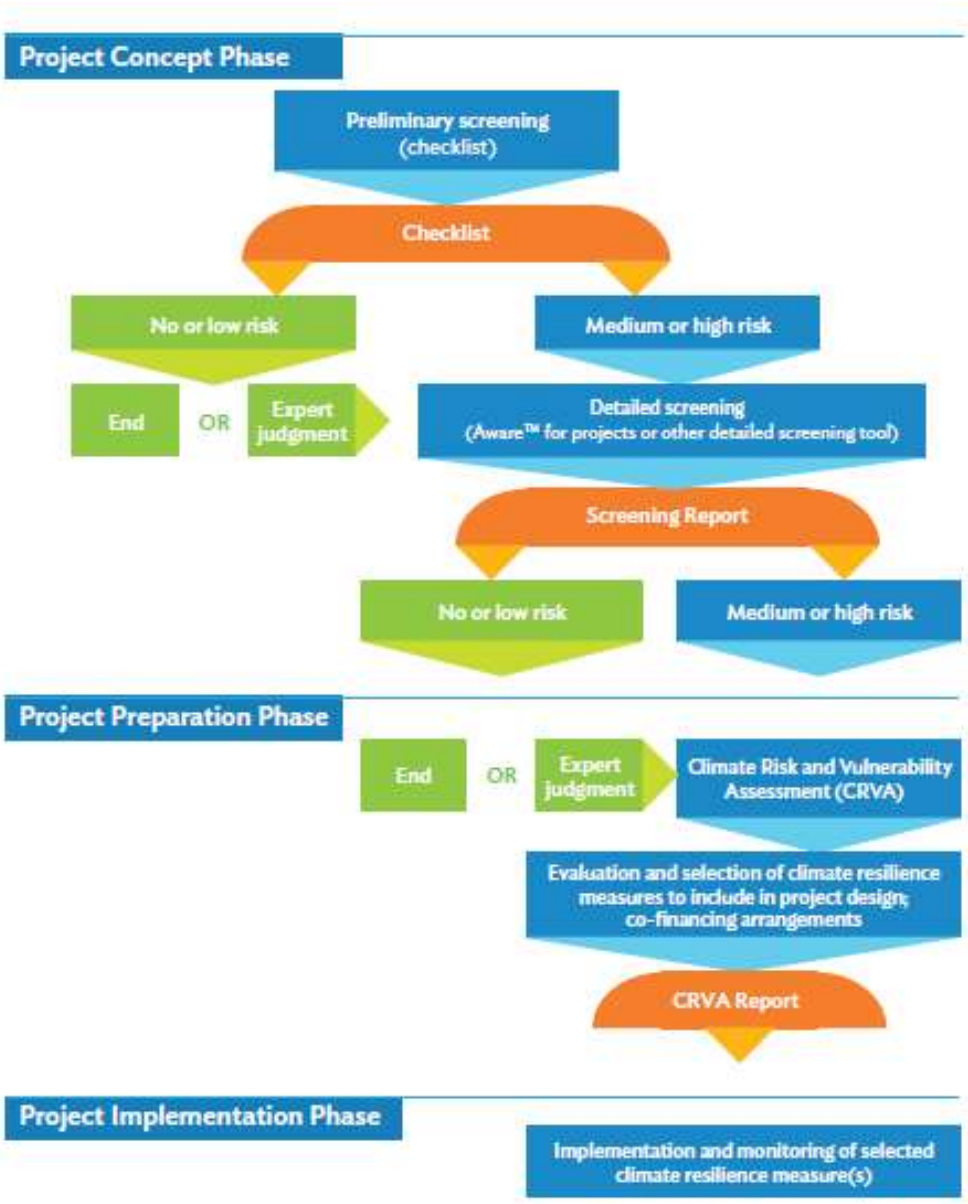


Figure 1.5: Framework for Climate Risk Screeningand Climate Risk Vulnerability Assessment

Source: (Bangladesh Climate and Disaster Risk Atlas, 2021)

1.2 Objectives

1) To investigate the existing cyclone management activities in the study area.
2) To find out the effects of these disasters on people's lives, health and economy.
3) To assess integration of technological aspects in current management practice.
4) To investigate the effect of natural disasters on household welfare and the preparedness of social protection systems.

1.3 Research Justification

The purpose of this research is to observe how cyclone management stages are now being conducted by both governmental and non-governmental entities. It offers a comparative examination of cyclone management actions at the regional, national, and worldwide levels. Additionally, this paper examines the technology components of contemporary cyclone management practices. It covers emerging technologies that are being implemented globally and recommends apocopate technologies that are ideal for Bangladesh in terms of availability, flexibility, and excess capability. Additionally, this research examines human behavior on technological sites and makes recommendations based on it.

1.4 Scope

The scope of this study is to compare the management stages and identify which is the most frequently practiced. Additionally, it assists in identifying service gaps in the existing cyclone management phase. This study can assist in developing cyclone management plans that incorporate technology by identifying technological gaps in existing plans and defining the role of various government and private organizations in developing management plans and promoting technology.

1.5 Limitations of the study

Almost every study has certain limitations. Nevertheless, this study had several limitations. These constraints were difficult to overcome entirely but were attempted to be mitigated to the greatest extent practicable. The following limitations apply to this study:

1. Individuals of the study area are usually more flexible to share information with Non-governmental organization rather than a student for research purpose.
2. Lack well connectivity to the remote area and security from burglar of the Sundarban area.
3. Scatter Settlement in the vulnerable area made it difficult to conduct survey.
4. Less co-operative behavior and information sharing from Upazila parishad.

CHAPTER 2: LITERATURE REVIEW

2.1 Disaster in Bangladesh

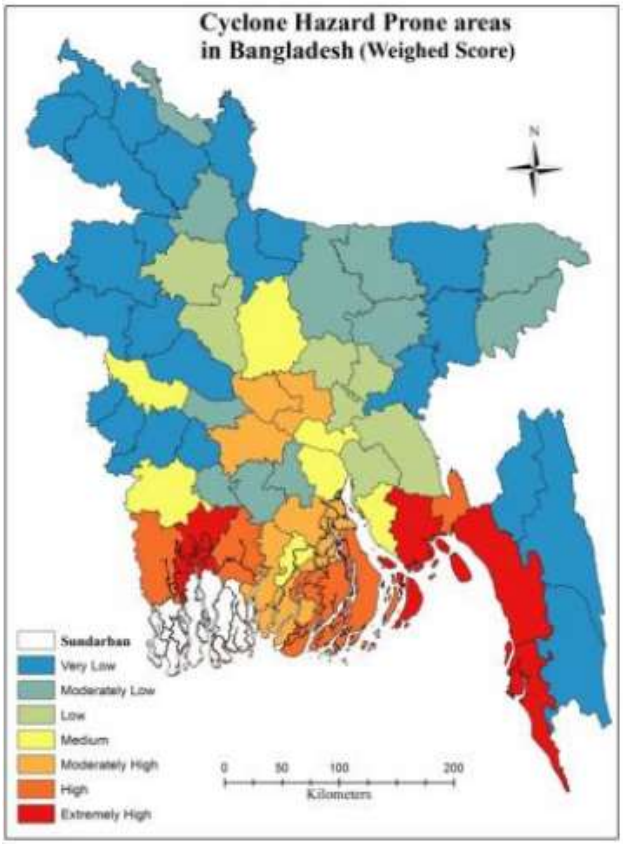
Floods, cyclones with incidental storm surges, droughts, tornadoes, river-bank erosions, and earthquakes are the most unfortunate natural hazards that frequently strike the nation. People's Republic of Bangladesh is one of the most disaster-prone countries in the world due to the recurrence and severity of natural disaster-related deaths and property destruction. Since the 1990s, as a result of a change in global temperature, the occurrence of natural disasters has become irregular and their intensity and frequency have increased dramatically. Cyclone Sidr was one of the strongest named cyclones in the Bay of geographical region. In 2007, Cyclone Sidr caused 3,400 fatalities, US$ 1.7 billion in damages, and impacted over 8.9 million people (J.C., 2015). In 2009, Cyclone Aila caused US$ 170 million in economic damage and 130 deaths, as well as affected 11 of 19 coastal districts (Akter S., 2013). The impact is primarily felt by the poor, who can hardly afford to construct cyclone-resistant homes and save a great number of lives. In many ways, the 2004 floods appeared to be as devastating as the 1998 floods within the context of flood history. The preliminary estimates of the joint mission indicate that total damage to assets and output losses amount to roughly $2 billion or 3.9% of total GDP, the majority of which correspond to lost assets (houses).

Figure 2.1: Major Hazards in Bangladesh

Source: (Bangladesh Climate and Disaster Risk Atlas, 2021)

A cyclone is an intense, circular storm that develops over warm tropical oceans and is characterized by low atmospheric pressure, strong winds, and heavy precipitation. Drawing energy from the sea's surface and sustaining its strength so long as it remains above warm water. In Bangladesh, they are a natural hazard. The word "cyclone" is derived from the Greek word "kyklos," which means snake coil. Typically, a cyclone is a low-pressure area characterized by strong winds that circulate counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. A tropical cyclone is a cyclone that occurs in tropical

regions. Cyclones that occur outside of the tropics are known as extratropical cyclones. The Bangla term for cyclones is tufan, derived from the Chinese "tai-fun." (Islam, 2011).



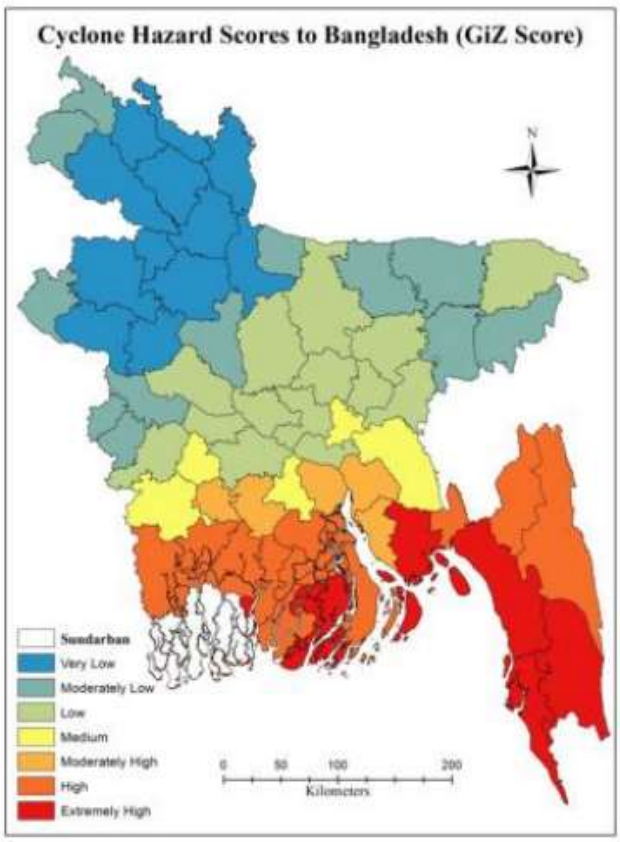


Figure 2.2 (a): Cyclone hazard prone areas based on weighed scores

Figure 2.2 (b): Cyclone hazard prone areas based on GiZ scores

Source: (M.S Hossain, 2019)

According to the official report of Bangladesh, nearly two million households and 8.7 million people were affected, 1.5 million houses were destroyed, 4.1 million trees were uprooted, and crops on one million hectares of land were completely or partially destroyed. The estimated damage and loss to livestock, crops, and fisheries was BDT 30.2 billion (US$437.6 million), of which BDT 1.5 billion (US$21.3 million) was for property damage and BDT 28.7 billion (US$416.3 million) was foPeterr production loss (Government of Bangladesh, , 2008). The cyclone struck right before the harvesting time as a result rice production heavily disrupted. According to the latest estimation of Government of Bangladesh, between 800,000 to 1.3 million MTs of paddy has been highly affected through cyclone. The tidal surge caused most of the damage on live stock that drowned birds, animals and falling of trees. An amount of BDT 1.3 billion (US$ 19.33 million) was the estimated value of the dame of livestock subsector

and consist of damage to the fisheries infrastructure and losses in catch or production was caused by SIDR. In the then most affected district, the damage and losses for fisheries subsector was estimated an amount of BDT 463 million (US$6.7 million) and according to Bangladesh Frozen Food Exporter's Association, the loss in shrimp or frozen food was around BDT 250 crore (Moni, 2015).

