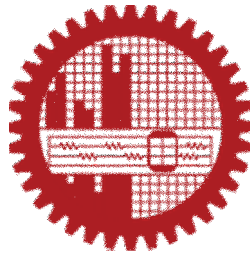


ASSESSMENT FOR NEED FOR ADDITIONAL CYCLONE SHELTERS IN SOME SELECTED COASTAL ZONE OF BANGLADESH

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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY
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SHELTERS IN SOME SELECTED COASTAL ZONE OF
BANGLADESH

A Project Submitted
by

Maruf Ahamed

(Roll No. 100616005P)

In partial fulfillment of the requirements for the degree of
Master of Engineering in Water Resources Engineering

**DEPARTMENT OF WATER RESOURCES ENGINEERING
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September, 2011**

CERTIFICATE OF APPROVAL

We hereby recommend that the M. Engg Project work submitted by Maruf Ahamed, Roll. No. 100616005 P, Session– October, 2006 entitled **“Assessment for need for additional Cyclone Shelters in some selected Coastal Zone of Bangladesh.”** has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Engineering in Water Resources on 26th September, 2011.

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ABSTRACT

Bangladesh is one of the most cyclone affected countries. Over the last 50 years at least 30 number of cyclone hit the country. Among them 1970, 1991 and cyclone Sidr in 2007 are the severe ones. Cyclones have caused extensive damage to Bangladeshi coast line again and again. One way of saving lives during cyclones is to take refuge in safe shelters which are able to withstand the strong winds and storm surges. In Bangladesh these are called cyclone shelters. Coastal zone of Bangladesh includes 19 southern districts with 147 upazilas, covering 47,201 sq. km that comprises 32% of the total geographical area of the country. About 27% of the total population lives within this coastal zone. There are a large number of people living in the area which is cyclone and storm surge vulnerability along the western, central and south-eastern coasts of Bangladesh. However, only 10% of the actual population in the cyclone vulnerability area could be accommodated in existing safe shelters (excluding Sub-district headquarters buildings and others public and private building). Approximately 12.5 million people will be in need of shelter places in the three cyclone-prone zones by the year 2021. Cyclone shelters are meant to provide shelter and reduce the number of casualties in the coastal area during cyclone and tsunami.

After 1990 many cyclone shelters have been constructed in the coastal area by unplanned way but these are quite insufficient to accommodate all the people in the designated coastal area. In this study, the estimation of the numbers of additional cyclone shelters were calculated to accommodate the total population living in the selected study area of Kalapara and Galachipa upazila under Patuakhali district, Noakhali Sadar and Companigonj upazila under Noakhali district and Ukhiya and Teknaf upazila under Cox's Bazar district. The proper locations of cyclone shelters would also be helpful for easy access to cyclone shelter for local people without destroying agricultural field and water bodies.

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List of Abbreviation

BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BDRCS	Bangladesh Red Crescent Society
BIDS	Bangladesh Institute of Development Studies
BUET	Bangladesh University of Engineering University
CARE	Centre for American Relief Everywhere
CDMP	Comprehensive Disaster Management Programme
CEGIS	Center for Environmental and Geographic Information Services
CS	Cyclone Shelter
CYSMIS	Cyclone Shelter Management Information System
CZP	Coastal Zone Policy
DMB	Disaster Management Bureau
EIA	Environmental Impact Assessment
EU	European Union
FGD	Focus Group Discussion
GIS	Geographic Information System
GPS	Global Positioning System
HRA	High Risk Area
IWM	Institute of Water Modeling
ICZMP	Integrated Coastal Zone Management Project
IDB	Islamic Development Bank
IFAD	International Fund for Agricultural Development.
LCB	Local Competitive Bidding
LGED	Local Government Engineering Department.
MCSP	Multipurpose Cyclone Shelter Programme
MES	Meghna Estuary study
NGO	Non Government Organization
NAPA	National Adaptation Programme of Action
NPA	National Programme of Action

PDO-ICZMP	Project Development Office for Integrated Coastal Zone Management Plan
PWD	Public Works Department
RS	Remote Sensing
RZ	Risk Zone
SCS	Super Cyclone Sidr
SPARRSO	Space Research and Remote Sensing Organization
UNDP	United Nation Development Program
UNEP	United Nation Environmental Program
UNRISD	United Nation Research Institute for Social Development
WED	World Environmental Day
WHO	World Health Organization

Chapter 1

INTRODUCTION

1.1 General

Cyclones have caused extensive damage to Bangladesh time and time. One way of saving lives during cyclones for the population is to take refuge in shelters which are able to withstand the strong winds and storm surges. In the 1990s a major programme for the construction of cyclone shelters along the coastline was undertaken and since then a large number of them have been built. In combination with a formidable early warning system and the help of thousands of volunteers, these have been able to reduce the loss of lives in the recent cyclones (Mallick and Rahman, 2008).

In coastal region where many people, particularly the poorest, live in flimsy one-story structures, the shelters offer the only real chance of surviving serious cyclones, tsunamis and other disasters. Bangladesh's worst-ever cyclone, in 1991, killed 138,000 people and left as many as 10 million homeless. But the death toll was far less than from a smaller storm in 1970 that killed 300,000 people before the storm shelter network was built. Elevated concrete storm shelters, built along Bangladesh's coast, have over the decades dramatically reduced the once catastrophic number of people killed by cyclones in the low-lying area of the country. Cyclone Sidr in 2007 officially killed 3,447 people, though some aid agencies believe the number may have reached 5,000 to 10,000. Cyclone Aila, which hit southern Bangladesh in 2009, killed 300 people, destroyed the homes of about 87,000 people and wiped out 4,000 kilometres of roads and embankments, many of which are still being rebuilt. According to Islam, 2010 the high rate of population growth, poor maintenance of some of the existing shelters and a lack of funding means the country today has inadequate shelters to protect all 7.8 million Bangladeshis most at risk during cyclones. With the monsoon season now underway, people living in disaster-prone coastal districts are worried that if cyclones or other large storm surges hit this year, they could carry huge costs in terms of lives and livelihoods. According to statistics from the Ministry of Disaster Management, the country's 16 coastal districts have

2,853 storm shelter centres, 262 of which are now unusable. To adequately protect the coastal population, the country needs another 2,500 shelters. After the 1991 cyclone, a report “Multipurpose Cyclone Shelter Programme” prepared by Bangladesh University of Engineering and Technology (BUET) and Bangladesh Institute of Development Studies (BIDS) recommended construction of 4,000 additional storm shelters. After Cyclone Sidr hit in 2007, that recommendation was reviewed by another committee headed by the then-secretary of the works ministry. That committee suggested the government construct at least 2,000 more shelter. Residents of the coastal areas most in need of shelters say that failure is putting large numbers of lives at risk (Islam, 2010).

After the 1970 cyclone 238 cyclone shelters were constructed in 1972-73 with the financial support of World Bank. Twelve years after that till 1985 no cyclone shelters were constructed. After the cyclone of 1985 Bangladesh Red Crescent Society constructed 62 and some NGOs constructed 24 cyclone shelters. Out of that in Urir Char some small house-based shelters were constructed with the financial support from Pakistan and India. After the 1991 cyclone different agencies constructed some of cyclone Shelters (WED, 2004). According to WED, 2004 the total number of cyclone shelter in the coastal area is not more than 1800, which are less than the need.

1.2 Background of The Study

Bangladesh is one of the most cyclone prone countries, over the last 50 years at least 30 number of cyclone hit the country. Among them 1970, 1991 and cyclone Sidr in 2007 are the severe ones. The disaster management methodology which was developed earlier gained considerable experiences and expertise in managing a wide range of disaster relief operations primarily concerned with cyclones and other natural disasters. The unprecedented floods of 1987, 1988 and 1998, the cyclone of 1970, 1991 and 2007; all these events had stimulated fresh management measures to reduce vulnerability of natural disaster (Karim, 2001). In this regard the main theme of this proposal is to review the options on structural and non-structural measures for reduction of risk against cyclonic storm surge.

Table 1.2.1 provides the necessary information about the tropical cyclones occurred in Bangladesh of the historical region of Bay of Bengal in general. This information has been taken from BMD (2009), Banglapedia (2006), Karim 2001, MES (1998) and Wikipedia.

Over last 50 years different scales of cyclones have been affecting the country with loss of valuable lives and property. According to EU, 1998 it was estimated in 1996 that about five million people live in the ‘High Risk Areas’ (HRAs) along the western, central and south-eastern coasts of Bangladesh. Among these, 4 million live in ‘Very High Risk Areas’. However, only 10% of the actual population in the HRAs could be accommodated in existing safe shelters (excluding Sub-district headquarters buildings and cyclone shelters built outside these HRAs). Approximately 12.5 million people needs shelter places in the three cyclone-prone zones by the year 2021 (EU, 1998). Cyclone shelters are meant to provide shelter and reduce the number of casualties in the coastal area during cyclone and tsunami.

The government, the non-government organizations and also funding from foreign countries has been used to build cyclone shelters, but the number still remains very low compared to the population in the HRAs. In 1991 cyclone, at Hatia island in the Meghna estuary, 80% of the 10000 people who died were drowned because they took refuge on the embankment when it was overtopped. In all of the affected areas, there were insufficient numbers of cyclone shelter to accommodate all the people (Haider et al., 1991). Cyclone Sidr confirmed that there were not enough shelters available to the high risk communities. Many people had to walk long distances and still could not find safe shelters. People in remote areas or on islands and detached chars may have had no means of moving to shelters (SCS, 2008). According to officials in the Galachipa upazila administration, the existing 70 cyclone shelters can accommodate 40 thousand people where as the total population of the Upazila is about 5 lakh. According to official sources, the cyclone shelters were built within the period of 1974 to 1976 which was disclosed in the Daily New age paper dated 1 July 2007.