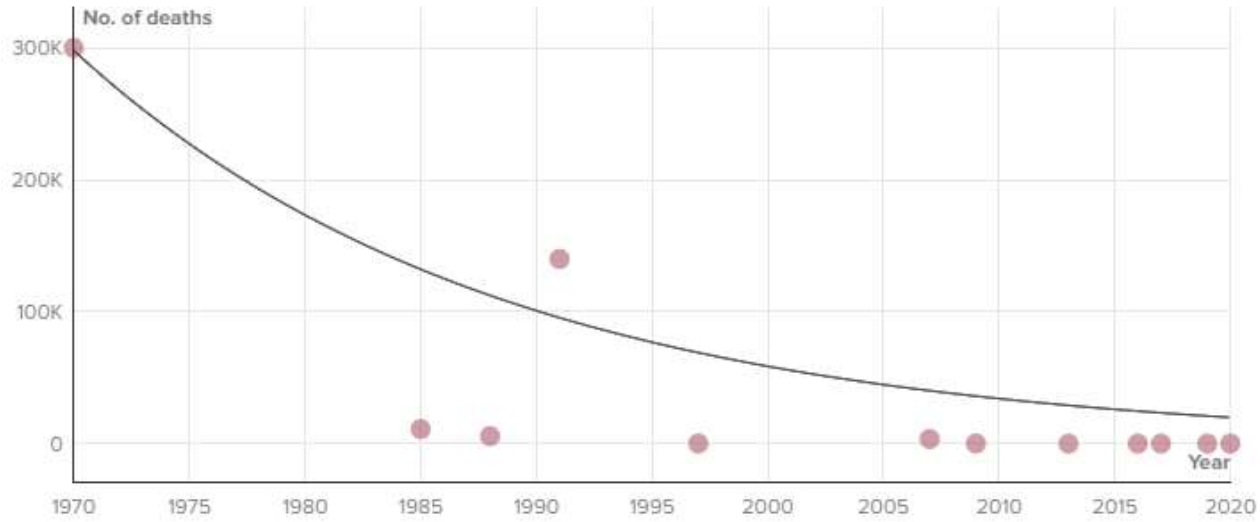


Figure 2.3: Deaths from cyclones in Bangladesh (1970-2020)

Source: (Peter Sammonds, 2021)

A number of 109,842 household was affected by the Aila in Khulna region where 58,499 household is fully damaged, 51343 household is partially damaged which was mentioned by Relief Control cell of Ministry of Flood and Disaster Management. According to the study of UO-HW-NK, 99% each made houses ruined into the flood area and the economic loss of households should stand well over BDT 450 million (US$ 6.5 million) due to the destructions (Roy K., 2009).

2.2 Definitions of the terms used in study

2.2.1 Disatster

Significant disruptions to the functioning of a community that exceed its capacity to recover using only its own resources constitute a disaster. Disasters can be caused by natural, technological, or man-made hazards, as well as by a variety of factors that increase a community's exposure and vulnerability.

2.2.2 Hazard

A hazard is something that has the potential to cause harm or have a negative effect on the health of a person or group of people. A hazard is any physical event, social or economic disruption, or environmental degradation that has the potential to cause harm. Typical hazards include a lack of rain, which ultimately resulted in drought, or an abundance of rain, which consequences in floods.

2.2.3 Disaster Risk

Risk refers to the probability that negative outcomes will occur when hazards interact with vulnerable areas, individuals, property, and the environment. While disasters are commonly viewed as external shocks, disaster risk results from the complex interaction of development processes that create conditions of exposure, vulnerability, and hazard. Therefore, disaster risk is the product of the severity and frequency of a hazard, the number of people and assets exposed to the hazard, and their susceptibility to damage. Intensive risk is associated with low-probability, high-impact events, whereas extensive risk is associated with high-probability, low-impact occurrences.

2.2.4 Vulnerability

Vulnerability refers to the attributes and conditions of a community, system, or asset that make it susceptible to the negative effects of a hazard. Due to numerous physical, social, economic, and environmental factors, vulnerability manifests itself in a variety of ways. Vulnerability varies considerably between and within communities. However, the term is frequently employed in a broader sense to refer to an element's exposure.

2.2.5 Disaster Risk Management

The process of implementing policies and strategies for disaster risk reduction in order to prevent new disaster risks, mitigate existing disaster risks, and manage residual risk, thereby contributing to disaster resilience building and loss reduction. The ISDR secretariat defines disaster risk management as the systematic process of employing administrative decisions, organizational structures, operational capabilities, and capacities to implement policies, strategies, and coping capacities of society and communities in order to mitigate the effects of all-natural hazards and associated environmental and technological disasters.

2.2.6 Mitigation

Mitigation is the permanent reduction of the risk of a disaster. Primary mitigation refers to decreasing the resistance and vulnerability of the hazard. Secondary mitigation refers to reducing the effects of the hazard. Awareness, education, readiness, and predictive and early warning systems can all assist communities in mitigating the disruptive effects of a natural disaster. To prevent or mitigate actual damage caused by hazards, however, mitigation measures like zoning, land-use practices, and building codes are necessary.

2.2.7 Prevention

Prevention is demarcated as those doings taken to avoid a natural phenomenon or potential hazard from having damaging effects on either people or economic assets.

2.2.8 Preparedness

Preparedness refers to the measures that guarantee the organized mobilization of personnel, funds, equipment, and supplies for effective relief in a secure setting. Disaster preparedness is the process of building capacities prior to a disaster's occurrence in order to mitigate its effects.

2.2.9 Response Phase

During the Response Phase, the disaster plan is implemented. Disaster response is the organization of activities used to respond to a disaster and its aftermath. The Response Phase focuses primarily on providing emergency relief: saving lives, administering first aid, minimizing and restoring damaged systems (communications and transportation), meeting the basic needs of those affected by the disaster (food, water, and shelter), and providing mental health, spiritual, and comfort care.

2.2.10 Recovery Phase

The Recovery Phase focuses on stabilizing and restoring the community and health care system to their pre-impact states, also known as "restoring normalcy." Rebuilding damaged structures and repairing a community's infrastructure, as well as relocating populations and implementing intermediate and long-term mental health interventions, can all be included in the Recovery Phase's activities.

2.2.11 Capacity

Capacity refers to all of a community's, organization's, or society's strengths, attributes, and resources available to manage and reduce disaster risks and strengthen resilience.

2.2.12 Disaster Resilience

Individuals, communities, organizations, and states must be able to adapt to and recover from hazards, shocks, or stresses without jeopardizing long-term development prospects.

2.2.13 Community-based disaster management (CBDM)

Community-based disaster management is a strategy for strengthening communities' capacity to assess their vulnerability to both human-caused and natural hazards and to develop strategies and resources for preventing and/or mitigating the impact of identified hazards, as well as responding to, rehabilitate, and rebuild following their onset.

2.3 Case Study

a. Cyclone Sidr

On November 15, 2007, a super cyclone named Sidr struck the coast of Bangladesh, with Bagerhat, Barguna, Patuakhali, and Pirujpur being the four worst-affected districts. Shariatpur, Bhola, Barishal, Khulna, Jhalakthi, Madaripur, Satkhira, and Gopalgani were among the eight districts that were moderately affected.

Bangladesh is a poor country with a poverty rate of 20.5 percent (2019), and the population density in the 12 affected districts was 800 inhabitants per square kilometer. The poverty rate in the two most affected divisions, Barisal and Khulna, is higher than the national average. Barisal had the highest rate of poverty in the nation at 50 percent, while Khulna's rate was 45.7 percent.

The estimated number of fatalities in the Sidr was 3,406 and the number of injuries was 55,000. The preliminary damage and loss assessment for crops, livestock, and fisheries was estimated at BDT 30.2 billion (USD$ 437.6 million), and the estimated value of damage to livestock was BDT 1.3 million (USD$ 19.33 million). One million people's means of subsistence were severely impacted by the slaughter of 2,688,942 livestock in Sidar. Where 2 million people were impacted by their farms. 58 million people were completely reliant on their farm incomes,

which they use to purchase food. In addition, 7,155 ponds and 11,612 tube wells were destroyed.

b. Cyclone Aila

Khulna and Satkhira were hit the hardest by cyclone Aila, which struck the southwest coast of Bangladesh on May 25, 2009. Other coastal districts affected included Barisal, Bhola, Pirojpur, Patuakhali, Barguna, Jhalokathi, Bagerhat, Chittagong, Cox's Bazar, Feni, Laxmipur, and Noakhali.

More than 67 percent of the inhabitants of four upazila in the districts of Khulna and Satkhira (the areas hardest hit by Aila) are originally poor. More than half (55%) are extremely impoverished and food insecure.

According to recent poverty estimates calculated by the Bangladesh Bureau of Statistics, the World Food Programme, and the World Bank, 65 percent and 58 percent of the population in the upazilas of Shyamnagar and Assasuni in the district of Satkhira are extremely poor, while the rates for Koira and Dacope are 35 percent and 60 percent, respectively. The primary source of income for the affected population is agriculture and fishing, with forty percent engaged in shrimp farming, thirty percent in agricultural work, and thirty percent in manual labor. (Nation United, 2010)

Aila affected more than 3.9 million people, resulting in approximately 190 fatalities and 7,100 injuries. A total of one million livestock were killed in Aila, which represents 80 percent of all affected areas. Approximately 350,000 acres of agricultural land were harmed, 70 homestead gardens were flooded, and 70 percent of the green vegetation was harmed. As a result of the destruction of all local markets and the disruption of physical access to the markets in the worst-affected areas, it became difficult to obtain food. Due to the injection of salt water into 4,000 protected ponds, 1,000 ponds with sand filters, and 13,000 tube wells, 50 percent of the region is immediately faced with a drinking water shortage. (UN, 2010)

c. Cyclone Mahasen

On the 16th of May, 2013, a cyclone struck southern Bangladesh, primarily the Barisal division, causing damage to agriculture, fishing ponds, and sea fishing, which represent the primary means of subsistence.

There were 17 fatalities and 4,63,303 people were directly affected by cyclone Mahasen, which caused a total loss of BDT 34,544,950 and affected 19,998 livestock and poultry. 13 percent of the households lost their livestock, and 6 percent lost their poultry. Farmers

struggled to acquire vegetable seeds, Aman seeds, and agricultural equipment, whereas fishermen struggled to acquire fishing boats and nets. No significant impact on water was reported in the absence of harm to household food stocks. (Government of Bangladesh, 2013)

d. Cyclone Bulbul

Cyclone "Bulbul" reincarnating from Cyclone "Mamto" categorized as "very severe", made landfall over India on 9 November 2019 before entering Bangladesh on 10 November 2019. The cyclone impacted thirteen southern districts of the country.

Around 2.1 million people were evacuated and moved to some 5,587 cyclone shelters on 9 November with the help of Cyclone Preparedness Program (CPP) volunteers, Bangladesh Red Crescent Society (BDRCS), Fire Service and Civil Defense (FSCD), Police Armed Forces and other organizations after BMD assigned various warning signals along the coastal districts in anticipation of Cyclone Bulbul.

The cyclone affected around 722,674 people in Satkhira, Khulna, Bhola, Bagerhat, Patuakhlai, Barguna and Pirojpur districts. More than 108,000 houses and 117,000 hectares of crops affected along with significant damages to several embankments by cyclone Bulbul. According to the daily disaster report published by Ministry of Disaster Management and Relief (MoDMR), nine people have died from various causes during the cyclone.

World's largest natural mangrove forest- the Sundarbans took a massive blow of Cyclone Bulbul which significantly slowed down the speed before it entered the locality. There were no wildlife casualties reported; however according to Bangladesh Forest Department around 4,589 trees were damaged. The western part of Sundarban saw a damage of approximately 4,000 trees and 587 trees in the eastern part as reported in Cyclone Bulbul 2019 joint rapid assessment by Need Assessment Working Group (NAWG). The assessment also reports that a loss of USD 5.5 million (approx. CHF 5.4 million) in fisheries was faced with a total of 11,223 hectares of affected pond/gher (fish farm) land and initial livestock damage was USD 285,000 (approx. CHF 281,979).

e. Cyclone YAAS

The severe cyclonic storm 'YAAS' made landfall in India's West Bengal and Odisha coast on 26 May 2021 during the lunar eclipse, which caused abnormal 6-8 feet tidal waves across the coastal districts, namely Bhola, Patuakhali, Satkhira, Khulna, Bagerhat, Jhalokathi, Barguna, Barisal and Pirojpur, resulting in breached embankments and inundation. Consequently, people in these areas were forced into temporary displacement or living in a marooned situation.

According to the Need Assessment Working Group (NAWG) report, the cyclonic event affected approximately 1.3 million people, damaged around 26,000 houses, 16,183 latrines and 1,986 water points in nine coastal districts. The most affected districts were Bhola, Patuakhali, Satkhira, Bagerhat, and Barguna. It is also estimated that the cyclone damaged 39 per cent of croplands and affected 3,599 hectares of areas. Three deaths were reported by the Directorate General of Health Service (DGHS) and the health emergency operation center (EoC).

Cyclone YAAS struck almost the same areas as Cyclone Amphan in 2020. These areas were still struggling when YAAS hit in the rainy season. Consecutive disasters impacted residents their entire lives, impeding their ability to recover. Frequent disasters in these coastal areas caused salinity intrusion and negatively affected livelihoods and agriculture sectors, forcing people to adopt negative coping mechanisms.

f. Cyclone Amphan

The Bangladesh Meteorological Department (BMD) issued 'danger' signal number 10 for coastal districts and their offshore islands and chars on May 20, 2020. More than 2.4 million people were relocated to 14,636 permanent and temporary shelters in response to the Government of Bangladesh's (GoB) signal and order of evacuation.