Table 1.2.1: Tropical cyclones in Bangladesh

Date and Year	Max. wind speed (Km/hr)	Storm surge height (m)	Affected area	Death in nos (approx)
1584	-	-	Bakerganj (presently Barisal) and Patuakhali.	-
1585	-	-	Mouth of the Meghna estuary and eastern side of Bakerganj.	-
Nov, 1797	-	-	Chittagong	-
May, 1822	-	-	Barisal, Hatiya Island and Noakhali district	40000
Oct, 1831	-	-	Barisal	-
Oct, 1872	-	-	Cox's Bazar	-
31 Oct, 1876	-	12.2	Meghna estuary and coasts of Chittagong, Barisal, Noakhali	200000
24 Oct, 1897	-	-	Chittagong and Kutubdia Island	14000
May, 1898	-	-	Teknaf	-
Nov, 1904	-	-	Sonadia	143
16 Oct, 1909	-	-	Khulna	698
24 Sep, 1917	-	-	Khulna	432
May, 1941	-	-	Eastern Meghna estuary	-
Oct, 1942	-	-	Sundarban	-
17-19 May, 1948	-	-	Chittagong and Noakhali	1200
16-19 May, 1958	-	-	East and west Meghna estuary, east of Barisal, Noakhali	870
9-10 Oct, 1960	201	3.05	Noakhali, Bakerganj, Faridpur and Patuakhali	3000
30-31 Oct, 1960	210	4.57-6.10	Chittagong, Noakhali, Bakerganj, Faridpur, Patuakhali and eastern Meghna estuary	5149
9 May, 1961	161	2.44-3.05	Bagerhat and Khulna	11468
26-30 Oct 1962	161	2.5-3.0	Feni	1000
28-29 May, 1963	203	4.27-5.18	Chittagong, Noakhali, Cox's Bazar and islands of Sandwip, Kutubdia, Hatiya and Maheshkhali	11520
11-12 May 1965	162	3.7	Barisal and Bakerganj	19279
14-15 Dec, 1965	210	4.57-6.10	Cox's Bazar and Patuakhali	873
1 Oct, 1966	146	4.57-9.14	Sandwip, Bakerganj, Khulna, Chittagong, Noakhali and Comilla	850

12-13 Nov, 1970	222	6.10-9.14	Chittagong, Barguna, Khepupara, Patuakhali, north of Char Burhanuddin, Char Tazumuddin and south of Maijdi, Haringhata.	500000
28-30 Nov 1971	97-113	1	Sundarban coast	-
24-28 Nov 1974	161	2.8-5.2	Coastal belt from Cox's Bazar to Chittagong and offshore islands	200
9-12 May 1975	96.5-112.6	-	Bhola, Cox's Bazar and Khulna	5
9-12 May 1977	112.63	-	Khulna, Noakhali, Patuakhali, Barisal, Chittagong and offshore islands	
14-15 Oct 1983	122	-	Offshore islands and <i>chars</i> of Chittagong and Noakhali	43
5-9 Nov 1983	136	1.52	Chittagong, Cox's Bazar coast near Kutubdia and the low lying areas of St Martin's Island, Teknaf, Ukhia, Moipong, Sonadia, Barisal, Patuakhali and Noakhali	300
24-25 May, 1985	154	3.05-4.57	Chittagong, Cox's Bazar, Noakhali and islands Sandwip, Hatiya, and Urirchar.	11069
8-9 Nov 1986	110	-	Offshore island and <i>chars</i> of Chittagong, Barisal, Patuakhali and Noakhali	14
24-30 Nov 1988	162	4.5	Jessore, Kushtia, Faridpur, offshore islands and <i>chars</i> of Barisal and Khulna	5708
29 April, 1991	225	6.10-7.62	Chittagong, Khepupara, Kutubdia, Cox's Bazar, and coastal islands Nijhum Dwip, Manpura, Bhola and Sandwip.	138000
29 Apr- 3 May, 1994	210	-	Offshore island and chars of Cox's Bazar	400
21-25 Nov, 1995	210	-	Offshore island and chars of Cox's Bazar	650
16-19 May, 1997	225	4.57	Chittagong, Cox's Bazar, Noakhali and Bhola	126
16-20 May, 1998	150	1.83-2.44	Chittagong, Cox's Bazar and Noakhali	-
15-16 Nov, 2007 (Sidr)	250	3.05	Barguna, Pautuakhali, Jhalokati, Pirojpur, Bagerhat, Barisal, Bhola, Lakshmipur, Chandpur, Madaripur, Shariatpur, Munshigong, Narayanganj, Dhaka, Comilla, Bramanbaria, Narsingdi, Habiganj, Kishoregonj, Maulvi Bazar, Sunamganj and Sylhet.	3447
25 May, 2009 (Aila)	90	1.83-2.44	Khulna, Bagerhat, Borguna, Satkhira, Barisal, Patuakhali, Bhola, Pirozpur, Jhalokathi, Laxmipur, Noakhali, Feni, Chandpur, Chittagong, Cox's Bazar, and their offshore islands and chars	8

After 1993 many cyclone shelters have been constructed in coastal area by unplanned way but these are not enough to accommodate all the people in the designated coastal area. In this study it will be shown that the number of additional cyclone shelter is required to accommodate the total population in the selected study area of Kalapara and Galachipa upazila under Patuakhali district, Noakhali Sadar and Companigonj upazila under Noakhali district and Ukhiya and Teknaf upazila under Cox's Bazar district. It will be also helpful for easy access to cyclone shelter for local people without destroying agricultural field and water bodies.

For this above mentioned reasons the study is necessary for the risk assessment of coastal area as there is inadequate number of cyclone shelters at present.

1.3 Aims and objectives of the study

The Major objective of the study is to prepare a locational plan to serve as a framework for the establishment of a network of Cyclone Shelter in some selected coastal area which will reduce the loss of life from cyclone, storm surges and tsunami vulnerability.

Objective with Specific Aims:

The objectives of the present study are:

1. Determination of the number of cyclone shelters required for the study area together with their location based on population, land use and distance.
2. Estimation of the total population for whom the cyclone shelters are necessary.
3. Preparation of map showing the location of existing and proposed cyclone shelters to minimize the risk.

1.4 Structure of the report

This research work consists of six chapters. The contents of the chapters are as follows:

Chapter 1 includes general introduction, background and objectives of the study. Introductory information is written in this chapter as well.

Chapter 2 includes literature review and review of previous similar studies. In this chapter Studies of similar kind by different authors have been added and also a relevant idea of the new proposed technique has been discussed.

Chapter 3 contains the theory and methodology to describe about cyclone and cyclone related term and the procedure to calculate number of new cyclone shelter required and finally prepare a GIS base map which shows the detailed locations of new cyclone shelter.

Chapter 4 contains the description of the study area, population and existing cyclone shelter related information in study area.

Chapter 5 includes the results and discussions of this study which shows the calculations and geographical presentations.

Chapter 6 includes the conclusions and recommendations of the study.

Chapter 2

REVIEW OF LITERATURE

2.1 General

Over the years Bangladesh has been ravaged by cyclones that have caused extensive damage to its economy, infrastructure, livelihoods of the population, agriculture, housing, livestock and so on, and have resulted in the death of hundreds of thousands of people. The country's attempts towards development have time and again been hampered by natural calamities. Each time a cyclone strikes Bangladesh, the development activities that took years to build up are compromised, setting back its pace. Construction of cyclone shelters was initiated in the 1960s. In the 1990s a major programme was undertaken and cyclone shelters were built in the coastal areas. Supported by a formidable early warning system and thousands of volunteers, these shelters have reduced the loss of lives by providing safe shelter for the population during cyclones. During normal times they serve as schools, health and community centres, and house other functions.

2.2 Previous study

2.2.1 Multipurpose Cyclone Shelter Programme (MCSP)

The catastrophic cyclone of April 29-30, as many as 1991 again demonstrated the inadequacy of the number of cyclone shelters in Bangladesh. As many as 138,000 deaths were reported officially while the actual death toll was said to be far more. Following this incidence, many governmental and non-governmental organizations started working on construction of more cyclone shelters in the cyclone-hit coastal areas. The government, under the aegis of the United Nations Development Programme and the World Bank, undertook a holistic approach to study the need for construction of multipurpose cyclone shelters in the coastal areas of Bangladesh. Multipurpose Cyclone Shelter Programme (MCSP), prepared by Bangladesh University of Engineering and Technology (BUET) and Bangladesh Institute of

Development Studies (BIDS) in 1993. The major objective of the study was to formulate a framework for the establishment of a cyclone shelter network in the coastal areas which would define the basic concept, strategy and location pattern to be followed in all future construction. As part of the study, all types of existing shelters were required with the aim of finding suitability for specific locations (Mallick and Rahman, 2008).

The study area of the MCSP is the Risk Zone comprises 12,046 sq. km. in 49 Thanas (313 Unions), whereas the HRA has 9,182 sq. km. in 46 Thanas (237 Unions); these represent 8.4% and 6.4% of the total area of Bangladesh.

MCSP prepared a detailed inventory of existing and under construction cyclone shelters. They inventoried that there are 132 Coastal Community Centers constructed in the sixties; 238 three-storied PWD type shelters constructed in the seventies out of which 12 shelters have been washed away; 62 cyclone shelters constructed by Bangladesh Red Crescent Society (BDRCS) in the eighties; 12 shelters built by Caritas an NGO; 12 shelters by other Education. In June 1992, a total of 40 shelters were under construction by BDRCS and another 58 under the initiative of various NGOs.

MCSP also found during May 1991 to June 1992, various organizations have proposed construction of additional shelters. BDRCS has selected 115 sites; Facilities Department has selected has 360 locations (under Saudi Fund and IDB assistance); EEC plans to fund construction of 200 shelters; LGED has proposed 10 shelters (under IFAD-funding) and 40 shelters (under Japanese assistance) and NGOs 190 shelters. Locations of some of the proposed shelters are yet to be finalized.

MCSP review architectural and structural design of existing and planned cyclone shelters have been carried out. Six designs viz. those of PWD, BDRCS (also adopted by Caritas), Facilities Department, LGED, Grameen Bank and BRAC have been critically evaluated. Deficiencies of some of these designs have been identified.

MCSP prepared an architectural and structural design for typical 250-student primary schools. In the first phase these schools, run on a double shift basis, would have 3 class rooms and a teachers room. There may later be extended to 5-class room schools. There are provisions for vertical extension also, so that other public/community facilities may be accommodated. Two types of designs of school-cum-shelters have been prepared, viz, shelter-on-killa and free-standing shelter. The preferred design solution is a shelter located on top of a killa. This would enable the people to move in along with their livestock, rather than leaving them unattended in a remote killa. This also appears to be the least cost solution. Three heights of killa, viz. 3m, 4.5m and 6m have been used depending on location. The land required for a typical killa including the borrow pit, varies from 0.84 ha (3.0m ht.) to 1.76 ha (6.0m ht.).

MCSP provided new shelters only in the High Risk Area. Detailed analysis of capacities of cyclone shelters (existing, under construction and already proposed for construction by various agencies), other public/community buildings and private buildings have shown that these can provide shelter to around one-third of the total population. Construction of 2500 new shelters, each with capacity of 1750 persons, would therefore be necessary under MCSP. This shelter capacity, which is provided by normal time use as primary school, also ensures that the farthest point in the catchment area of a shelter would, in most locations, be within 1.5 km., the maximum distance people are willing to travel during cyclone.

A major element in the educational policy of the Government is to ensure Universal Primary Education by the year 2000 and the Government has enacted legislation to make attendance in primary schools compulsory. To achieve this target, a total of more than 3000 primary schools would be necessary in HRA. Similarly, using the criterion of one secondary school for every 5 primary schools, a total of 600 secondary schools would be necessary. These requirements of educational facilities match very well with the number of additional shelters planned.

Out of the 2500 shelters proposed, around 60% are proposed to be located in existing primary school sites, 23% in new primary schools, 10% in madrasas and 6% in

secondary schools. Only in some special locations the shelters would have other normal time uses.

In order to protect the livestock from storm surge, killas or earthen mounds, with the top level raised above maximum probable surge height, appear to be the least cost solution and yield a very high rate of economic return. From planning point of view, an integrated solution with a shelter on top of a killa appears to be the best solution. The area required for sheltering the cattle and goat/sheep in the catchments area of a shelter has been calculated. For almost all the Unions, the net area available on top of a standard killa is adequate to meet the needs of livestock shelter. In some Unions, it may be necessary to have a larger killa, but the total number of such cases would be very small. In some newly accreted land, where there is an influx of transient agricultural labour during harvesting season, a small number of killas may have to be built to protect human lives.

The overall communication network in the study area, mostly served by road and water transport, is relatively less developed compared to the rest of the country. The problems have been reviewed and improvements in road network and construction of jetties have been suggested. The criterion adopted after consultation with local people is that the approach road should be of such standard as to allow at least 3-wheeled Rickshaw Vans to ply over it. On the basis of field survey, it has been estimated that an average of 80m of new road would be necessary for each shelter.