According to the Need Assessment Working Group (NAWG) report, homes were destroyed in 19 of the affected districts. A total of 26 people were killed. Moreover, 40,894 latrines, 18,235 water points, 32,037 hectares of crops and vegetables, 18,707 hectares of fish cultivation area, 440 kilometers of roadway, and 76 kilometers of embankments were damaged.

A strong tidal surge impacted cyclone-affected communities in Khulna and Sathkira once more in August 2021 due to active monsoon conditions and a lack of sustainable repair of the embankment. In the Koyra and Paikgachha Upazilas of the Khulna district, some 50,000 people were severely affected. At least 250 shrimp enclosures were washed away, and 15,000 individuals were exposed to severe waterlogging issues. In the district of Satkhira, 375 acres of land were flooded, along with 250 acres of farmland and fish enclosures.

Land cover maps and precipitation data are subject to significant change over time. Similarly, drainage densities, distances to roads/streams, TWI, NDVI, SPI, and adjacent infrastructure might change over time. As a result, these variables are referred to as 'dynamic variables'. The remaining levels are referred to as ' persistent variables'.

2.4 GIS and Remote Sensing Applications

As evidenced by our location observation programs, remote sensing and GIS applications have developed into successful tools for disaster management, and the need for hazard mitigation and monitoring is a top priority in the planning of new satellites. By utilizing models, GIS enables the merging of diverse types of data. It enables the combination of various types of spatial data with non-spatial data and attribute data, as well as their use throughout the disaster management procedure.

The use of remote sensing techniques can effectively reduce the risk of natural disasters and aid in identifying the hazard zone and its causes. The wind is one of the environmental causes of disaster. Using remote sensors, it is possible to detect and forecast hurricane-related catastrophes. The inhabitants of the affected area are alerted by these sensors, allowing them to relocate to avoid damage.

After any natural disaster, many areas are inaccessible, making damage assessment and management extremely difficult. However, the operation was protected by remote sensing. Again, the remote sensing technique is widely utilized for identifying areas susceptible to natural disasters.

The remote sensing technique plays a crucial role in emergency mapping in order to facilitate simple and rapid disaster response. The sensors provide extensive, timely, and widespread data that the rescue team uses to plan the rescue mission.

Human actions frequently contribute to the onset of natural disasters. To control this, however, the remote sensor can be used to map human risks that are likely to cause catastrophe. Risk mapping generates a report and data that can be used to warn people about their disaster-causing activities and to prepare for and prevent the disaster.

2.5 Current cyclone warning system

A study titled "The Current Cyclone Early Warning System in Bangladesh: Providers' and Receivers' Views" describes how the Bangladesh Meteorological Department Forecasts Tropical Cyclones (TCs) and distributes warning messages.

The Bangladesh Department of Disaster Management (DDM) has developed three mobile-network-based warning message dissemination methods so that coastal residents and field-level disaster management committees have easy access to warning messages:

• Cell Broadcasting System can be used to send warning messages to a specific population, namely coastal residents.

• Interactive Voice Response is a system that allows residents to hear a recorded warning message by dialing a number.

• Short Message Service is a text messaging service designed specifically for disaster management committees at the field level. In the event of a cyclone emergency, members of these committees receive updated information about the approaching TC on their mobile phones.

(Chandan Roy, June 2015)

2.6 Study Area Profile

Dacope, Paikgacha, Koira, Terokhada, Dumuria Upazilas under Khulna district have been affected mostly in recent cyclones in Khulna division. In this study Dacope has been taken as the study area.

2.6.1 Location

Between 22°24' and 22°40' north latitudes and between 89°24' and 89°35' east longitudes, Dacope Upazila (Khulna district) encompasses a total area of 991.57 square kilometers. It is bordered on the north by Batiaghata upazila, on the south by the Pasur River, on the east by Rampal and Mongla upazilas, and on the west by Paikgachha and Koyra upazilas. There are 10 unioins and 107 villages in Dacope.

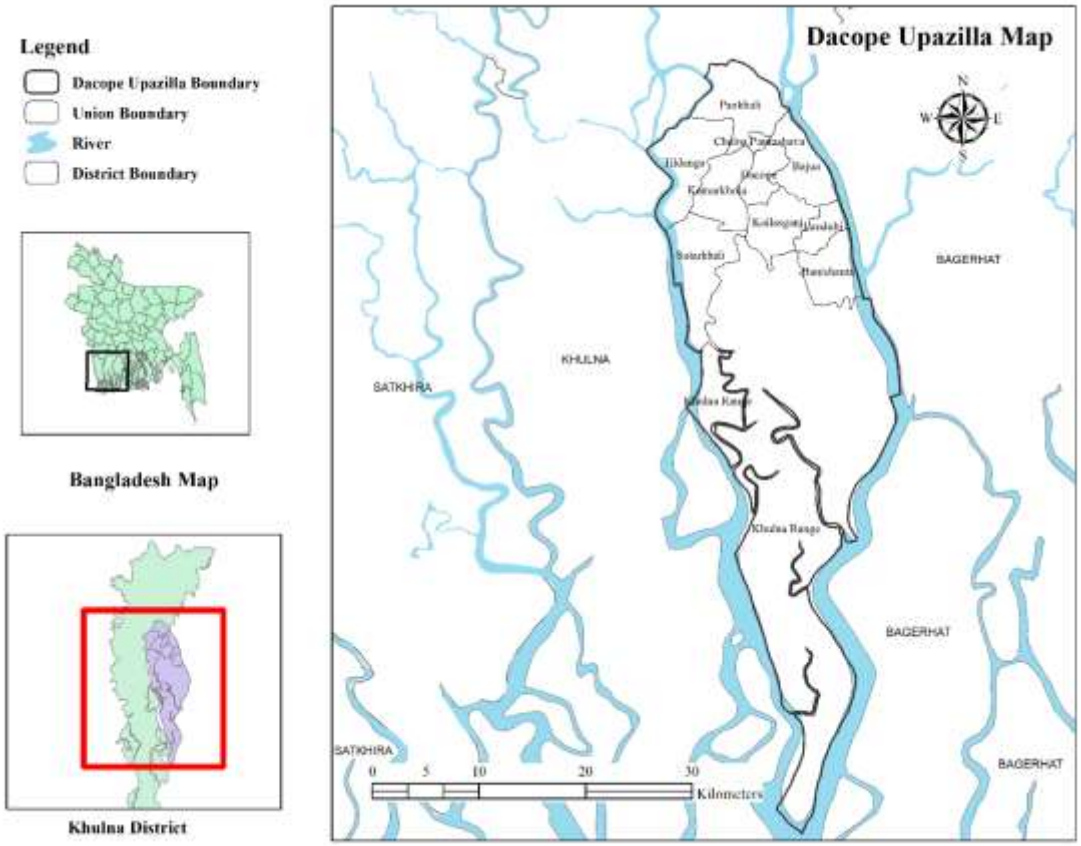


Figure 2.4: Locator Map of Dacope

2.6.2 Population and Literacy Rate

The total population of Dacope is 1,57489, with 83193 male and 74296 female residents. There are approximately 19804 urban residents and 137685 rural residents in the region. Approximately 65756 people are Muslim, 88842 are Hindu, 2760 are Buddhist, and 131 are of other faiths. The average rate of literacy is 46.66 percent, with males scoring 53.89 percent and females 38.98 percent. The urban area has a literacy rate of 54.7%, while the rural area has a rate of 48.57%. (BBS, May 2021)

2.6.3 Occupation

Primary sources of revenue Agriculture 66.07 percent, non-agricultural laborer 4.85 percent, commerce 12.86 percent, transport and communication 1.72 percent, service 4.10 percent, construction 0.93 percent, religious service 0.24 percent, rent and remittance 0.05 percent and others 9.18 percent. The possession of agricultural land Landowner 55.02 percent, landless 44.98 percent; agricultural landowner: urban 42.04 percent and rural 57.06 percent. Their

primary crops are rice, potatoes, pumpkins, and vegetables. Crops that are extinct or nearly extinct Jute, sesame, aush, and boro paddy. The principal fruits are coconut, guava, plum, sofeda, bangi, and watermelon. In this upazila, the fishing, dairy, and poultry industries are extensive, as is shrimp farming. (BBS, May 2021)

According to a field study, watermelon cultivation has become highly popular in these locations due to the soil composition, the fact that watermelon cultivation takes more water, and the fact that these areas do not have enough water for farming. Recently, certain governmental and non-governmental organizations (NGOs) had provided sewing machines and instruction to idle housewives to help them become more self-sufficient. However, due to the difficulty in obtaining raw materials for this operation due to inadequate road conditions, they were compelled to liquidate their machines for cash.

2.6.4 Water bodies

Main rivers of Dacope is Pasur, Shibsa, Manki, Bhadra. Also, Palashbari, Churia, Nalian and Jugra canals are notable water bodies of the region.

2.6.5 Utilities

All unions of the Dacope upazila have access to electricity through the rural electrification network. Nevertheless, 6.35 percent of homes have access to electricity. Tube-well 39.78 percent, pond 54.06 percent, faucet 3.15 percent, and others 3.01 percent are sources of potable water. Sanitation 38.83 percent (71.75 percent in urban areas and 33.66 percent in rural areas) of dwelling households in the upazila use sanitary latrines, 48.70 percent (21.17 percent in urban areas and 53.02 percent in rural areas) use non-sanitary latrines, and 12.44 percent of households lack latrine facilities. (BBS, May 2021)

CHAPTER 3: METHODOLOGY

3.1 Desktop Research

To conceptualize the project, desktop research was conducted. A research question and a set of objectives to accomplish the goal were identified. Desktop research was used to conduct the case review and secondary data collection. Although the desktop survey alone is insufficient to determine the feasibility of any given area, it assisted in determining the study's type, primary features, and work areas. That further establishes that additional surveying and investigation were necessary.

3.2 Theoretical Framework

A literature review was prepared for the project. Conceptualization of several topics like community problem, priority ranking of community problem. A conceptual framework was prepared and shown in a form of diagram which presented all aspects of conceptualized knowledge concerning this project.

3.3 Selection/ Analysis of the study area

For this study, Dacope Upazila in Khulna was selected as the study area based on previous record of cyclone and vulnerability. Among all the union, five vulnerable unions (Pankhali, Tildanga, Kamarkhola, Sutarkhali and Banishanta) is selected based on vulnerability, loss of life and asset, exposure etc. After that this area was analyzed to know about the social condition of the people. And through some surveys and analysis which are discussed in further steps of methodology.

3.4 Reconnaissance field Survey

A primary reconnaissance field survey was conducted to gather information of the study area and understand the existing condition of the people. Primary conceptualization of the infrastructure condition, roads, connectivity, water sources, settlement pattern, structure and material type, and educational institutions etc. of the study area was possible through this reconnaissance survey.

3.5 Sampling

Among 9 unions, 4 vulnerable unions are selected based on previous data where 120 sample was collected according to the following list:

3.6 Key Informant Interview

This key information interview is related to the data collection. The main ideas of our project that we are getting from the people of study areas and the data we are getting from different focus groups, are actually true or not. So, to verify the information from different focus groups, key information interview is important. Another purpose would be to get main or key information from them. In case of not getting the key information from the focus group that we selected, then we will get the information from the key information interview. So, basically key information interview refers to getting the main information about our project and also the overall overview of the project area.

3.7 PRA and RRA method

On the participatory dimension, both RRA and PRA can be applied in ways that are more or less participatory. PRAs in which community members take full control of the process are at one extreme of the participatory continuum. In RRAs, there is generally little expectation that the community will be in charge of the process but they too may be carried out in a way that is more or less participatory depending on how the study is set up, the information is used, etc. on the other hand, RRAs put the higher premium on the collection of quality information and, while they seek participation, will be willing to settle for somewhat less participation in order to assure that they meet their information gathering objectives.

3.8 Focus Group Discussion

First of all, focus discussion is a part of data collection that helps us to get descriptive data of different studies. For this a group of people is selected who are staying in this area from many years and those who can provide different information, statistics and over all view of our study area and also key information of the area related to our project. The main idea behind the focus group discussion is to provide an opportunity to the participants to talk to each other about the project. After selecting the focus group, a discussion was held to find out different data and key information.

The members of the working group concur that there is no single set of methods for Part Planning. The success of a method is contingent on regional conditions and customs. In the working group, we discussed ways to work with farmers and farmer groups by establishing

projects on farmers as water managers, focusing in particular on working with key personnel and "kitchen table talks."

3.9 Key Persons Part

Planning is not only about organizations working together but about individual people as well. When starting up a project where authorities and community people have to work together, it's often a success when a key person is involved as an intermediate between authorities and community organizations.

Characteristics of such a key person are:

- Can work on a local scale.
- Understanding of governmental issues and affinity with the communities' practices. - Good networking and communicating skills.
- Can rely on some trust from community and of authorities as well.
- Can be 'used' as ambassador on different levels, even within (national) government. It has been stated that the right key person is sometimes difficult to find. It depends on some luck and coincidence: "the first one is the best one". Skills are often more important than technical knowledge on its own. These people can be found within (institutional) agricultural advisory organizations, private consulting firms, farmers' unions (commercial branch), but also in the network of (retired) policy makers.

3.10 Kitchen table talks

A specific piece of equipment. Planning entails "kitchen table discussions." This implies that authorities, scientists, and the community meet at the local level, such as at a kitchen table. Or on a larger scale with a group of local farmers in the town hall. The success of this method depends on factors such as meeting time, location (accessibility), invitation method (via/coproduction with agricultural organization), meeting atmosphere, etc.

3.11 Analysis & Interpretation

After collecting the data, it needs to be analyzed properly to justify the scenario. To analyze the data there are some maps are produced such as social map, resource map, mobility map and dream map.

3.12 Conclusion & Recommendation

After the analysis the data has been showed the condition study area. And provide some recommendation based on problem of the community people. The interpretation of the findings has given a view of the project and helped to take a better condition of community people.

3.13 Methodological Framework

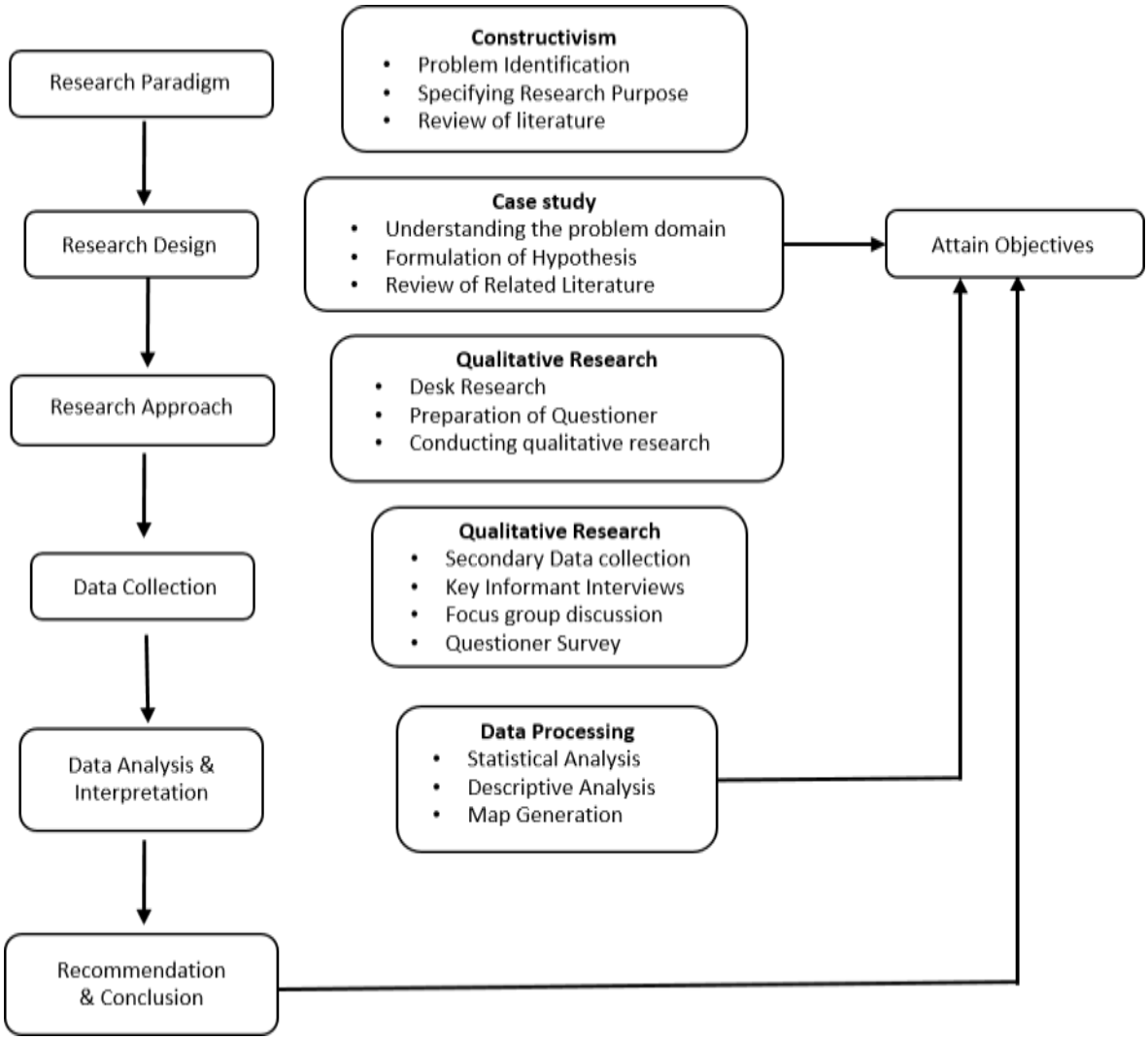


Figure 3.1: Flowchart of the Methodology

CHAPTER 4: DATA ANALYSIS & INTERPRETATION

4.1 Basic Information

4.1.1 Housing and Sanitary Condition

In the field survey it was found that 70% people owned katcha house because of being poor or having low income and most of them use katcha toilet. In these remote area, by the help of Government and some Non-Governmental Organizations (NGOs) people are moving towards hygienic toilet system. As a result, sub urban and some of the remote area is drive to Pacca (Non-water sealed) toilet system and the urban area contain Pacca (Water sealed) toilet.

Some NGOs are building awareness about hygienic toilet system and they provide knowledge, technology and sometime materials also.

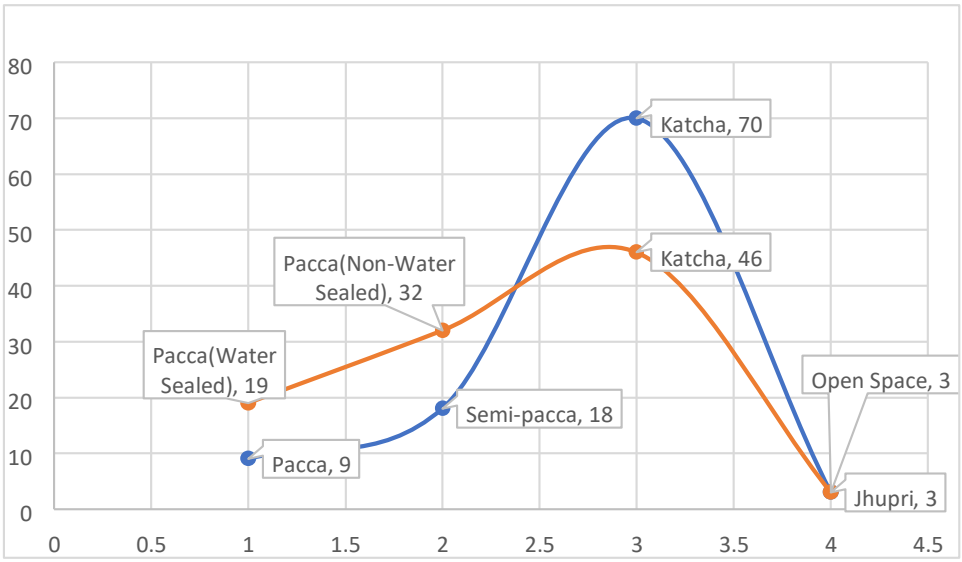


Figure 4.1: Relation Between House and Toilet

Source: Field Survey, 2022

4.1.2 Vulnerability Analysis

Dacope is an area which is surrounded by 08 rivers and covers 106 km length and southern part of it is covered with Sundarban. The river and lack of facilities make Dacope vulnerable and Tildanga, Banishanta, Pankhali, Sutarkhali amd Kamarkhola is considered as more vulnerable union whereas most of them is bounded by river. Lack of good connectivity, awareness, technological advancement and low quality of life me the area more vulnerable.