In order to make the use of shelters more effective during normal time, so as to ensure better maintenance and greater emergency time use of shelters, community development activities, including involvement of women, have been proposed. The activities proposed for a shelter include identification of catchments area, formation of a community development Committee, preparation of Community Emergency plan, awareness creation and education, training of volunteers and an annual drill.

MCSP prepared detailed engineering specification for construction of new shelters. A combination of Lump Sum and measure and value contracts had been recommended. Based on an assessment capability of local contractors, the consultants have concluded

that the construction of the shelters and killas may be undertaken by the local contractors. LCB (Local Competitive Bidding) procedure, after proper pre-qualification of contractors, is recommended. However, in order to attract the more competent larger contractors, the bid-package^{4s} should be based of a cluster of shelters.

The implementation of the Master plan may commence in FF 1994-95 and it should be possible to complete the construction of all the shelters and killas by the year 2000. Based on a prioritization exercise, it has been proposed that 1250 shelters would be in Priority 1 (i.e. most severely affected areas) and 1250 shelters would be in priority 2 (i.e. severely affected areas). The priority 1 shelters would be constructed during first 3 years.

2.2.2 Cyclone Shelter Management Information System (CYSMIS)

Over 8900 km² of coastal area of Bangladesh is identified as high risk zone from cyclone disaster considering that there is risk of loss of lives due to inundation by storm surge. To protect and save human lives and resources, various mitigation measures such as formal cyclone shelters, coastal embankments, raised roads; killas etc have been built over different periods since 1960s by both GoB and NGOs. Many of them are in poor condition due to the lack of maintenance (DMB, 2011).

Tropical cyclones accompanied by storm surges are one of the frequent major disasters in Bangladesh. More than 5 million people living in High Risk Areas (HRA) of the coast are extremely vulnerable to cyclonic disaster. The Government of Bangladesh together with other agencies to date has built 2895 cyclone shelters. In 2004 an initiatives has been taken by to accumulate information of these shelters in an organized and accessible database for maintenance and planning (DMB, 2011).

Disaster Management Bureau (DMB) with technical support from CEGIS and financial support from USAID and CARE conducted a survey in January-February 2004 to gather physical and management information of the existing cyclone shelters (CYSMIS). This was validated and refined in December 2004. In order to better

planning, management and maintenance a criteria based framework, it has been developed for decision making by different stakeholders. The CYSMIS database will assist disaster practitioners and other stakeholders to access information about existing cyclone shelters situated in high-risk cyclone zones. The CYSMIS database will also assist development partners in decision-making process by helping to prioritize resource allocation for further work. However, this system has been developed with a user friendly CD of CYSMIS which will give details of each individual shelter e.g. location and capacity, facilities and use, existing conditions of the shelter with photograph, name of donor, age/date of establishment, maintenance mechanism, distance from nearby shelter etc. (DMB, 2011).

2.3 Cyclone Shelter Programme in Bangladesh

In the 1960s, a programme for the construction of 2000 units of two-storied buildings as Coastal Community Centres and single-storied buildings as Sub-Coastal Community Centres was undertaken by the then government. At normal times these would serve as Union Parishad (Union Council) offices, and be used as cyclone shelters, when necessary. This programme was reported to have been abandoned after the construction of 100 units (Mallick and Rahman, 2008).

The devastating cyclone of 1970, which resulted in the loss of some 300,000 lives lead to the construction of designated cyclone-shelters for the first time. During the period 1972–79, some 238 shelters were constructed in various locations in the coastal belt of Bangladesh. The International Development Association, IDA funded this Coastal Area Rehabilitation and Cyclone Protection Project and the Public Works Department (PWD) under the Ministry of Works was responsible for the design and supervision of the project (Mallick and Rahman, 2008).

Following the 1985 cyclone, the Bangladesh Red Crescent Society (BDRCS), with assistance from the League of Red Cross, undertook an ambitious project of building 500 shelters in five years starting from 1986. However, they could not achieve their target because of financial constraints. Nevertheless, by the year 1990, some 62 shelters were constructed in 16 different districts along the coast. Later, many

organizations adopted the BDRCS typology for construction of cyclone shelters (Mallick and Rahman, 2008).

2.4 Summary

There are not so many studies about cyclone shelter planning in coastal belt in Bangladesh. One of the complete study, Multipurpose Cyclone Shelter Programme (MCSP), was prepared by Bangladesh University of Engineering and Technology (BUET) and Bangladesh Institute of Development Studies (BIDS) in 1993 after the devastating cyclone 1991 and another study lead by Disaster Management Bureau (DMB) with technical support from CEGIS with financial support from USAID and CARE conducted a survey entitled "Cyclone Shelter Management Information System (CYSMIS)" in January-February 2004 to gather physical and management information of the existing cyclone shelters. In this study, they gathered basic information of all the cyclone shelters about their physical status, management and uses, and prepared a software system to identify the new shelter locations and carry out maintenance planning considering various criteria.

After preparing MCSP in 1993, it have already passed 18 years, in the mean time increase in coastal population and simultaneously the frequency of cyclonic storm has also increased. So this project work is an extension in complementary with MCSP at par with the span of time. In Cyclone Shelter Management Information System (CYSMIS) study, mainly discussed existing cyclone shelter information, management and maintenance and prepared a software system (CYSMIS).

In this project work recent data (numbers of existing cyclone shelter, their capacity and population) have used for the study area. In this study, a complete attributes table and a map of existing cyclone shelters have been prepared. In addition a full planning of newly proposed cyclone shelters like number of cyclone shelter, number of populations required to accommodate under safe shelter during disaster and locations of newly proposed cyclone shelters has been emphasized. For geographical representation of all these information of existing and proposed cyclone shelters are shown in different GIS maps.

Chapter 3

THEORY AND METHODOLOGY

3.1 General

Cyclone and storm surges are among the most destructive of all natural disaster. The region of the world which are vulnerable to such disaster include the islands in the South-West Pacific, South-East Asia (e.g., the Philippines, Viet Nam), countries adjoining the Bay of Bengal (viz., India, Bangladesh and Myanmar), South-East Africa, the Caribbean and part of the USA and Latin America around the Gulf of Mexico and Atlantic Ocean (Choudhury, 1994).

Bangladesh is among the countries vulnerable to devastating storm surges which accompany cyclones. About 10 percent of the global total cyclones originate in the Bay of Bengal and about one-sixth of these have landfall in the Bangladesh coast. The funnel shaped coastline in the northern bay, coupled with a gently sloping continental shelf (the 10 m depth contour ranges from 20 to 200 km from the coastline), results in surge heights up to 7.5. These may move up the flat deltaic land or along the numerous rivers and creeks in the coastal zone and affect places as far as 40 km from the coastline (Choudhury, 1994).

Cyclone and storm surges are not new phenomena in Bangladesh, there are records dating back to 1584, when 200000 people are reported to have been killed in one southern district due to storm surges. During the last 100 years, a total of about seventy cyclonic storm have hit the Bangladesh coast, out of which seventy have been classified as severe cyclonic storm (i.e., with sustained wind speed greater than 119 km/hr) (Choudhury, 1994).

The most devastating, in terms of human fatalities, was the November 1970 cyclone, which killed around 500000 people. The official death toll in 29 April 1991 cyclone was around 140000 (Choudhury, 1994), and category 4 cyclone sidr on 15 Nov 2007 killed 3447 (Wikipedia, 2011). More than 98 percent of these deaths are due to

drowning in the surge water. The average human death toll during the last thirty years has been around 25000 per year, which is the highest in the world (Choudhury, 1994).

A comprehensive analysis of all available data reveals that there are around 5.2 million people (approx. 4.5 percent of Bangladesh total) living in an area of 9182 km² (6.4 percent of Bangladesh total), where the surge height may be 1 m or more. This area has been classified as high risk area where people are likely to be killed if they do not move to shelter (BUET-BIDS, 1993).

One of the possible mitigatory measure is the construction of community shelters capable of providing refuge to the population likely to be affected appears to be a feasible option. The concept of building cyclone shelter in the coastal belt of Bangladesh dates back to the early sixties. After the devastating cyclones of 1960-61, the Government decided to build a number of two-story buildings in areas close to the coast, the upper floor of which could be used as shelter during cyclones. These were proposed to be used as offices of the Union Council (the lowest level of local government) and community centres during normal times. A total of 132 of these building were built, but lack of maintenance has resulted in rapid deterioration and many of these have been abandoned (Choudhury, 1994).

3.2 Theory

3.2.1 Coastal area of Bangladesh

Coastal zone of Bangladesh consists of 19 districts with an area of 47,201 sq. km which is about one third of the total area of the country. Out of 19 districts, 12 districts (i.e. Satkhira, Khulna, Bagerhat, Pirojpur, Barguna, Patuakhali, Bhola, Lakshimpur, Noakhali, Feni, Chittagong and Cox's Bazar) comprising 48 upazilas/ thanas are considered as 'exposed' directly to vulnerabilities from natural disasters (CZP, 2005).

The coastal region has about 710 km long coastline and 123 embanked polders, which were constructed in late sixties to protect the land from saline water, tidal and

monsoon flooding and to increase the crop production. The characteristics of coastal zone is very complex network of rivers, enormous river water flow heavily laden with sediments, strong tidal and wind actions, waves and tropical cyclones and associated storm surges. The Meghna estuary is located in the central part of coastal zone. The estuary contains a number of deltaic islands which are morphologically dynamic (CZP, 2005).

The coastal region of Bangladesh vulnerable to cyclone, tsunami and storm surge. Figure 3.2.1 shows the coastal region of Bangladesh.

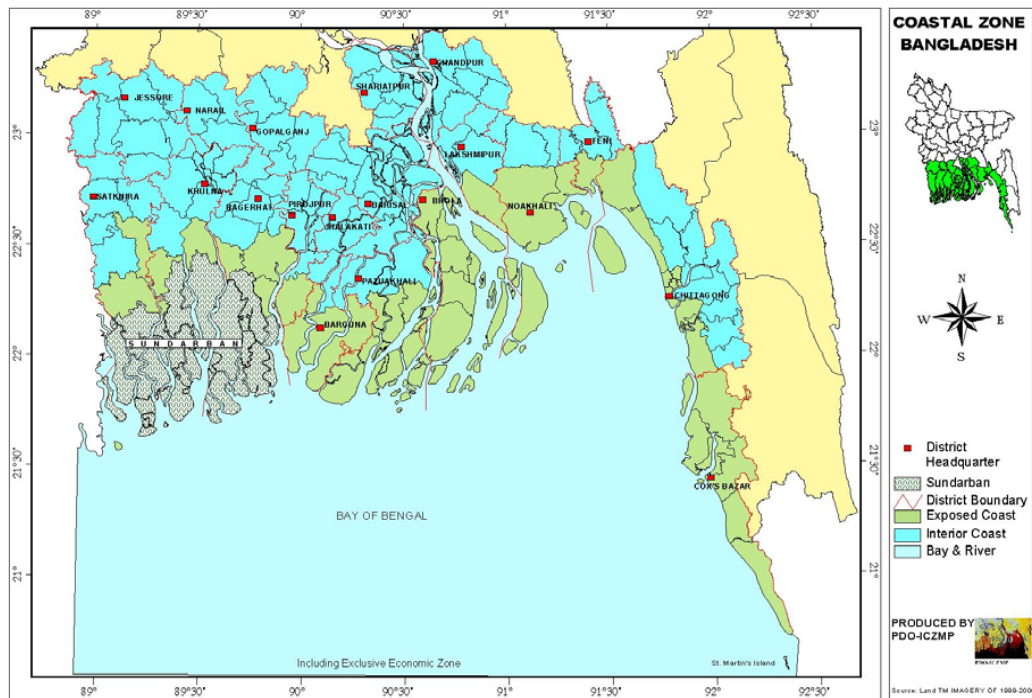


Figure 3.2.1: Coastal Region of Bangladesh (Source: PDO-ICZMP, 2005)

3.2.2 Cyclone

Typhoons are tropical revolving storms. They are called 'Cyclones' in English, when they occur in the Indian Ocean area. The coastal regions of Bangladesh are subject to damaging cyclones almost every year. They generally occur in early summer (April-May) or late rainy season (October-November). Cyclones originate from low atmospheric pressures over the Bay of Bengal. Figure 3.2.2 shows a typical cyclone structure formed in the tropics of the northern hemisphere.