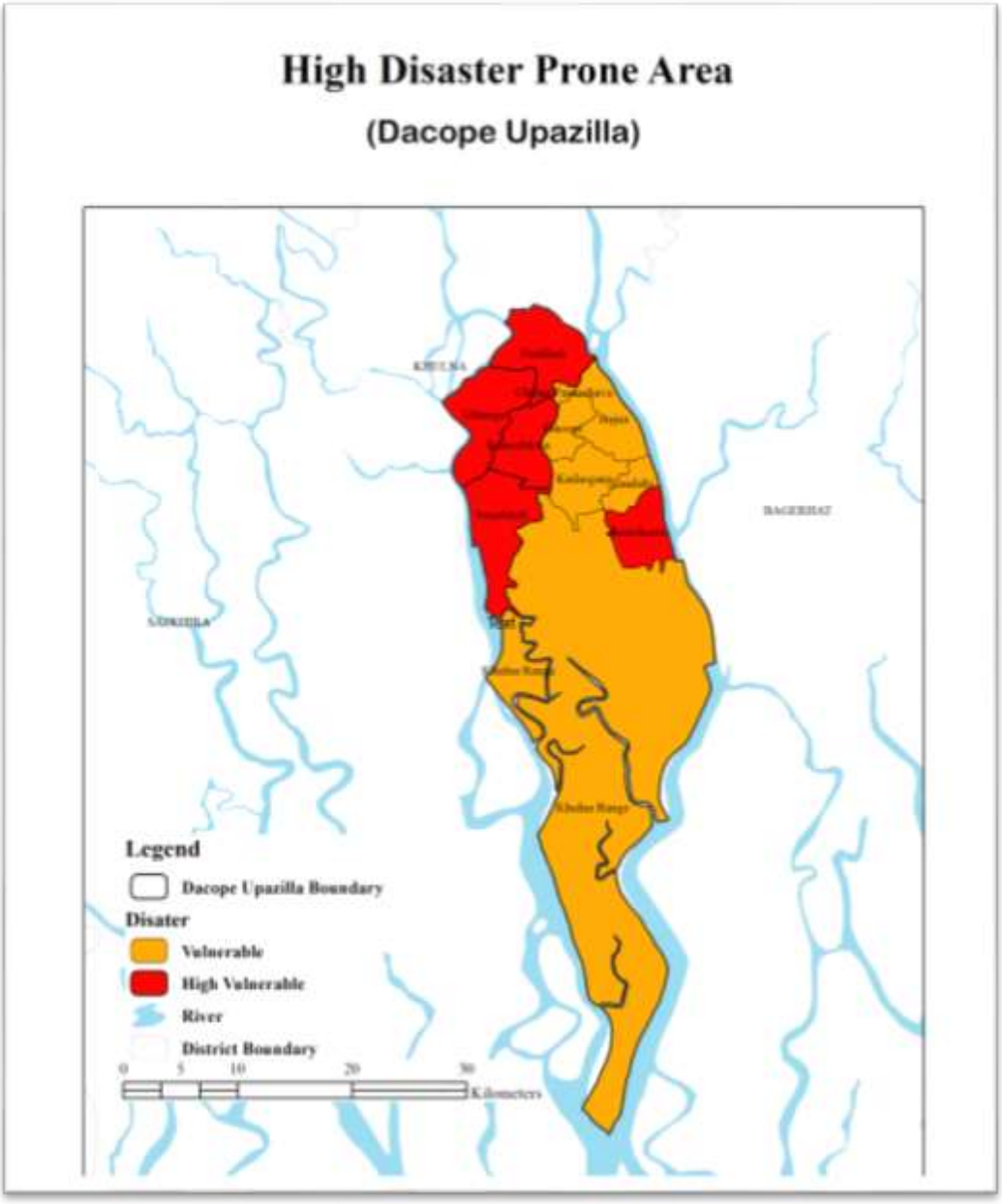


Figure 4.2: Vulnerable Area of Dacope Upazila

Source: Author,2022

4.1.3 Connectivity and Road Network

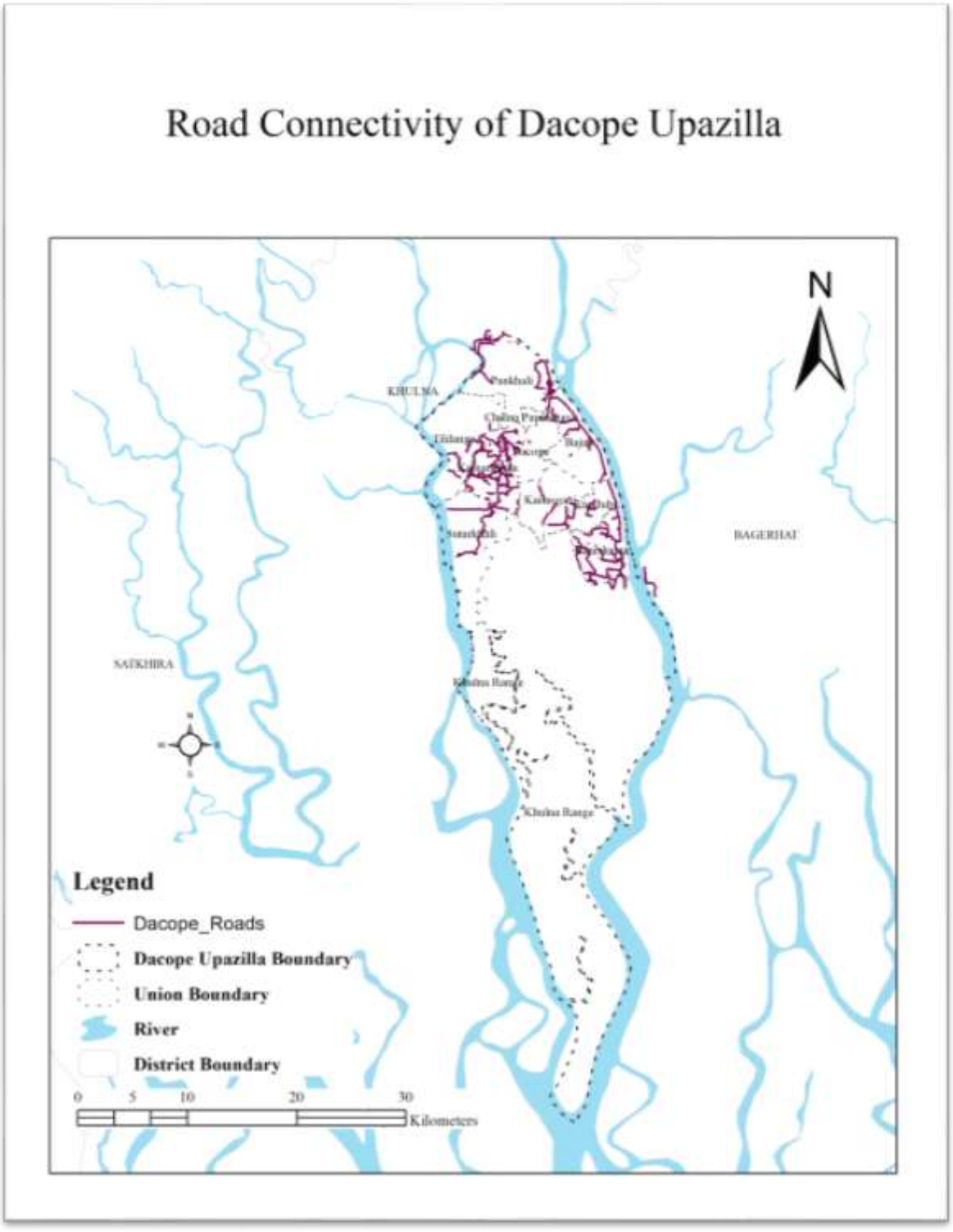


Figure 4.3: Road Network of Dacope Upazila

Source: Author, 2022

In the study area, 79 % roads are Katcha and rest of them are pacca, Brick ceiling Half Brick, Rigid Pavement etc. The road condition and connectivity are quite good in the urban area where as the rural area has very poor road condition as well as in the rainy season boat became the only vehicle to transport goods and people. An embankment is on process of preparation which is 5 ft high from the sea level financed by United Nations which will be used as Pucca road to the community.

Inefficient road network with major cities occur challenging while relief distribution to the affected area. According to my findings on study area, individuals have trouble transporting their goods to significant business areas, resulting in substantial economic loss. Agricultural products are occasionally ruined as a result of incidents that occur when transporting items. That is why most people work as day laborers during the dry seasons, when farmers with limited capital cannot afford to pump water from their firm land.

Table 4.1: Road Conditions in the Study area

Road Type	**Number**	**Length (Km)**	**Road Type**	**Number**	**Length (Km)**
Pucca		39	Union Road	10	69.04
Brick ceiling Half Brick		190	Village Road -A	40	192.13
Katcha		617	Village Road -B	209	424.25
Rigid Pavement		1			
Upazila Road	14	160.48			

Source: (Government of Bangladesh, 2015)

The most vulnerable area for cyclone of Dacope Upazila (Pankhali, Sutarkhali, Banisanta, Tildanga and Kamarkhola) contain very less pacca road (7km) whereas the total pacca road is 39 km and most of them are in the upazila side. The upazila contain 190 km Half Brick road and 617 km Katcha road where as the total road of the area is 846 km and that's why it contains a few small industries.

4.1.4 Cyclone Shelters

According to the Bangladesh Bureau of Statistics (BBS), there are 38 cyclone shelters in Dacope upazilla, with a total capacity of 34691. In the unions of Bajua, Baniashanta, Laudubi, Chalna, Dacope, Kailshganj, Kamarkhola, Sutarkhali, and Tildanga, the number of cyclone shelters is 3, 3, 3, 11, 1, 2, 2, 9, and 4, respectively. When compared to other localities,

Sutarkhali and Chalna are unquestionably the worst afflicted. However, the Baniashanta, Tildanga, and Dacope unions are all cyclone red zones, with insufficient cyclone shelters. During discussions with residents of those places, it was discovered that the capacity of the cyclone shelters is insufficient for the population. Inadequate bathrooms exacerbate hygiene concerns at cyclone centers, and separate sanitary solutions for women are hard to come across at these shelters. The water supply has also been determined to be inefficient. On these cyclone centers, there is no extra space for ladies or disabled individuals, causing hygienic issues for women and hardship for impaired people.

4.2 New Technological Aspects in Bangladesh

Recovery policies also should include not only livelihood generation and restarting industries, but also regenerating human/natural capital as well as resuming infrastructure investments for physical resilience. Natural hazard and climate change never wait until the end of the pandemic. It requires careful examination about the magnitude and depth of the impacts and losses across sectors and vulnerable communities, to take most appropriate recovery measures as well as prevention measures for next crisis immediately even the present Pandemic situation. The urgent focus on short-term needs does not always meet the needs for achieving long-term goals. These are the initiative to address the trends of climate change taken by Bangladesh:

- Cyclone shelter database information was made available online by the Disaster Management Information Centre (DMIC).
- Conducted comprehensive study on the future trends of temperature, humidity rainfall and using the study findings in cropping pattern and adaption in agriculture practices.
- Developed climate modeling and scenario building with the projection of 25, 50, 100 years of return period of flood, drought and cyclone.
- Documented the cyclone route and tract change and findings are using in policy decision to construct cyclone shelter and strengthen the cyclone preparedness programme.
- Risk reduction programme used the historical data and climatic risk from the study and research to protect the investment and in building resilience.
- Establish climate change trust fund and developed plan by incorporating disaster risk and focus at the high risk area for risk reduction programme in building resilience.

GIS and Remote sensing are widely used in all over Bangladesh in disaster management practice for simulation modelling specially storm surge, return period etc. and preparing

vulnerable, risk etc. maps. GIS and RS are Used all the phases in cyclone management practice such as simulation forecasting for prevention and preparedness phase, escape route, cyclone shelter location map etc. area used in response phase, initial assessment, loss and damage assessment, spatial planning etc. used to recovery phase.

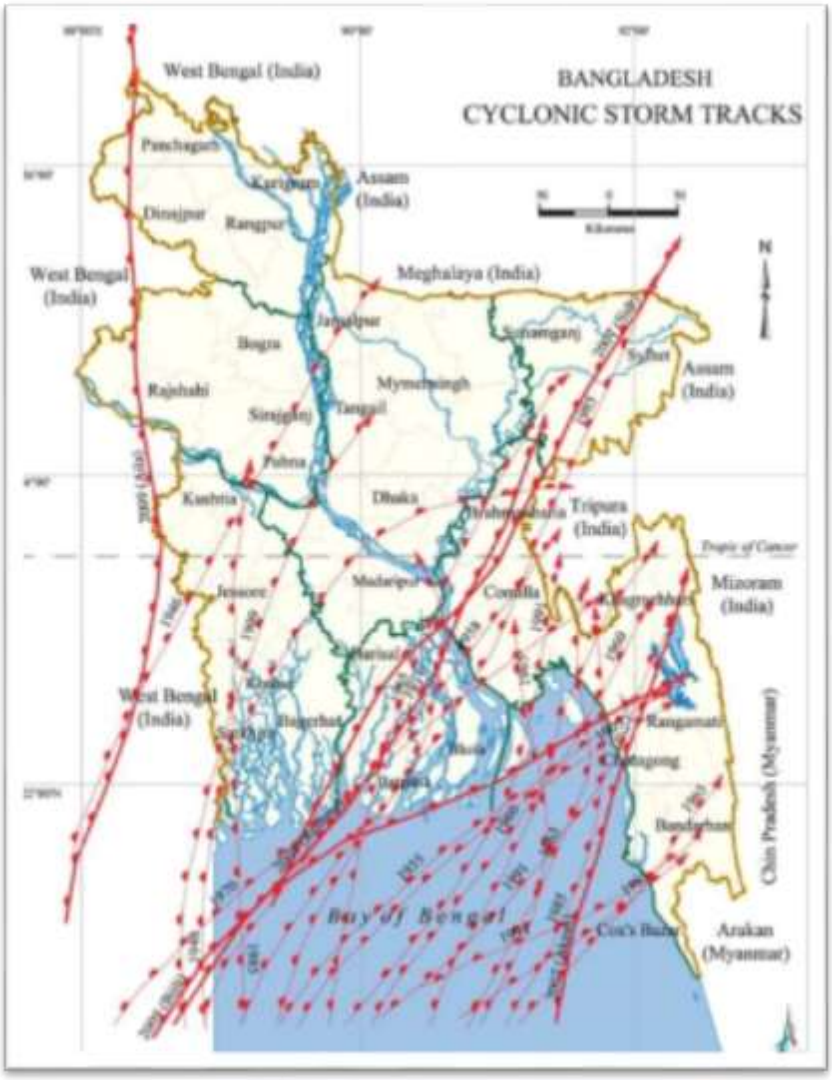


Figure 4.4: Bangladesh Cyclonic Storm tracks

Source: (Ministry of Disaster Management and Relief, November 2020)

4.3 Technological Aspects in the study area

In the study area, there is an embankment which is 3ft high from the sea level and used to protect from flood where it requires 20ft height to protect from cyclone. There is some afforestation project of 8million plum tree was taken but due to negligence, monitoring and lack of honest governing body the project failed to see any progress.

In preparedness phase, VHF and HF radio is used to disseminate the danger signal where it consumes 15-20 minutes from Bangladesh Metrology Department to Cyclone Preparedness Program (CPP) volunteers and they forward it through traditional way which some time consume 1-2 hours. In this phase, they take the help of multimedia to build awareness of the people. They use manual forecasting map with the help of experts and information rather than the digital or GIS and RS based maps.

In rescue phase, CPP use some basic tools like Multi-Tool, Hammer, Nails, Handsaw, Crowbar, Shovel, Drill etc. If a cyclone conducts with high speed and more than 100 people got repressed with concrete structure, tree etc. it is impossible to rescue them rapidly due to lack of latest and advance equipment. Besides that, they do not have enough vehicle for rapid connectivity to the remote area. Due to poor road connectivity, it is difficult to transport relief to these deserted areas, which requisite attention of concerned authorities.

In recovery phage, adequate steps not been taken by the government organizations but the NGOs and non-governmental organizations provide some facilities like training on farming, workshop on agricultural side etc. but they do not provide training or workshop on Information and Communication sector which can be a long-term solution for the affected people.

4.4 Prevention

4.4.1 Training and Awareness Building

Cyclone is quite impossible to prevent as a result most of the country run for the preparedness phase and in Bangladesh the government focus on training and awareness programme rather than another programme.

The upazila parishad conduct a complete training module with the help of Cyclone Preparedness Program (CPP). Training is occurred within every 2-3 month with having a duration of 2-3 days and a group of people is selected for the training.

The Union parishad select the CPP members (10 Male and 5 Female members per unit) and there are 91 units in the upazila. The Government organization with the help of some NGOs train the selected CPP volunteer. They provide necessary books and training materials to the volunteer for their better understanding.

The CPP team consist a medical support which is trained by government and NGOs and they work for any emergency situation like quick response after any disaster. Basically, they are trained medical volunteer and are not engaged with regular medical practice. In each unit there is a medical team for emergency response and it contain 2 male member and a female member.

The trained CPP members ran a workshop with the help of Government and NGOs about pre and post disaster management and they provide a complete understanding about their role. As being the member of the community, the volunteers get more acceptance to the people. Sometime the Upazila, Union porishad chairman and special guest be present in the workshop and it boost up the importance of training to the community.

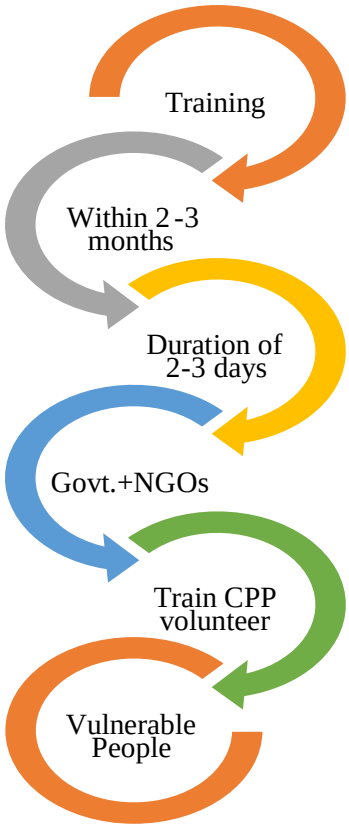


Figure 4.5: Training Framework through CPP

4.5 Preparedness

4.5.1 Warning Network

Bangladesh Metrological Department is the only way of any kind of warning or forecasting any kind of disaster which is disseminated to the vulnerable community through the administrative network of Bangladesh along with the infrastructure of the Bangladesh Red Crescent Society where CPP is a project of BDRCS. BDM send the warning massage to BDRCS and CPP through high frequency satellite radio. Every CPP team leader is provided a transistor radio for receiving the massage and they receive training about the warning system and how to operate transistor. Then the warning system is disseminated among the villagers through CPP by megaphones, sirens etc.

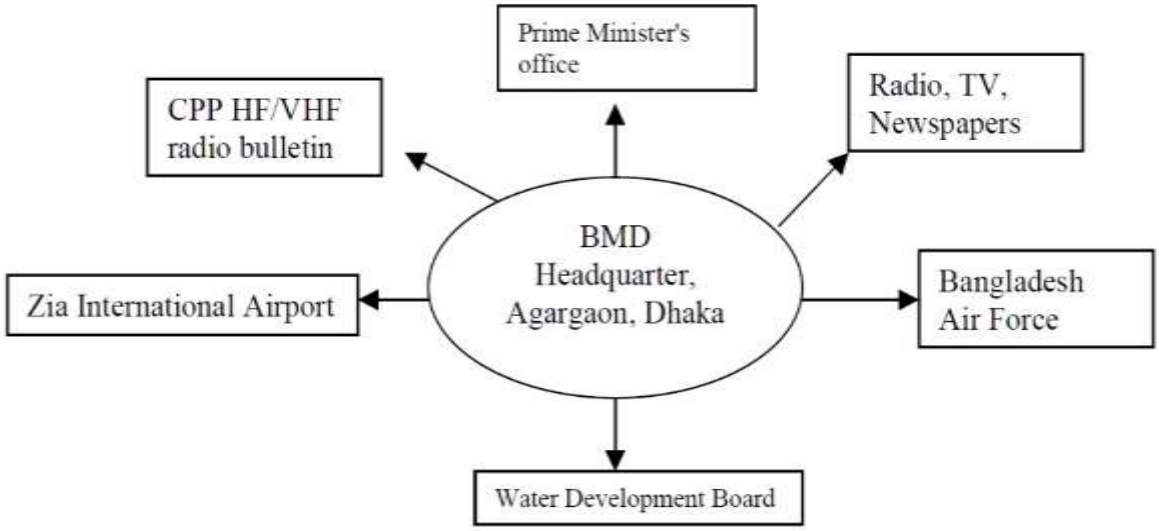


Figure 4.6: Governmental Organizational Chart for Disaster Warning

An extensive network of Radio communication facilities, in the coastal areas, linked to its Head Quarters (Head Quarters of BDRCS) at Dhaka is operated by Cyclone Preparedness program. The network consists of a combination of High Frequency and Very High Frequency radios, which covers most of the high-risk cyclone areas.

4.5.2 Warning Receiving Media

The most vulnerable areas of Dacope Upazila are surrounded by rivers and in the remote area electricity is not available. Most of the house in the remote area use traditional fuel-based lamp for lighting purpose and some of the household is covered with solar with the help of Upazila parishad. As result 56% people receive warning alert through CPP members and recently 30% people receive it through Radio/TV and most of the use mobile to listen radio.

The young generation has a craze on Facebook or other social media which help them to gain the cyclone warning and sometime they acquire knowledge about cyclone and their duties.

4.5.3 Preparedness

The purpose of the Cyclone Preparedness Program is to develop and strengthen the disaster preparedness response capacity of cyclone-vulnerable coastal communities, to increase the efficiency of volunteers and officers, and to maintain and strengthen the cyclone warning system to ensure an effective response in the event of a cyclone. CPP is involved in a variety of pre-disaster, during-disaster, and post-disaster activities in order to reach its objective. The

following main activities of the program are being implemented to fulfil the objectives of the Cyclone Preparedness program:

1. Disseminate cyclone warning signals issued by the Bangladesh Meteorological department to the community people.
2. Assist people in taking shelter.
3. Rescue distressed people affected by a cyclone.
4. Provide First Aid to the people injured by a cyclone.
5. Assist in relief and rehabilitation operations.
6. Assist in the implementation of the BDRCS Disaster Preparedness Plan.
7. Assist in participatory community capacity build-up activities.
8. Assist in the co-ordination of disaster management and development activities.

Government spend more money in strengthening house and the upazila parishad mentioned that they have work with 86% houses to strength them. But in field survey 39% people receive found around Tk 15000-23000 for housing purpose and they didn't receive any technological knowledge or raw materials for this purpose.

The Upazila Parishad claimed that they rise and reconstructed the tube well amount up to72 % but in the remote area the tube well amount is around 18%. The reason of this gape of information is that most of the tube well is constructed in the urban area and the people of remote area use rain harvesting water and pond water.

The Upazila Parishad claim that the roads are upfilled and raised around 73% and in the field survey almost 70% respondent concurrence with the UP opinion. In the field survey, most of the roads are found Kaccha or Mud made. Some of the Embankment/ Dam are using as road and those are financed by World Bank.

4.5.4 Emergency Preparedness

Almost 90% people try to protect their valuable goods like Ornaments during cyclone because of being their life time savings and sometime emotional attachment. Being farmer 75% people keep a backup of Food grain and seed which will used after the cyclone.

People keep their life stock to cyclone shelter or they let not leave them during the cyclone time which make them more vulnerable in the cyclone time and the number is 78%. One of the main income sources for the females is Poultry farming. Sometime poultry is the only resource for the low-income people and sometime they take SME or small loan for poultry farming and that's why 73% people did not want to leave them.

Almost 90% people tries to shift the pregnant mother to a safe place because of having good social bonding and 25% people keep dry food during cyclone time where most of them are middle to high income people. A number 22 % people keep drinking water in big jar or drum due to having less drinkable water and focusing water scarcity.

4.6 Response

4.6.1 Emergency Response

Big governmental organization like Army is engaged with rescue when the scale of cyclone is high or the affected people in much. In recent time several cyclones are happened which is completely recue by CPP and local people which is financed by government and some NGOs. After the rescue, relief is supplied by government and in high scale cyclone foreign donner has a great influence by providing financial support.

4.6.2 Shelter after Cyclone

In the remote area most of the people take shelter in open sky and the amount is 43.45% and in the field survey people mentioned that high elevated road is the main shelter after cyclone due to high distance of cyclone shelter, poor condition of road and lack of transportation mode. A number of 30% people went to cyclone shelter which is nearby their house and distance of less than 1km, 19% people went their relatives house, 4.58% to temporary house and 5% tent which is provided by NGOs and foreign donners.

Beside those there are some other reasons like emotional attachment, fear of stolen property or asset, unavailable transportation, unknown route. Again, distribution of cyclone shelters is not well proportioned with the number of people, besides powerful and higher middle class people do have cyclone shelters resided close to them, found while discussing with locals.

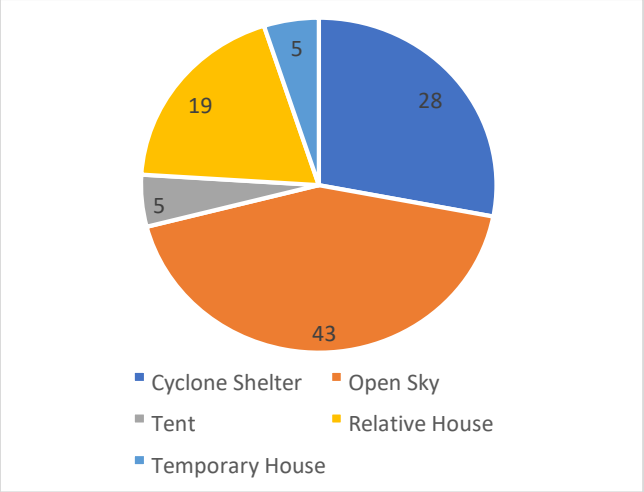


Figure 4.7: Shelter after Cyclone

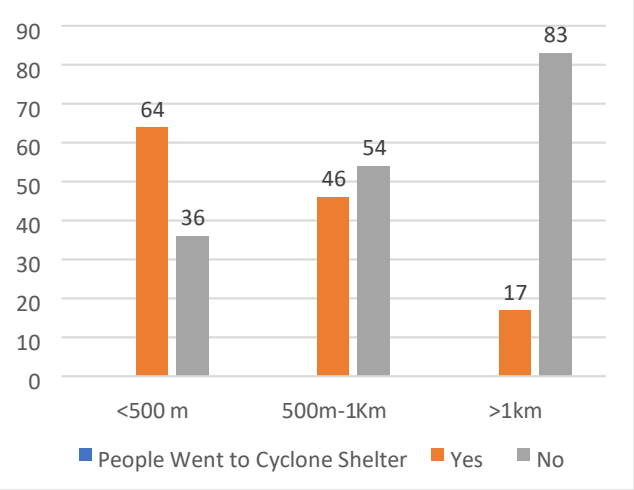


Figure 4.8: Willingness to go to cyclone shelter

Source: Field Survey, 2022

4.6.3 Drinking Water

After the cyclone most of the water source became useless due to salinity problem as a result the affected people face scarcity of drinking water and in this time the deep tube well also became non functionable. As a result, 81% people have to depend on supplied water which is supplied by government organizations and various organization. Those people are supplied water through big water tank which is not sufficient for them as a result sometime they use deep tube well water or pond water with primary treatment.

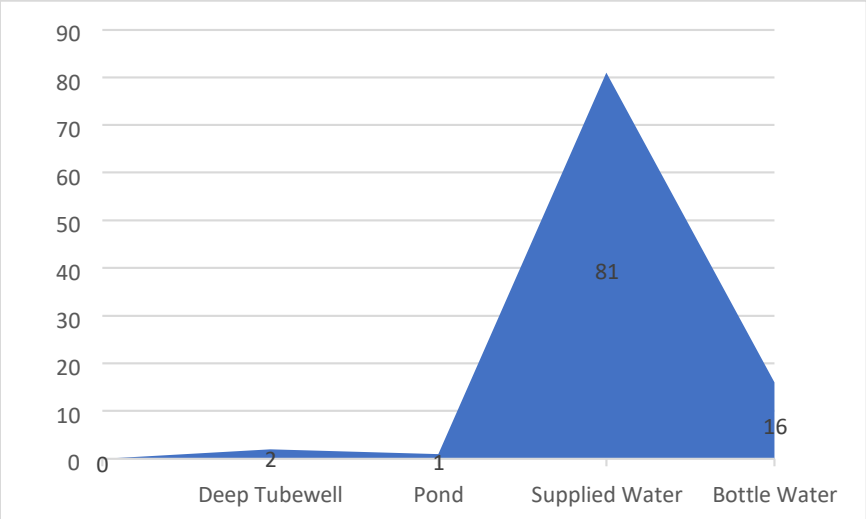


Figure 4.9: Drinking Water source after cyclone

Source: Field Survey, 2022

The highly reputed families receive extra facilities then the general people and they are supplied Bottle water and the amount of this type people is 16%. Morley Chairmen, Members and reputed families, Government officers etc. receive this facility.

4.7 Recovery

In 2007, after sidar a recovery programme was adopted by the government of Bangladesh where it spends US$ 16 million on the agricultural sector. The resource was used to improve production, marketing technology, improving technologies and agronomic practice. It was also including fisheries sub-sector like improving boats, nets and safety equipment.

To support the livestock sub-sector, the resource was used through restoration of cold chain system of vaccination delivery, stocking of improved cows, goats, sheep and poultry sheds. To achieve sustainable coastal development, technological advancement was recommended. Reconstruction and construction of multipurpose shelter, improving community mobilization and community network to shelter etc. was performed through the programme. Rehabilitation of coastal embankment, design and construction supervision of coastal embankment was focused in the programme.

4.8 Technology in Cyclone Management practice

4.8.1 Prevention & Mitigation

Prevention mitigation is the primary and most effective stage to be wiped out the effect of cyclone and also save the life of human as well as the livelihood.

4.8.1.1 Disaster Specific Research

Hazard or disaster specific research will open new window to invent new technology to mitigate cyclone. In the context of Bangladesh, some simple research is conducting recently but which is not sufficient. It needs to invent new applicable technology which is appropriate for this country and people can easily adopt it which require more research. Lack of financial support is the main reason behind it. The is a crying need for taking steps against the cyclone providing relevant data, return period, forecasting etc.

4.8.1.2 Project Stromfury

Between 1962 and 1983, scientists conducted experiments in which they "seeded" storms with silver iodide in an effort to weaken the system. Cloud seeding is a method of altering the quantity or type of precipitation produced by a weather system. It was hypothesized that by dropping silver iodide into the eyewall of a tropical cyclone from an aircraft, a new, larger eyewall would form. The larger eyewall would then aid in reducing the storm's winds by lowering the system's pressure gradient. The goal was to accomplish this before a system made landfall in order to mitigate the potential storm damage.