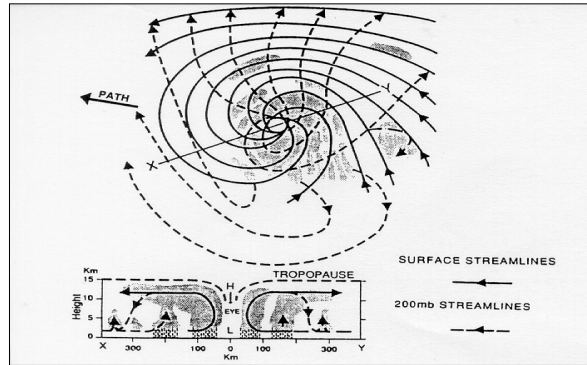


Figure 3.2.2: A model of the aerial and vertical structure of a tropical cyclone. The areas of rainfall are indicated in the vertical section X-Y across the system (Source: Barry and Chorley, 1992).

Cyclones in the South Asian Sub-Continent are presently classified according to their intensity and the following nomenclature is in use (Choudhury, 1992):

Table 3.2.1: Classification of Cyclone

Depression	Winds up to 62 km/h
Cyclonic Storm	Winds from 63-87 km/h
Severe Cyclonic Storm	Winds from 88-118 km/h
Severe Cyclonic Storm of Hurricane Intensity	Winds above 118 km/h

Tropical cyclones or hurricanes are common within latitude 300 north and south. These intense storms move across shallow shelf seas; the water is being piled-up along the coast as a surge. In most cases the mixture of these effects creates most dreadful effects in the coastal regions - a gradual rise in the regional sea level produces enhanced landward penetration of surges and storm waves (Choudhury, 1992).

3.2.3 Storm surges

In addition to the waves associated with winds, abrupt surges of water known as storm surges are associated with cyclones. They strike the coast nearly at the same time that the centre of the storm crosses the coast. In Bangladesh the maximum value of this storm surge has been reported to be as high as 13m. Most of the damage during a cyclone is done by the storm surges, which sometimes wash over entire offshore islands and large areas on the coast (Banglapedia, 2006).

The most destructive element of a cyclone is its accompanying surge. There is little that can withstand a great mass of onrushing water often as high as 6m. In Bangladesh, cyclones occur in April-May and also in September-December. On an average, five severe cyclonic storms hit Bangladesh every year and the accompanying surge can reach as far as 200 km inland. Surge-heights increase with the increase of wind speed. Astronomical tides in combination with cyclonic surges lead to higher water levels and hence severe flooding (Banglapedia, 2006).

Storm surges accompanying cyclones hitting Bangladesh have been noted to be 3m to 9m high. The 1970 cyclone (12-13 November) with a cyclonic surge of 6m to 10m and a wind speed of 222 km/h occurred during high tide causing an appalling natural disaster that claimed 0.5 million human lives. The cyclone of 29 April 1991 hit Chittagong, Cox's Bazar, Barisal, Noakhali, Patuakhali, Barguna and Khulna along with a tidal bore (6.1m to 7.6m), killing 140,000 people (Banglapedia, 2006).

3.2.4 Risk Zone and High Risk Area in Coastal area

The coastal area prone to storm surge flooding has been termed as the Risk Zone (RZ) where there is a risk that loss of lives and damages to properties may occur due to inundation by storm surge water. The Risk Zone is further subdivided into the High Risk Area (HRA) where there is a possibility of loss of lives due to appreciable inundation by storm surges (BUET-BIDS, 1993).

The distance of intrusion of storm surge water during a cyclone varies widely along the coast. It depends on several regional and local factors related to hydrology, topography and oceanography. Some of the important factors are:

- storm surge height at the coast;
- angle of the storm track with respect to the coast line;
- tidal condition;
- offshore and near-shore bathymetry;
- slope of the land;
- curvature of the coastline;
- width and depth of river mouth through which the surge will travel;
- presence of islands and chars;
- land topography; and

land use and surface resistance including presence of forest (BUET-BIDS, 1993).

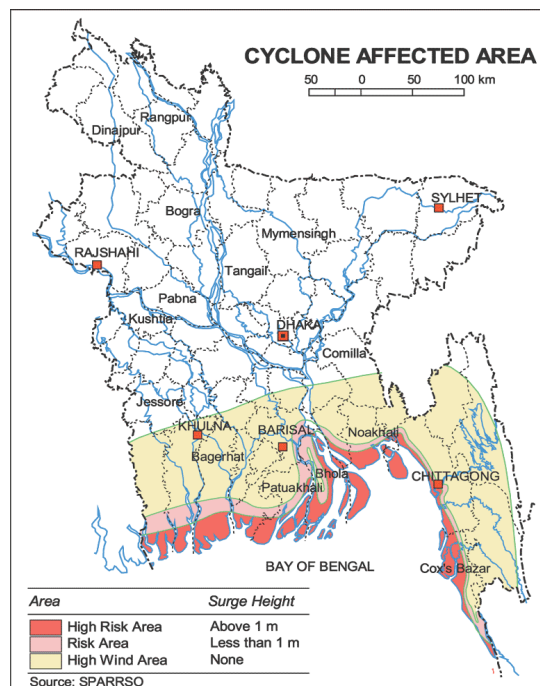


Figure 3.2.3: Risk Zone and High Risk Area of Bangladesh (Source: Banglapedia, 2006).

The following criteria have been adopted in delineating the Risk Zone (RZ) and High Risk Area (HRA);

- 1) The RZ extends from the coast line (sea coast or river bank) to an inland limit up to which surge water can reach.
- 2) The HRA includes a strip of land within the RZ. It extends from the coast line up to a limit where the depth of storm surge inundation may reach one meter. The one meter depth criterion has been selected based upon the experience narrated by survivors during past storm surge inundations. It was reported that an adult could force his/her way through water as long as the depth of water remained below waist height. So a depth of one meter, which is near to the height of the waist of an average adult, has been selected as the criterion for delineation of HRA (BUET-BIDS, 1993).

The HRA has been further sub-divided into “most severely affected area” and “severely affected area” (BUET-BIDS, 1993).

3.2.5 Settlement Patterns

Settlement pattern of human population, obtained from Google Earth satellite image. In the West and Central Zones there exist an extensive network of rivers and canals. Water is the main mode of transportation in these areas, and linear settlements have been built up along the banks of these rivers and canals. Linear settlements have also been formed along the coastal embankments specially in the islands located mostly in Central Zone, and along the sides of roads and banks of rivers in the East Zone (BUET-BIDS, 1993).

The major three zones in Coastal area have been briefly discussed in section 4.2 and figure also shown in figure no 4.2.1.

Other pattern of human settlement in the HRA are the nucleated, scattered and mixed types. Nucleated human settlement have been formed on the plains and foothills in East Zone. In the hilly areas, different tribes also live separately from each other forming mostly nucleated settlements. In the Central Zone where the density of

population is high, human settlement is mostly of scattered type. Mixed settlement pattern of linear settlement and scattered settlement is also observed generally in the Central and East Zones. In the newly formed char lands the human settlement is thin and of scattered type. A brief overview of settlement patterns by Zone is presented below (BUET-BIDS, 1993).

West Zone

The human settlement pattern in West Zone of Ganges Tidal Plain is mostly of linear type in the Thanas of Dacope, Koyra, Sarankhola, Monglaport, Shyamnagar, Barguna, Patharghata and Kalapara along the banks of innumerable rivers and canals, and along the side of roads. Some scattered settlements are also noticed in some settled char lands and by the sides of swamps in the Thanas of Dacope, Morrelganj, Shyamnagar, Mathbaria, Bamna and Betagi (BUET-BIDS, 1993).



Figure 3.2.4: Linear Settlement at Kalapara Paurashava under Kalapara Upazila (Source: Google Earth)

Central Zone

The human settlement pattern in this Zone is mostly of scattered type because of existence of a high proportion of char lands- both settled and newly formed. Scattered

settlements are observed in almost all Thanas under the Zone, but such a settlement pattern is specially pronounced in the settled/newly formed char lands in the districts of Bauphal, Dasmina, Char Fasson, Lalmohan, Manpura, Sonagazi, Ramgati, Raipur, Hatiya and Companiganj. Mixed types of linear, scattered and nucleated patterns are noticed in such Thanas as Daulatkhan, Tazumuddin and Sandwip; Galachipa Thana combines mostly nucleated and linear patterns (BUET-BIDS, 1993).



Figure 3.2.5: Scattered settlement in Char Elahi union under Companigonj upazila
(Source: Google Earth)

East Zone

Predominant human settlement patterns are both linear and scattered/nucleated. Nucleated settlement pattern is noticed in the Thanas of Banskhali, Sitakunda, Kutubdia, Chakaria, Ramu, Teknaf and Ukhiya forming along the sides of the roads, highways and foot hills, and along the banks of rivers and canals in the region. In all these Thanas, in addition to linear settlement scattered settlements are also noticed in the low lying areas, as well as, in some other parts of these Thanas. Scattered/nucleated settlements are also observed in Thanas of Mirsarai, Anwara, Patiya, Chandanaish, Cox's Bazar and Maheshkhali (BUET-BIDS, 1993).

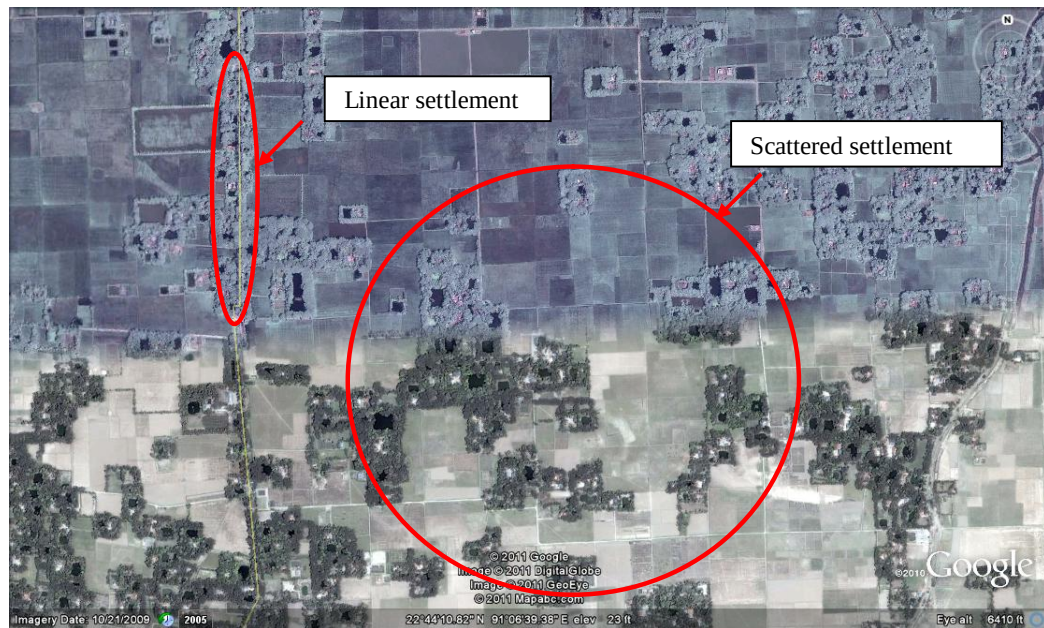


Figure 3.2.6: Mixed settlement in Noakhali union under Noakhali Sadar upazila
(Source: Google Earth)



Figure 3.2.7: Linear settlement on the foot hill in Nhilla union under Teknaf upazila
(Source: Google Earth)

3.2.6 Demographic characteristics in Coastal area

The coastal area of Bangladesh as defined by the Integrated Coastal Zone Management Plan (ICZMP) of the Water Resources Planning Organisation (WARPO), comprises 19 districts, located in the southern part of Bangladesh and influenced by the Bay of Bengal (PDO-ICZMP, 2005). According to the population census 2001, the population of the coastal area is about 28 million, which is about 22% of the total population of Bangladesh (CEGIS 2009).