Later, scientists determined that there was insufficient super-cooled water in tropical systems to produce ice during seeding, and that these systems already contained a substantial amount of ice crystals, so the idea of creating more ice to modify the storm was doomed to fail. (H. E. Willoughby, 1985)

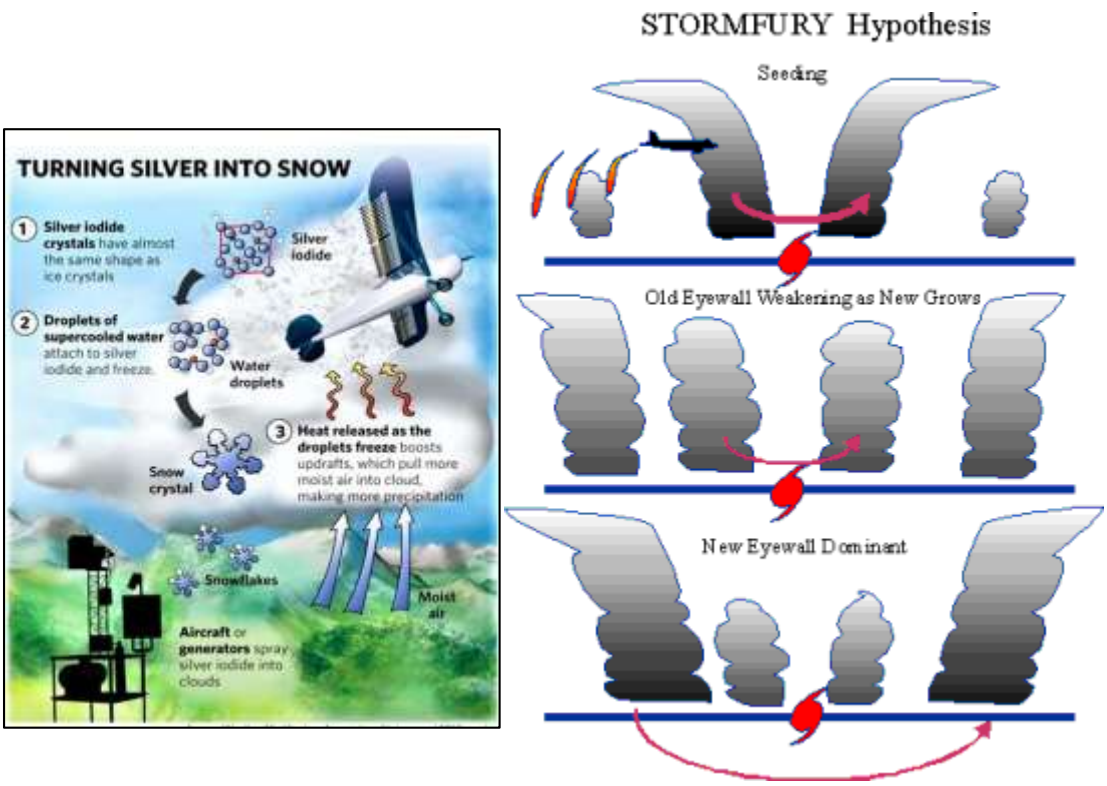


Figure 4.10: Project Stromfury

Source: (H. E. Willoughby, 1985)

4.8.1.3 Structural Measures

Some structural advancement might mitigate the impact of cyclone and for example concrete framing house is 40% more efficient and resilient during cyclone (Aquino, 2008). Examples: Engineering Cyclone Walls and Coral reefs. In Bangladesh, those measures have to take by the government but financial inability and lack of willingness of government is the main obstacles. In Bangladesh, the government only prepare cyclone shelter which is not the only way for apocopate preparation. (Renaud F. G., 2013)

4.8.1.4 Non-Structural Measures:

Non-structural measures play crucial role to mitigate cyclone impact and examples are Land use zoning using GIS and Remote sensing, Maintaining Natural Sand dunes etc. Bangladesh has conducted several non-structural measures though they are poor in condition like Land Use zoning.

4.8.2 Preparedness

4.8.2.1 GIS and Remote Sensing

GIS and Remote Sensing is used for preparing various maps, cyclone route, select best location of cyclone shelter, shelter route etc. In the study area, the government and nongovernment organizations are not engaged with GIS and Remote Sensing.

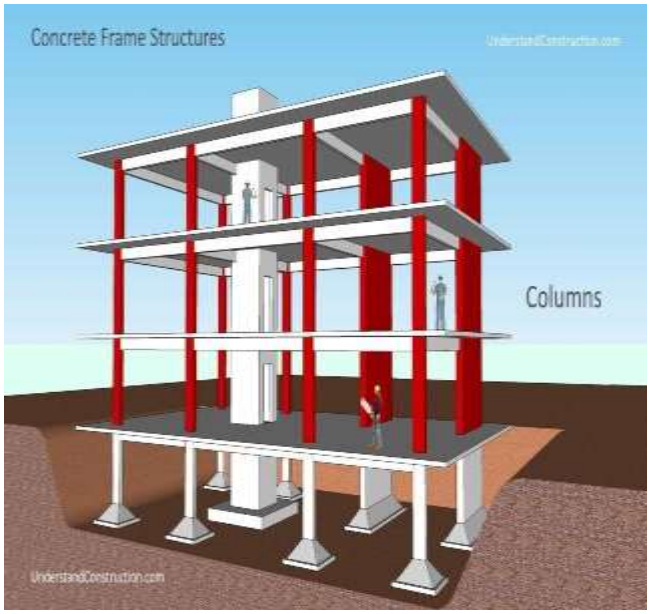
4.8.2.2 Mobile Apps

Mobile became a connector between user, metrology department and rescue team. Now a day to distribute information related to warning system rapidly, social platforms like, apps, SMS, call etc. are used. Several apps are developed which receive the metrology data and pass it to the user.

Figure 4.11: Mobile Apps for Cyclone Alert

4.8.2.3 Cyclone Resilient House

Steel frame or concrete frame house is more suitable during cyclone whereas the traditional houses are too weak. The developed country used steel or concrete frame house but in the developing country like Bangladesh poor people cannot afford this type of house.



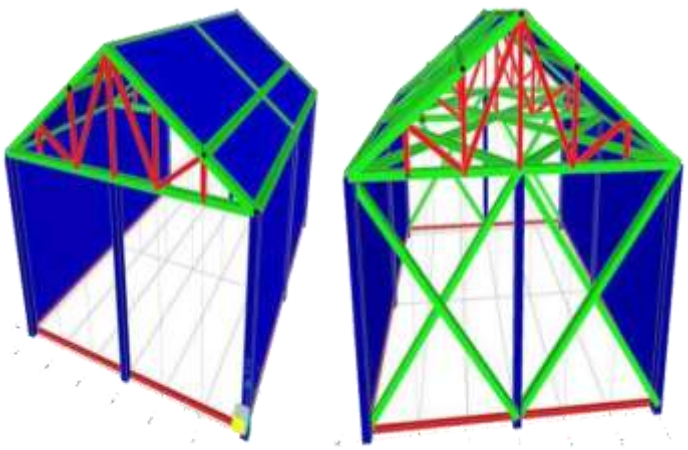


Figure 4.12: Cyclone Resilient House

4.8.3 Warning System

4.8.3.1 NCAR GPS Dropsonde

New technology invented and used by US to track and analysis the cyclone and its movement. The dropsonde contain some sensor like humidity sensor, temperature sensor, GPS etc. which help to acquire more knowledge about the cyclone. It also helps to determine the intensity of cyclone and route which helps to reduce vulnerability. (Wang, 2004)

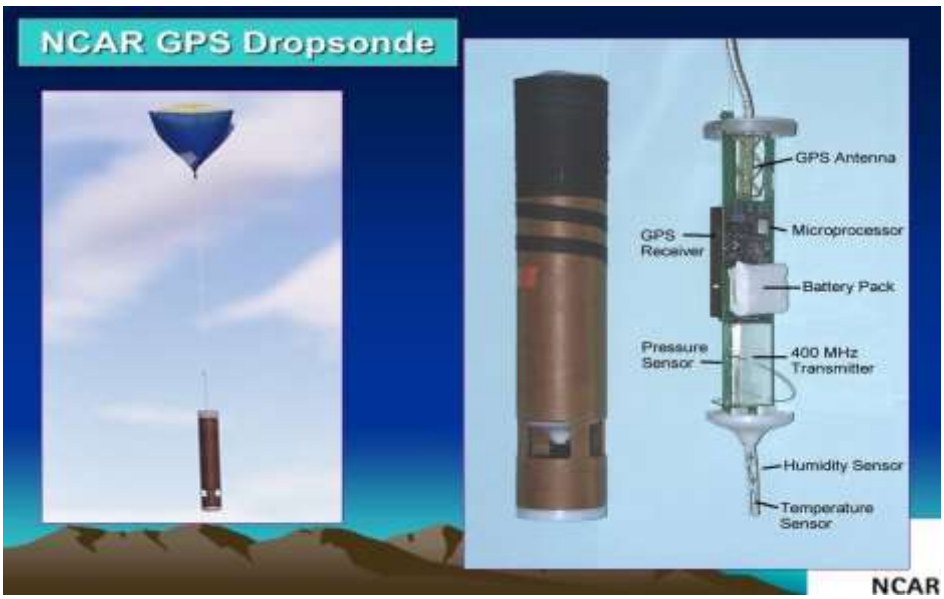


Figure 4.13: NCAR Dropsonde

4.8.4 Response and Rescue

4.8.4.1 Building Strong Road Network

Due to inefficient road network infrastructure, relief delivery is delayed. For the wellbeing of the inhabitants in such places, there is also a need for a long-term road network. In most cases, people must travel by boat two to three times to get from their business to their residence. A well-functioning road network would also allow for speedy reaction to affected communities, potentially saving lives.

Roads play a critical role in economic development and progress, as well as providing significant social advantages. They are critical to the growth and development of a specific area. A road network is also critical in the fight against poverty since it provides access to job, social, health, and education services.

4.8.4.2 Renovation of Health complex and Hospitals

In terms of serving marginalized individuals, public health centers are inefficient. According to my research, the number of private hospitals is higher than the number of public hospitals. Again, public hospitals are inadequate for the residents of these locations. Inadequate medicines in these public health complexes encourage marginalized people to purchase them at a greater cost, forcing them to sell their livestock and, in some cases, their property in order to receive treatment. More public health facilities are expected to be built in cyclone-prone areas to serve in emergency situations.

4.8.4.3 Robots and drones

Artificial Intelligence playing an important role in term of detecting lives through heart beats, breathing etc. like robot "FINDER". Several robots are using to execute rescue in tough condition where it is not possible to reach and it also used for removing heavy particle or structural blocks. For example: t7, Thor, octopus etc.

Robots and drones are widely used to supply food, water etc.to the victims and emergency medicine supply became easy through drone to the remote area where road network totally collapsed.

Figure 4.14: Robots and Drones in quick

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4.8.4.4 GIS and Remote Sensing

GIS in combination with Remote sensing may be used in most of the phases of cyclone management practice. It can be used very effectively to identify hazards, risk, vulnerability, exposure etc. In the time of cyclone, storm surge became a big problem and after and using

GIS and Remote Sensing storm surge can forecast from historical data and Digital Elevation Model which generates the hazard maps for different return periods. Field Survey and satellite image can be used to assess the vulnerability in GIS and RS platform. (Rana, 2010)

Early warning, long range climate etc. can be easily done through GIS and Remote sensing which works in preparedness phases. If the government know the possible, route of cyclone then the can shift vulnerable people to reduce the impact of cyclone. Crisis Mapping, Regular monitoring of cyclones storm surge identifying the route to escape etc. will help to accomplish quick response to the victim. Damage assessment, Spatial Planning etc. will help to make better recovery plan for the people. (Krishnamorthi, 2016)

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

5.2 Recommendations

5.1 Conclusion

Absence of decent connectivity, awareness, geographically vulnerable location, poor livelihood, and technological advancement are the primary reasons for the region's heightened vulnerability, while the government's lack of prudence plays a crucial role.

The government plays a crucial role in the rescue and recovery phases of cyclone management, while the other phases are avoided. Government has a vision of achieving sustainable development against cyclones, which is why the National Plan for Disaster Management has a theme of "Building Human Resilience for Sustainable Development." In this plan, the phases of Preparedness and Recovery are addressed, whereas a field survey revealed negligence.

Due to the impossibility of mitigating cyclones in developing countries, the preparation phase of cyclone management is regarded as a top priority. Incorporating technology into both the structural and non-structural sectors makes the plan or phase effective, and in this context, the government failed. The people in remote areas are unfamiliar with the term technology in cyclone management practice because the government failed to provide them with adequate training and resources.

The people construct their homes and embankments using traditional methods, whereas both developed and developing nations have already embraced technologically.

The quality of the water sourced from rainwater harvesting, ponds, and deep tube wells is so poor that it is undrinkable. Drinking water is becoming increasingly difficult and scarce for the population.