Population growth rate in the coastal areas is higher than the national average. In between 1991- 2001 the average population growth rate was 1.29, if so continued then by 2020 the coastal population will be 44 million, more people will be landless, and more people will be city bounded for livelihood earning (Shamsuddoha et al., 2007).

Table 3.2.2: Population growth trend in the coastal areas

Year	Population(million)		
	Coastal rural	Coastal urban	Total
2001	27	8	35
2010	25	14	39
2020	22	22	44

Source: Coastal Livelihoods, ICZM June 2003

3.2.7 Population Projection

Population projections are needed for development planning and there is no doubt that they should be as accurate as possible. The estimates will be accurate if data used are accurate and assumptions involved in the projections hold true in reality. Hence, data need to be properly evaluated and adjusted for errors before using for projection and the most likely assumptions need to be made. However, the most plausible assumptions used in the projection will not be exact in reality. As such, other alternative assumptions have to be used. The various combinations of assumptions about fertility, mortality and migration will lead to a large number of population projections (Mehta, 2003).

Population Projection Techniques

According to Mehta, 2003 there are various methods of projecting population (mathematical, economic and component methods). Some are very sophisticated and rigorous while others are simple and less sophisticated. Normally, population in future is governed by the following equation:

$$P_n = P_o + \text{Number of Births (B)} - \text{Number of Deaths (D)} + \text{Net Migration (N}_m) \quad (3.2.1)$$

For the projection of population in 2011 (P_n), base year population (P_o) in 2001, the number of births and deaths between 2001 and 2011 and net migration is required. Keeping in view the in-migration and out-migration, net migration may be either positive or negative. Though population in the base year (2001) is available, number of births, deaths and migration in future needs to be projected which is not an easy task. One such method that considers all these aspects is known as component method of population projections. This method is suitable for projecting sub-national i.e. district and block level population. It requires detailed age-structure of population in the base year alongwith estimation of a variety of demographic indicators. For projecting age and sex distribution of population in 2011, distribution of population in 2001 in different age groups such as, 0-4, 5-9, 10-14 etc. is required. The same is then used with the birth and death rates to know age-specific mortality rates and fertility rate among the child bearing women population. Similarly, by using the appropriate life-tables, expectation of life at birth is projected. The data required by the component method is generally not available at the district level. Even if available, they are out-dated and their quality is also not reliable. Use of the method requires expertise in demography and understanding of the demographic structure of the population, which may not be available at the district level. Therefore, the module discusses simple and easy-to-handle methods of population projections given the purpose. Let us first consider the *growth rate method*.

For computing the annual rate of growth (simple), the following formula can be applied to the information at any two points of time.

$$r = \frac{1}{n} \frac{[P_n - P_o]}{P_o} \times 100 \quad (3.2.2)$$

where

r = annual rate of growth

P_n = population in the current year

P_o = population in the base year

n = number of intermediary years.

If population of Kalapara upazila under Patuakhali district is 174921 in the year 1991 (P_o), as against 202078 in the year 2001 (P_n), then ' r ' would be,

$$r = \frac{[202078 - 174921]}{174921} \times 100$$

$r = 15.53\%$ gives the decadal rate of growth which has taken place between the two given years, 1991 to 2001. The annual rate of growth can be simply obtained by dividing the decadal rate of growth by 10; thus 1.55 per cent is the annual rate of increase. By assuming that this rate of growth would continue in the future, population figures can be obtained in any given year. Thus, in this method, the net increment between two years is obtained by applying ' r ' to the base year population which means the increment remains constant irrespective of the year, and, hence, considered as a crude method of projection (Mehta, 2003).

A slightly improved method is the *compound rate of growth method*, which can be computed with the help of the following formula.

$$R = [(P_n / P_o)^{1/n} - 1] \times 100 \quad (3.2.3)$$

By the formula

$$P_n = P_o (1 + R/100)^n \quad (3.2.4)$$

population in any requisite year can be projected. The value of the expression can be obtained with the help of a scientific calculator by using the function $[Y^x]$ or $[X^Y]$.

$$\begin{aligned} R &= [(202078/174921)^{(1/10)} - 1] \times 100 \\ &= [(1.1553)^{0.10} - 1] \times 100 \\ &= 1.45\% \end{aligned}$$

Thus, during the period 1991 to 2001, population increased at the rate of 1.45 per cent per annum. This rate can now be applied to know the population figures in any given year. For example, population in the year 2011 would be,

$$\begin{aligned}
P_{2011} &= P_{2001} \times (1 + R/100)^n \\
&= 202078 \times (1 + 0.0145)^{10} \\
&= 233367
\end{aligned}$$

The same method can also be used for projecting other variables like enrolment. One of the limitations of this method is that while computing the rate of growth, it considers information at only two points of time (Mehta, 2003).

3.2.8 Cyclone Shelter

Cyclone shelters are meant to provide shelter and reduce the number of casualties in the coastal area during cyclone and tsunami (CEGIS, 2009). At present, cyclone shelters in the coastal region of Bangladesh play a very important role in protecting human lives and livestock during cyclones. During Cyclone Sidr in 2007, for example, 15 percent of the affected population took refuge in cyclone shelters, which were estimated to have saved thousands of lives (Dasgupta et al., 2010).

3.2.9 Distribution of cyclone shelters

Since the devastating 1970 cyclone, a number of multi-storied permanent structures have been built intermittently in different coastal districts to provide shelter to the people during emergency. After the 1991 cyclone, Bangladesh government with the support of different foreign agencies, have been building multi-purpose cyclone shelters so that these can be used as primary schools during the normal period of time. But most of the cyclone shelters are in poor condition with minimum or no maintenance at all (Karim, 2001).

The population of 16 coastal districts was 31 million in 2001 while the projected population in 2009 is 38.2 million. There are 2,583 usable cyclone shelters located in this area with the capacity to serve 2.8 million people, which is only 7.3% of the total coastal population. A district-wise Summary of Cyclone Shelters and PEDP-II Buildings along with population data is presented in the table 3.2.3 (CEGIS, 2009).

Table 3.2.3: District-wise Summary of Cyclone Shelters and PEDP-II Buildings

District	Population (2001)	Population (2009 Projected)	Nos of Upazila	Shelters washed away/ destroyed	Unusable	PEDP-II	Usable	
							Nos	Capacity
Bagerhat	1,549,031	1,791,666	8		11	54	98	86,159
Barguna	848,554	1,010,525	5	2	10	59	147	147,590
Barisal	2,355,967	2,658,166	9		-	15	37	41,050
Bhola	1,703,117	2,055,226	7	49	53	195	429	390,050
Chandpur	2,271,229	2,714,329	6		1	58	21	26,350
Chittagong	6,612,140	8,657,530	22	11	29	71	573	683,010
Cox's Bazar	1,773,709	2,318,343	7	6	10	104	504	607,310
Feni	1,240,384	1,455,142	4	3	12	5	57	61,275
Jhalokati	694,231	899,504	4		2	3	12	7,650
Khulna	2,378,971	3,079,694	6		2	46	77	76,541
Lakshmipur	1,489,901	1,761,806	4	5	10	119	106	118,000
Noakhali	2,577,244	3,034,143	3	5	33	16	245	266,112
Patuakhali	1,460,781	1,794,098	7	7	72	103	165	157,675
Pirojpur	1,111,068	1,250,245	6		1	33	36	32,300
Satkhira	1,864,704	2,430,898	6		-	16	65	55,071
Shariatpur	1,082,300	1,280,954	4		-	27	11	14,375
Total	31,013,331	38,192,269	108	88	246	924	2,583	2,770,518

3.2.10 Spatial Distribution Maps of Cyclone Shelters

The cyclone shelters shown in maps were mainly separated in two broad categories, shelters and shelter-cum-killas. Each of these categories was classified into two groups (usable and unusable) based on the condition of the shelter. Figure 3.2.8 presents a map of the coastal area showing the locations of all existing cyclone shelters. There are a total of 2,583 cyclone shelters and 924 school buildings (PEDPII) located in the coastal districts. Figure 3.2.8 shows that the concentration of shelters is higher in the east coast (Noakhali, Chittagong, Cox's Bazar and Feni) than the west coast. They are fewer shelters in the west coast districts (CEGIS, 2009).

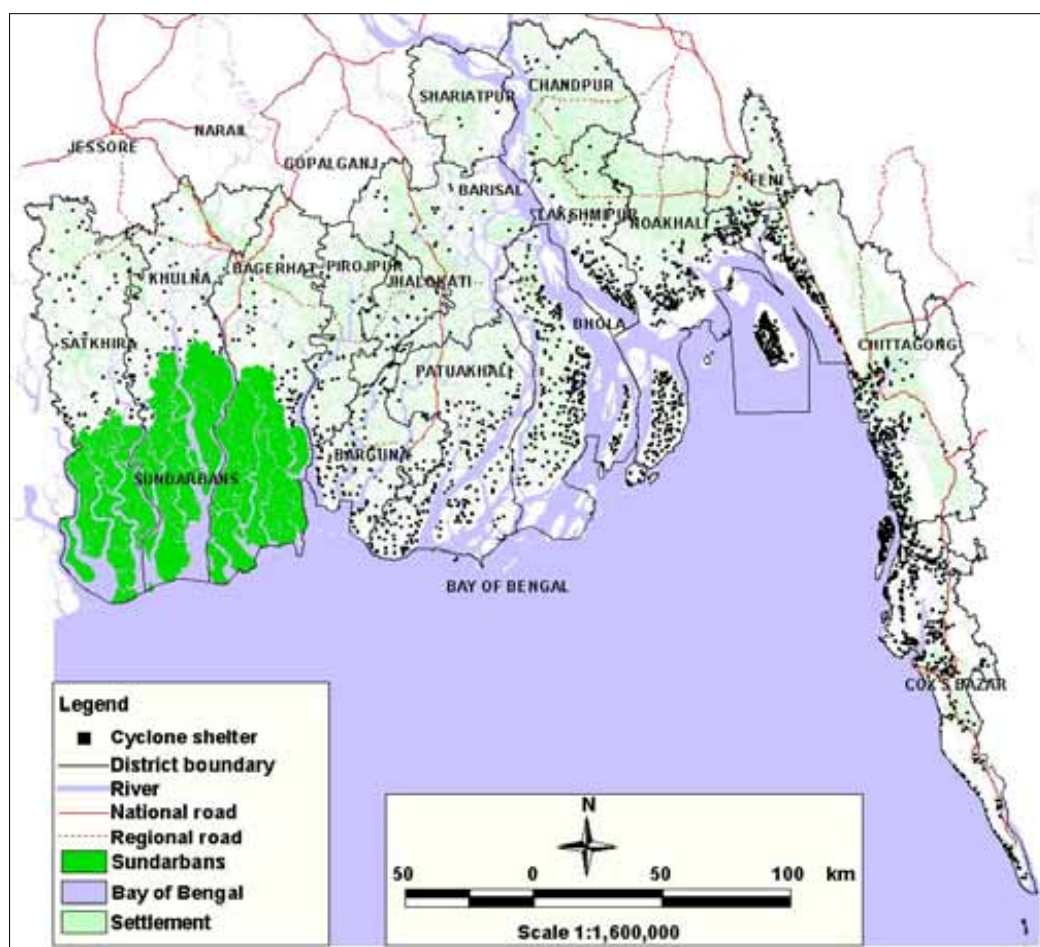


Figure 3.2.8: Spatial locations of cyclone shelters in coastal areas (Source: CEGIS, 2009)

A district-wise summary of cyclone shelters is presented in figure 3.2.9 This figure shows, Bhola, Chittagong and Cox's Bazar districts have the highest and Shariatpur, Jhalokati and Chandpur districts have the lowest number of shelters (CEGIS, 2009).

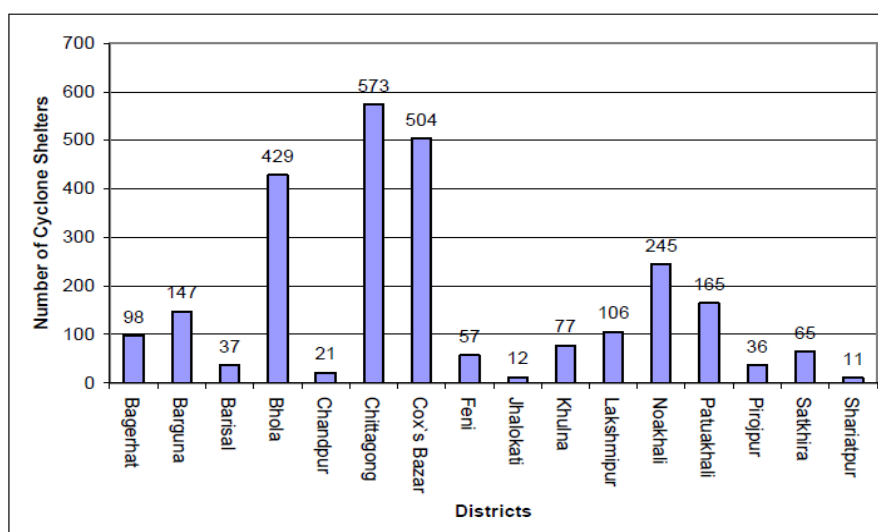


Figure 3.2.9: District-wise distribution of cyclone shelters (Source: CEGIS, 2009)

3.2.11 Normal Time use of Existing Cyclone Shelter

Cyclone shelters are constructed for multipurpose use. It was found from field investigation that among 2,583 shelters 82% was used as education centres, 8 % as offices, 1% as community centres, 1% as health centres and 6% do not have any normal time use. A summary of the use of cyclone shelters during normal time is presented in figure 3.2.10.

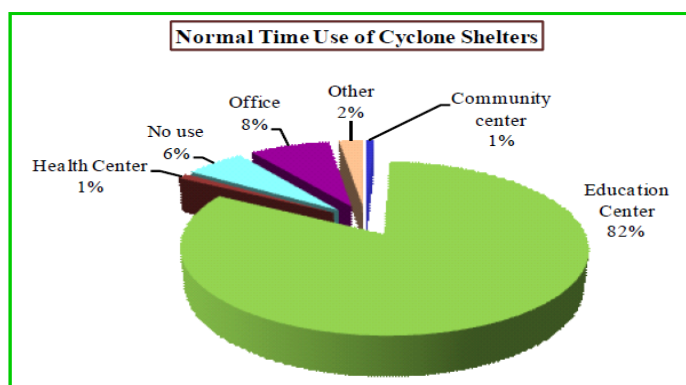


Figure 3.2.10: Normal time use of cyclone shelters (Source: CEGIS, 2009)

3.2.12 Road access of Existing Cyclone Shelter

The access roads to the cyclone shelters were divided into three categories, good, average and poor based on their condition. The condition of the access roads to the cyclone shelters are presented in figure 3.2.11. The figure shows that the access roads are in average condition in most of the districts. They are, however, in good condition in the districts of Jhalokati (for 58% of the shelters), Lakshmipur (for 36% of the shelters), Chittagong (for 35% of the shelters) and Stakhira (for 31% of the shelters), and poor in the districts of Patuakhali (for 60% of the shelters), Barguna (for 58 % of the shelters), Chandpur (for 57% of the shelters) and Khulna (for 55% of the shelters) (CEGIS, 2009).

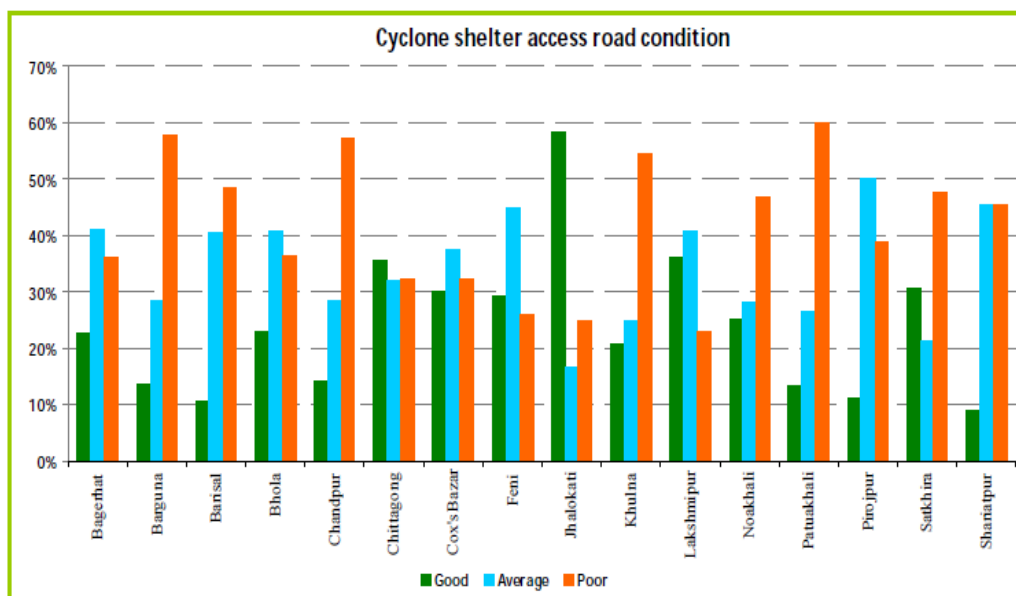


Figure 3.2.11: Condition of access roads to the cyclone shelters (Source: CEGIS, 2009)

3.2.13 Facilities of Existing Cyclone Shelter

The facilities available in the shelters are presented in figure 3.2.12. The figure shows that almost 100% of the shelters have sanitation facilities, but water supply is poor. It can be noted that over 80% of the shelters in Shariatpur, Barisal and Jhalokati districts and less than 50% of the shelters in Barguna, Bagerhat, Cox's Bazaar and Pirojpur districts have water supply facilities (CEGIS, 2009).

As we know women, children, disabled and elderly people are more vulnerable to the impact of cyclones than others. The shelters need to provide necessary and adequate facilities (separate space and toilet for women, and access facilities for the disabled) so that they are willing to come to the shelters during cyclones. However, the figure shows that most of the shelters fail to provide facilities for women. Only 32% of the shelters of Lakshmipur, 30% of Noakhali and 27% of Shariatpur have separate space for women. None of the shelters in Jhalokati district has separate spaces for women. There are also no separate toilets for women in many shelters. However, every shelter in Shariatpur district has separate toilets for women. In Barisal 70%, in Khulna 62%, in Chandpur 57%, and in Feni, Noakhali and Satkhira district 52% of the shelters have separate toilet facility for women. Most of the shelters lack in access facility for disabled. Only Chandpur (5%), Barguna (3%), Bhola (2%), Cox's Bazaar (1%), Lakshmipur (1%) and Noakhali (1%) districts have access facilities for disabled.

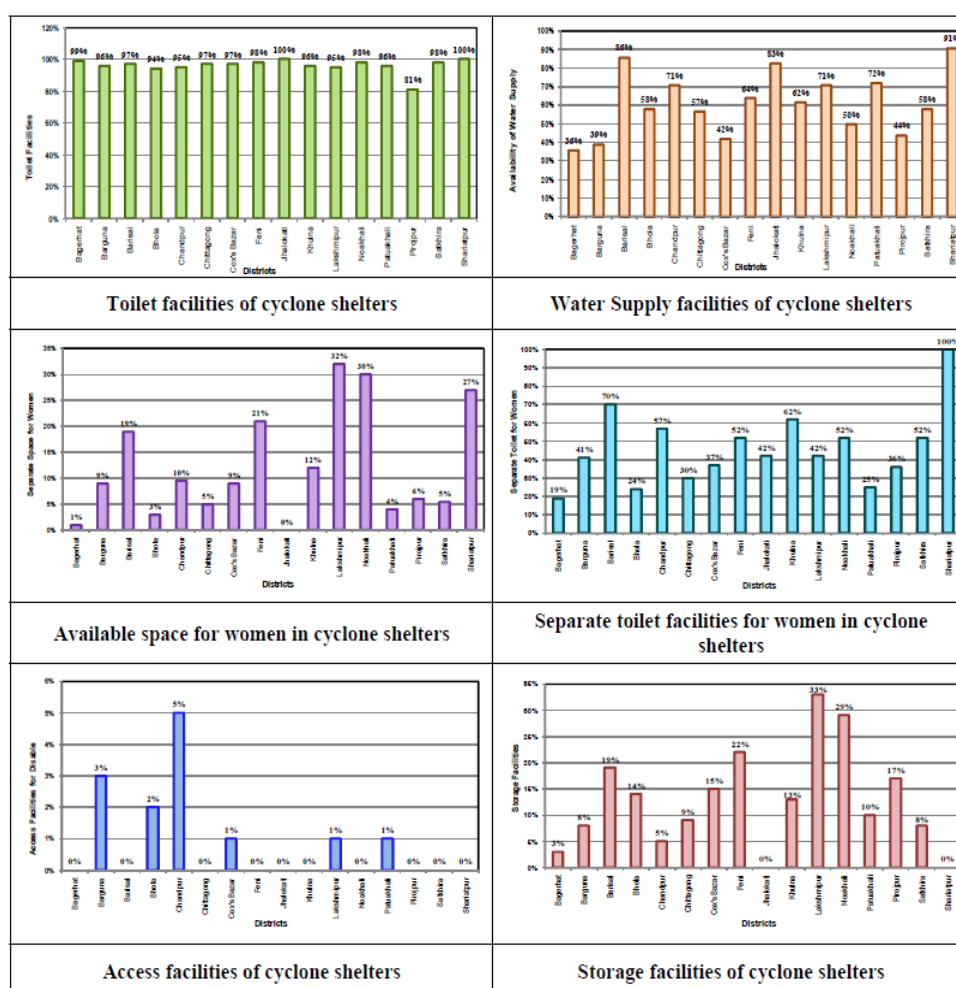


Figure 3.2.12: Available facilities in cyclone shelters in different districts (Source: CEGIS, 2009)

Cyclone shelters should have storage facilities for the valuable goods of people who take shelter in them during cyclones. However, this facility too is not available in many shelters. The following figure shows that 33% of shelters in Lakshmipur, 29% in Noakhali, 19% in Barisal and 17% in Pirojpur have storage facilities for valuable goods (CEGIS, 2009).