The upazila parishad was given a budget for cyclone management, but the lack of a proper guideline, plan, and law implementation, as well as limited access to information, acted as an impediment to its success.

5.2 Recommendation

5.2.1 Education and Training

Villagers in disaster-prone areas require proper training and advice on what to do in the event of a disaster. During their removal from their home, there was some social taboo and fear of financial loss. The focus of the training session should be on getting them safe and informing them about the alleviation and other benefits they would be receiving. If there isn't a place where they may inquire about their reliefs, they are about to receive and publish their cyclone-

related difficulty throughout social media platforms in order to attract national and international attention.

5.2.2 Integrated Farming

People of our study areas lack training and guidance on farming techniques, in addition they face lots of natural hindrances in terms of growing rice, watermelon and other crops.

Integrated Farming Systems (IFS) is a well-recognized and effective technique for coordinating cooperative management of land, water, vegetation, livestock, and human resources. It has the potential to result in a significant increase in long-term productivity and improve people's livelihood security. Crop intensification is achieved by the use of mixed cropping, intercropping, and crop rotation. Legumes are used in rice-based cropping systems to maintain soil fertility.

Guidance and training facilities on IFS to these people would certainly improve their livelihood and made them more economically stable. Furthermore, their positive contribution to the economy, despite of facing constant struggles would surely attract our policymakers to ensure more budget on the infrastructural development of these areas.

5.2.3 Policy Advocacy

We can advocate some policies and solutions for effective disaster management plan for the study area. Development of road network can resolve so many problems related to cyclone management, livelihood development, relief distribution, economical benefits and so on. Again, strengthening river embankment of the area would more likely to protect the people of Dacope from frequent flash floods and economic loss. Moreover, governmental initiatives on implementing more training facilities for the people of affected area would be needed.

5.2.4 Renovation of Cyclone centers

From our field survey, inadequate space for the locals been found. Again, no detached washroom and separate space for women not been established on these cyclone centers. Moreover, due to covid-19 scenario we accustomed with different situation where need of isolation for contagious diseases would certainly become a sure thing to add while considering renovation of cyclone centers or incorporating policies for building cyclone centers.

5.2.5 Renovation of public health complexes

Public health clinics are ineffective when it comes to helping marginalized people. Public hospitals of our study areas are insufficient for the people who live in these areas. Inadequate drugs in these public health complexes push marginalized people to buy them at a higher price from private drug stores. In cyclone-prone locations, more public health facilities are projected to be created to serve in disaster situations, where strong intervention of Government officials and acquainted policies are obligatory.

5.2.6 Mobile Use

In the study area, the people are less educated and CPP volunteers are the main way to provide warning signal. It consumes 15 minutes to 1 hour to receive the warning signal from BDM to volunteer where providing smart phone may reduce the time. Beside the CPP volunteers, special persons like Headmasters, College principals, religious important persons might contain smart or feature phone. Mobile application or Call based warning system can rapidly reach to vulnerable people.

5.2.7 GIS and RS

Application of GIS and RS can be used for various purpose like map cyclone shelter, cyclone route mapping etc. which is very rapid and reliable as well as require less but, skilled personnel. From the analyses found from the GIS and RS data, better decisions are more likely to undertaken by policy makers.

5.2.8 Afforestation

It requires more afforestation to prevent or mitigate the impact of cyclone. The Sundarban works like a green belt or embankment for cyclone. An integrated project of afforestation, with the help of government and non-government organization may help to fulfill the required tree.

5.2.9 Strengthening of Existing Houses

Houses of the coastal village need to be built to withstand strong wind because of its vulnerable location. Strengthening the house structure might at last provide resistance to the cyclone, wind and storms due to the existing houses might not permit for withstand.

5.2.10 Pond Sand Filter (PSF)

According to UNEP, a PSF can serve 50-60 household considering distance from water source to the community and to avoid inundation of the PSF a good height is required with a convenient layout. A regular maintenance and through community involvement are required to keep the system functional. Pond re-excavation is required to get sweet water after cyclone to deal with the saline water and during dry season.

5.2.11 Rain Water Harvesting

After cyclone drinking water became the major problem and rain water harvesting can play an important role to solve it. A large number of catchment area is required to collect the water and an integrated catchment system run and monitored by the general people with the help of NGOs can play the role. A treatment plant which make the water drinkable can have arranged by the Government and NGOs.

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APPENDIX

List of Cyclone Shelters in Dacope Upazilla

Cyclone Shelter Name	District	Upazilla	Union	Village
Bajua Government Primary School	Khulna	Dacope	Bajua	Bajua
Chunkuri Mukto govt. primary school	Khulna	Dacope	Bajua	Chunkuri
Shahidsreeti Girls School	Khulna	Dacope	Bajua	Chunkuri
Amtala Baniashanta Cyclone Shelter	Khulna	Dacope	Banishanta	Amtala
Khajuria Binapani GPS Cum Shelter	Khulna	Dacope	Banishanta	Khajuria
Sent Zocef Primary School (Dhanmary)	Khulna	Dacope	Banishanta	Dhanmary
Laudubi M.N. Cyclone shelter	Khulna	Dacope	Laudubi	Laudubi
C.S.S School	Khulna	Dacope	Laudubi	Khotakhali
Saddi Teheja School (Laudubi)	Khulna	Dacope	Laudubi	Laudubi
Baruikhali Lakshmikanto Government Primary School	Khulna	Dacope	Chalna	Baruikhali
Khona Khatail GPS	Khulna	Dacope	Chalna	Khona
40 No. Maukhali GPS	Khulna	Dacope	Chalna	Maukhali
Uttar Maukhali Ishak Mamorial Primary School	Khulna	Dacope	Chalna	Maukhali
35 No. Pankhali 2 Government Primary School	Khulna	Dacope	Chalna	Pankhali
28 No. Hoglabunia GPS	Khulna	Dacope	Chalna	Hoglabunia
Ananda Nagar Government Primary School	Khulna	Dacope	Chalna	Ananda Nagar
World Vision Cyclone Shelter	Khulna	Dacope	Chalna	Pankhali
Pankhali-1 GPS (Pankhali Cyclone shelter)	Khulna	Dacope	Chalna	Pankhali
Chalna Bazar govt. Primary School	Khulna	Dacope	Chalna	Chalna bazar
Chalna Bazar Government Primary School	Khulna	Dacope	Chalna	Chalna Bazar
Dacope Girls High School	Khulna	Dacope	Dacope	Dacope
Ramnagar Binapani high school	Khulna	Dacope	Kailasganj	Ramnagar
Kailasganj Shamapod Government Primary School	Khulna	Dacope	Kailasganj	Kailasganj
J.P High School	Khulna	Dacope	Kamarkhola	Joy Nagar
Sreenagar Uttarpara Non GPS	Khulna	Dacope	Kamarkhola	Sreenagar
Gunari Shital Chandra High School	Khulna	Dacope	Sutarkhali	Gunari
South Kalabagi govt primary school	Khulna	Dacope	Sutarkhali	Kalabagi
19 No. Kalabagi Saleha GPS	Khulna	Dacope	Sutarkhali	Katabagi
Kalabagi Sundarban High School	Khulna	Dacope	Sutarkhali	Kalabagi
38 No. Purba Kalbagi GPS	Khulna	Dacope	Sutarkhali	Kalabagi
Nalian Forest govt. primary school	Khulna	Dacope	Sutarkhali	Nalian
Nalian high school cum cyclone shelter	Khulna	Dacope	Sutarkhali	Nalian
Nalian Forest GPS	Khulna	Dacope	Sutarkhali	Nalian
Sutarkahli high school cum cyclone shelter	Khulna	Dacope	Sutarkhali	Sutarkhali
Tildanga Union Girls High School	Khulna	Dacope	Tildanga	Tildanga
Kaminibasi Hamida Khatun Government Primary School	Khulna	Dacope	Tildanga	Kaminibasi
Kaminibasi Rashkhola Registered Primary School	Khulna	Dacope	Tildanga	Kaminibasi
Kaminibasia govt. primary school	Khulna	Dacope	Tildanga	Kaminibasia

Figure: Road Network

Figure: Housing Condition

Figure: Water Reservation for irrigation

Figure: Agricultural Land

Source: Field Survey, 2022

Khulna University of Engineering & Technology, Khulna 9203
Department of Urban & Regional Planning
(Only for research purpose)

Village:

Questionair No:
Date:

Name of the interviewer:

Time:

1.Basic information about the household:

Name	Age	Marital Status	Education	Occupation
Family Type	1. Single Family	2. Joint Family		
Total Monthly income		Monthly Savings		

Types of house	1. Present	2. Jupri	3. Kutcha	4. Semi pucca	5. Pucca	
Housing		Roof	Wall	Floor	No of rooms	Plinth level
Materials						
Sanitation	1.Sanitary/ community toilet 2. Sanitary (no water seal) 3. Non sanitary 4. None	Drinking Water Source			Electricity	Gas/Others

2. Cyclone Information

Month of occurance			
Frequency (per year)			
Storm surge			

3. Mitigation

Do you have cyclone shelter? a. Yes b. No	If yes, then address the amount: 1) One 2) Two 3) More
Have embankment to protect land from saline water?	a. Yes b. No
Do you know about cyclone management plan?	a. Yes b. No
Do you receive any kind of financial or technological help to improve housing condition?	If yes, then who provide it? 1. Govt. 2. NGOs 3. Community 4. Other donners
Indegenous technology for house building:	a. Yes b. No
Do you know about cyclone management plan?	a. Yes b. No
Do you receive warning before cyclone? 1. Yes 2. No	If yes then do you use any app related to cyclone or disaster?
How do you receive warning system?	1. LDMC 2.TV/Radio 3. Mobile call 4. Mobile sms 5. Internet 6. Others
Do you know various cyclone management plan? 1. Yes 2. No	If yes do you know your role? a. Yes b. No
Do you use smartphone? 1. Yes 2. No	If yes then do you use any app related to cyclone or disaster? a. Yes b. No
Do you use your mobile phone during the rescue time?	a. Yes b. No

Do you receive any training on what to do during cyclone? 1. Yes 2. No	If yes then who train you? 1. Government 2. LDMC 3. NGOs 4. Others
Do you know various cyclone management plan?	If yes then do you know your role? a. Yes b. No
Does any public awareness program induce within the community?	If yes then who do this? 1. Government 2. Community 3. NGOs 4. Others

4. Preparedness

Do you preserve food and drinking water for cyclone?	If yes then do you receive any training on it? a. Yes b. No
Do you receive any training on purifying water?,	a. Yes b. No
Do you have savings for cyclone time? a. Yes b. No	If No then do you have any alternative income source?
Do you have clinic or medical center nearby?	1) Within 500m. 2) 500m-1km 3) More than 1km
Did you received any training on primary treatment?	a. Yes b. No
Do you preserve fast aid for cyclone time? a. Yes b. No	If no then do you have any alternative income source? a. Yes, b. No, If Yes/No, If yes then how? 1. By the Community 2. NGOs 3. Themselves
Do you know about emergency operation center or who will help you during cyclone?	a. Yes, b. No

	Yes/No	Assisted by LDMC	Assisted by NGO
Increase of height of plinth level			
Using new material in house			
Change in housing pattern			
Rain water harvesting			
Water filtration and purification			
Others			

5. Response:

Is there any fire station around your area? a. Yes, b. No	If yes then how far it is?
Do you receive rapid assistance to recover the victim?	a. Yes, b. No
Who help you?	1. Government organisation (like fire service, Army, etc) 2. Community and LDMC 3. NGOs 4. Others (mention)
Do you receive rapid assistance to recover the victim?	a. Yes, b. No
Do you receive rapid assistance to recover the victim?	a. Yes, b. No
Where do you take the shelter?	1. Cyclone shelter 2. Open sky 3.Tent 4. Relative House 5. Temporary House
What mode do you use?	1.Walking 2. Van/Rickshaw 3.Auto 4.Others
From where you arrange drinking water?	1.Deep tube well 2.Pond 3.Purification through chemicals like Phitakiri 4. Bottled water
Sanitation condition during disaster	1 Kacha 2. Pacha 3. Semi-pacha 4. Portable

6. Recovery

Category	Amount	Provider	Category	Amount	Provider

Commercial loan			Investment on Infrastructure		
Job opportunity			Investment on Road Network		
Job for food program			Investment on Housing		
Skill development Program			Investment on safe drinking water		

Activity	Description	Assisted by Govt.	Assisted by NGO	Assisted by LDMC
Rehabitation				
Construction of Houses				
Construction of Road				
Financial support				
Physiological support				

Organizational Response:

Relief type	Providers/Assist by	Distributors/ Field level work	Corruptions and comment
Rescue			
Food			
Water			
Medicine			
Clothes			
Shelter			
Technical Support			
Job opportunity			

Relief Type	Organisation	Support			
		Financial	Material	Labor	Technological
Rescue					
Drinking water					
Re-habitation					
Construction of Houses					
Construction of road					
Facilities					
Sanitation					