3.2.14 Types of Existing Cyclone Shelter

Various types of structures have been constructed by a number of organizations, which are serving as cyclone shelters. Similar types of structures were grouped according to structural dimensions, construction and funding agencies and year of construction. The shelters were assembled into 13 major groups classified as types 1 to 13. Besides these, there are some other types of shelters as well (CEGIS, 2009).

A brief description of all 13 types of shelters is presented in the following.

Type 1

Type 1 shelters were constructed by the Bangladesh Red Crescent Society (BDRCS)/ Caritas/World Vision/CCDB and funded by BDRCS/Caritas/CAFOD/World Vision/German Red Cross/CCDB. According to the survey, there are 377 type 1 shelters, spread over 37 Upazilas of 12 Districts. The shelters were constructed between 1976 and 2003. Most of them have multipurpose use (CEGIS, 2009).



Figure 3.2.13: Type 1 cyclone shelter (Source: CEGIS, 2009)

Type 2

Type 2 shelters were constructed and funded by BRAC/ Local Government and Engineering Department (LGED). According to the survey total number of type 2

shelter is 19 and these shelters are spread in 3 Upazilas of 2 Districts. Most of the shelters were constructed in Kutubdia area. The construction period is 1986 - 1999. The design of the shelters show a distinct difference in conceptual and formal aspects from those designed by other agencies. At normal time most of these shelters are used as Community centres, Education centres or offices. Only 3 shelters are used for other purposes e.g. to live in or Madrassa, while 5 are not used at all during normal time.



Figure 3.2.14: Type 2 cyclone shelter (Source: CEGIS, 2009)

Type 3

This type of Shelters were constructed by LGED and funded by the Cabinet Division of GoB. According to the survey there were only 4 type 3 structures spread over 4 upazilas of 4 different districts. These shelters were constructed during 1991-2003. One of these shelters is used as Police Camp and the rest as education centres.



Figure 3.2.15: Type 3 cyclone shelter (Source: CEGIS, 2009)

Type 4

These shelters were constructed by PMED/EU and funded by EU. A total of 194 Type4 cyclone shelters were surveyed and found spread over 8 upazilas of 6 districts. The shelters were constructed between 1955 and 2003. Normally all shelters are used as Education centres, but one shelter is used as a health centre and another shelter is not used during normal time.



Figure 3.2.16: Type 4 cyclone shelter (Source: CEGIS, 2009)

Type 5

Shelters of this design type were constructed by LGED and funded by German Grant (KFW). According to the survey there are a total of 112 Type 5 shelters spread over 52 upazilas of 15 districts. These shelters were constructed during is 1972-2008. All type 5 shelters are used as Education centres during normal time.



Figure 3.2.17: Type 5 cyclone shelter (Source: CEGIS, 2009)

Type 6

The Type 6 shelters were constructed and funded by Grameen Bank. A total of 20 shelters of this type were surveyed and found spread over 11 Upazilas of 5 Districts. The shelters were constructed between 1992 and 2004. Normally all shelters are used as Grameen Bank offices, but one is used as an education centre, two for family and banking purposes and two have no normal time use.



Figure 3.2.18: Type 6 cyclone shelter (Source: CEGIS, 2009)

Type 7

Shelters of this type were constructed by the Japan International Cooperation Agency (JICA)/LGED and funded by JICA. A total of 45 Type 7 cyclone shelters were surveyed and found spread over 12 upazilas of 4 districts. The shelters were constructed between 1994 and 2008. Most of the shelters are used as education centres, 3 shelters are used as community centres, offices or other purposes while 3 shelters have no normal time use.



Figure 3.2.19: Type 7 cyclone shelter (Source: CEGIS, 2009)

Type 8

This type of shelters were constructed by JICA/LGED and funded by JICA. A total of 28 Type 8 cyclone shelters were surveyed and are spread over 9 Upazilas of 3 Districts. The shelters were constructed between 1995 and 2005. All these shelters are now used as education centres.



Figure 3.2.20: Type 8 cyclone shelter (Source: CEGIS, 2009)

Type 9

This design type has been constructed by LGED/Char Development and Settlement Project (CDSP) and funded by CDSP/Netherlands Government. According to the survey there are a total of 33 Type 9 cyclone shelters spread over 4 upazilas of 2 districts. There are some other types of shelters constructed by LGED that are very

similar to Type 9 shelters. The type 9 shelters were constructed in 2000-2008 and most of them are now used as education centres. However, three shelters are used as offices and 3 have other uses, while only 2 shelters are used as health centres. Other shelters have no normal time use.



Figure 3.2.21: Type 9 cyclone shelter (Source: CEGIS, 2009)

Type 10

This type of shelter was constructed by the Public Works Department (PWD) and funded by GoB/World Bank/PWD. A total of 214 shelters of this type were surveyed and these shelters are spread over 37 Upazilas of 9 Districts. The shelters were constructed between 1947 and 2002. Most of the shelters are used as education centres, offices and for other purposes while two shelters are used as health centres. A few have no normal time use.



Figure 3.2.22: Type 10 cyclone shelter (Source: CEGIS, 2009)

Type 11

Shelters of this design type were set up by the Facilities department and funded by Saudi Grant. A total of 446 Type 11 cyclone shelters were surveyed and these shelters are spread over 36 upazilas of 5 districts. The shelters were constructed during 1991-2000. Normally, these shelters are used as education centres and health centres. Only 1 shelter is used as mosque and 3 have no normal time use.



Figure 3.2.23: Type 11 cyclone shelter (Source: CEGIS, 2009)

Type 12

This type of shelters were constructed by LGED and funded by GoB/LGED. According to the survey there are a total of 133 type 12 shelters that are spread over 39 upazilas of 12 districts. The shelters were constructed between 1997 and 2008. Most of these shelters are used as education centres and offices, however, 5 are used for other purposes and 1 has no normal time use.



Figure 3.2.24: Type 12 cyclone shelter (Source: CEGIS, 2009)

Type 13

This design type was constructed by LGED and funded by Primary Education Development Program (PEDP II)/Asian Development Bank (ADB)/LGED/GoB. According to the survey there are 924 Type 13 cyclone shelters/buildings spread over 72 upazilas of 16 districts. The shelters were constructed during 1910-2009. Most of the shelters are used as education centres with only 5 used as offices and 9 have no normal time use.



Figure 3.2.25: Type 13 cyclone shelter (Source: CEGIS, 2009)

3.2.15 Proposed New Cyclone Shelter

On the basis of Multipurpose Cyclone Shelter Programme (BUET-BIDS 1993) there are two types of cyclone shelter proposed in this study. Figure 3.2.26 and 3.2.27 shows New Cyclone Shelter type1 (NCS1). NCS1 contain three floors, ground floor

can use as Killa for livestock. First and second floor contain eight number of rooms and four number of toilets and capacity 1750 person. Normally NCS1 can use as education center, Health center, office or community center.

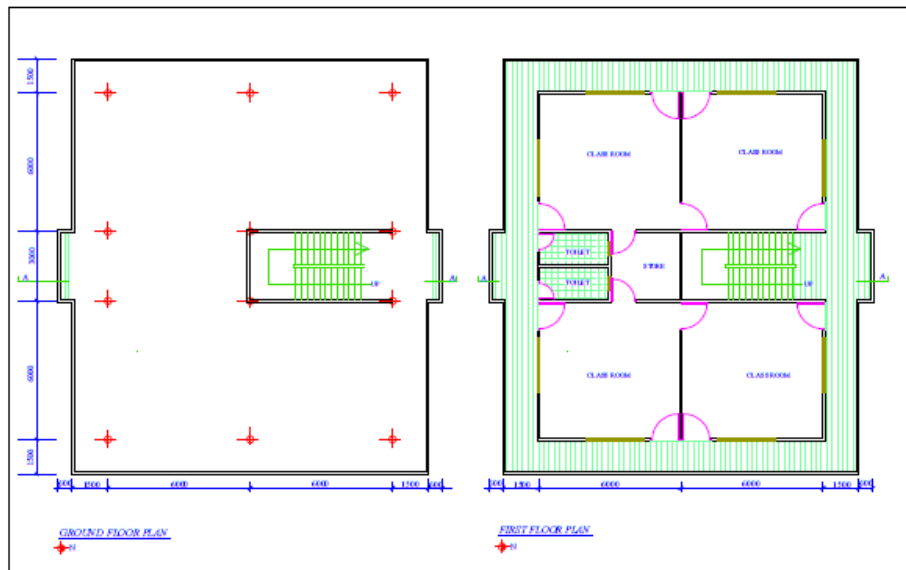


Figure 3.2.26: Floor Plan for proposed new cyclone shelter type1 (NCS1)

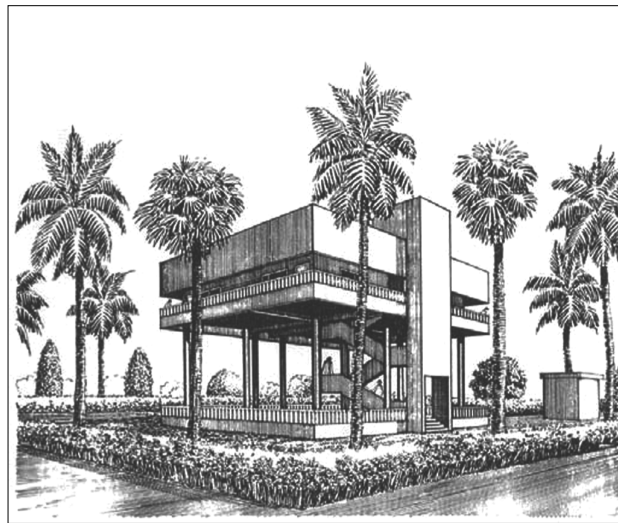


Figure 3.2.27: Perspective view of proposed new cyclone shelter type1 (NCS1)

Figure 3.2.28 and 3.2.29 shows New Cyclone Shelter type2 (NCS2). NCS2 contain three floors, ground floor can use as Killa for livestock. First and second floor contain twelve number of rooms and four number of toilets and capacity 2500 person. Normally NCS2 can use as education center, Health center, office or community center.

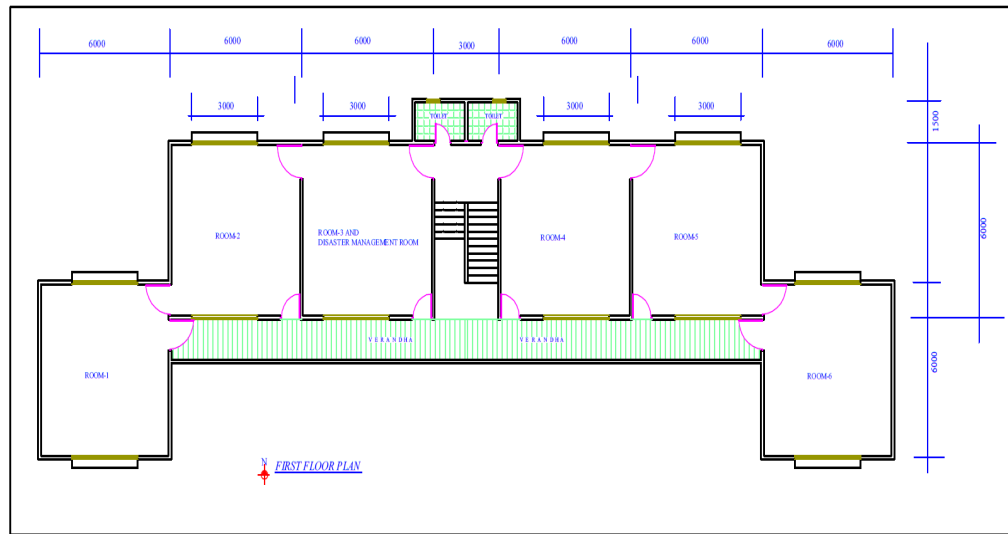


Figure 3.2.28: Floor Plan for proposed new cyclone shelter type2 (NCS2)

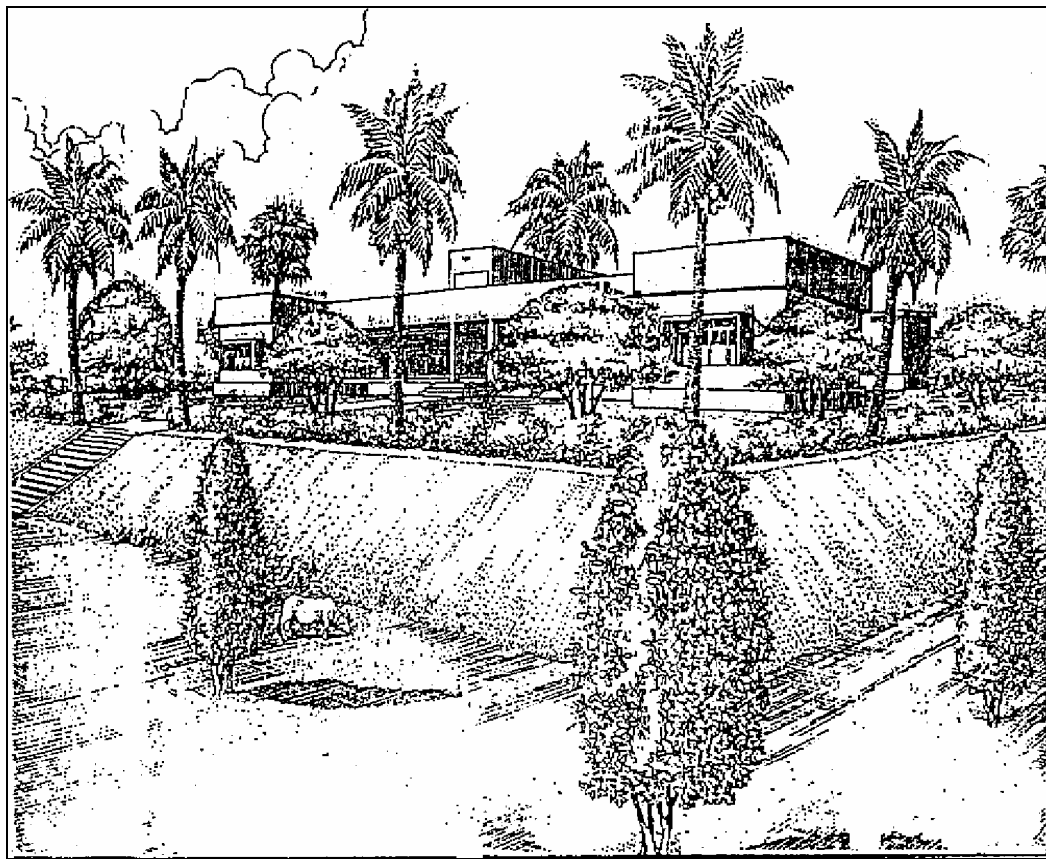


Figure 3.2.29: Perspective view of proposed new cyclone shelter type2 (NCS2)

3.3 Methodology

3.3.1 Outline of the Methodology

Based on initial literature review the methodology developed for spatial location information collection and preparation of spatial distribution maps (figure 3.2.8), data and information were first collected from relevant sources like CDMP official website, Disaster Management Bureau (DMP), LGED, Multipurpose Cyclone Shelter Programme prepared by BUET and BIDS etc. These data were used for developing a list of existing cyclone shelters and their related information. After data collection through the field survey data entry was carried out and all collected information were then stored in an MS Excel database.

Based on the information and database, Upazila-wise spatial distribution maps were prepared using a GIS tool (ArcGIS). The maps were prepared using the Bangladesh Transverse Mercator (BTM) projection. The base maps were prepared comprising roads, rivers, embankments, administrative boundaries (upazila and union), settlements and forests using the National Water Resources Database (NWRD) and recent available satellite images. Using all these information, spatial distribution maps and attributes (District, Upazila, Union, Mouza, Village, Shelter ID, Shelter Name, Shelter Condition, Design Type, Structure Type, Nos. of Floor, Capacity, Nos. of Toilet, Funded agency, Constructed agency, Water availability, Year of construction, Type of use, Vulnerability for Cyclone, Tsunami and Earthquake and Latitude, Longitude) of cyclone shelters were prepared. Based on attributes, calculate the union wise capacity for existing usable cyclone shelter.

Considering fifteen percent of the total population of a union can take refuge at existing strong wind and storm surge prove public and private building during cyclone. From MCSP report it was found that about fifteen percent or near population can take shelter at public private building during cyclone.

Based on the Population Census 2001 the projected population of 2015 and 2025 of a union were determined with the help of equations 3.2.2, 3.2.3 and 3.2.4.

After calculate the projected population study area was studied to establish the total population that needs to be accommodated in shelters during a cyclone. It would be also determined the number of cyclone shelter in a union. Considering 0.185 sq. m area need a person as shelter (BUET-BIDS, 1993).

In the study area Unions were considered as planning areas. Time and resource constraints and non-availability of information did not permit the Mouzas to be taken as planning areas. For determination of exact locations of cyclone shelters, Mouzas might be considered as the primary level.

Planning steps are summarized as follows;

- current and future population by planning unit (Union);
- inventory and condition of existing cyclone shelters,
- potentials of existing public and private buildings as shelters;
- rural settlement patterns in the planning unit;
- existing communication networks; and

The locations of new shelters were finished tentatively, at this study, on the base maps, by considering the communication networks e.g. rural roads and water-way.

3.3.2 Sitting of the Proposed New Cyclones Shelter

In selecting the tentative locations of a proposed New Cyclone Shelter, the following points were considerate in this study:

- Proposed cyclone shelters are not too close to each other or existing shelters;
- Distribution of Proposed cyclone shelters follows the settlement pattern and distribution of population of the Union;
- Proposed cyclone shelters were as close as possible to the existing communication network;
- Proposed cyclone shelters were as near as possible to the existing human habitations;
- Proposed cyclone shelters were as far away as possible, considering above factors, from the coast line;
- Proposed cyclone shelters were inside the embankment where such embankments existed.

3.3.3 Preparation of GIS maps

Maps showing the administrative boundaries, coast line, rivers and creeks, existing shellers, location of educational institutions, other important public and private buildings, road and waterway network, settlement pattern etc. are essential inputs for preparing the proposals for locating new cyclone shelters to be proposed under this study. Therefore, one of the first tasks under this study was to collect available maps and imagery from different sources.

Base maps of thanas from LGED and google image were used for preparing maps of the Thanas under study area. LGED thana base map (1:50000 scale) were available from Physical Planning and Mapping Section of LGED found quite helpful for various information like boundaries, roads, settlement, markets, growth centers etc. Using GIS tool (ArcGIS) and above information the maps were prepared using the Bangladesh Transverse Mercator (BTM) projection.

3.4 Summary

In This Chapter all the terms of cyclone and cyclone shelter related terms like coastal area, definition of cyclone, storm surge, Risk Zone (RZ) and High Risk Area (HRA), settlement pattern, demographic characteristics, definition of cyclone shelter, distribution of cyclone shelter, spatial distribution, normal time use, road access, facilities and types of existing cyclone shelter, description and figure of proposed cyclone shelter are briefly discussed. Outline of the methodology to determine the required number of cyclone shelter to accommodate all the people in study area is describe in this chapter.

Chapter 4

THE STUDY AREA

4.1 General

The coastal belt of Bangladesh is hit by cyclonic storms and associated storm surges regularly causing loss of human lives and lives and livestock and severe devastation of crops and property. The main cause of loss of lives is the storm surge and the extent of the study area is thus limited from that consideration. Cyclones and storm surges may hit the Bangladesh coast at any location (Dasgupta et al., 2010).

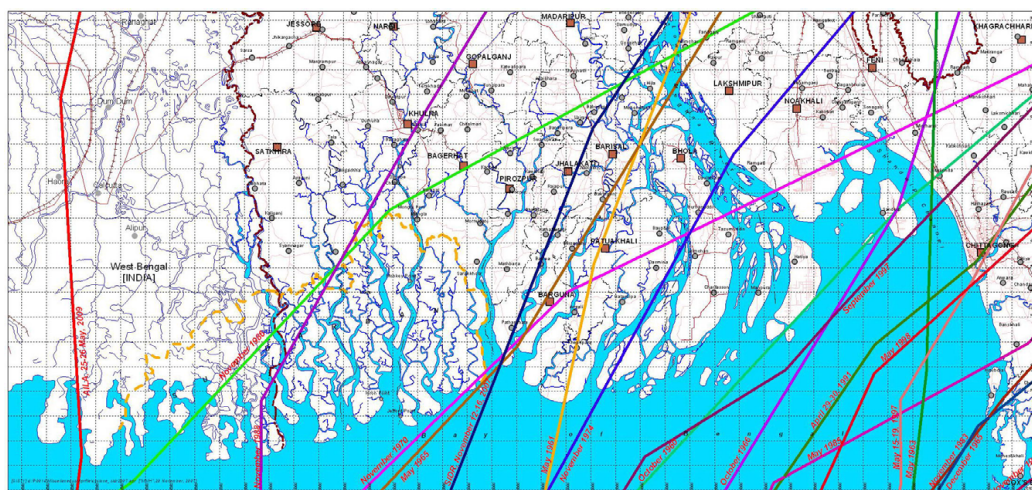


Figure 4.1.1: Tracks of major cyclones that crossed the coast of Bangladesh during the period 1960-2009 (Source: Dasgupta et al., 2010)

The main affected area of the 1970 cyclone was the coastal inlands and the Meghna estuary area; the 1988 cyclone had hit the Khulna/Satkhira belt; the 1985 cyclone affected Sandwip, Urir Char and Noakhali area while the major impact of the 1991 cyclone has been in Chittagong-Cox's Bazar zone (BUET-BIDS, 1993). And on November 15, 2007 the super cyclone Sidr roared across the south western coast of Bangladesh with driving rain and high waves affected total 30 districts. Government has classified four districts as 'worst' affected – Bagerhat, Barguna, Patuakhali and Pirojpur and eight districts as 'badly' affected – Khulna, Madaripur, Sariatpur,

Barisal, Bhola, Satkhira, Jhalakathi and Gopalganj of the total 30 affected districts (SCS, 2008).

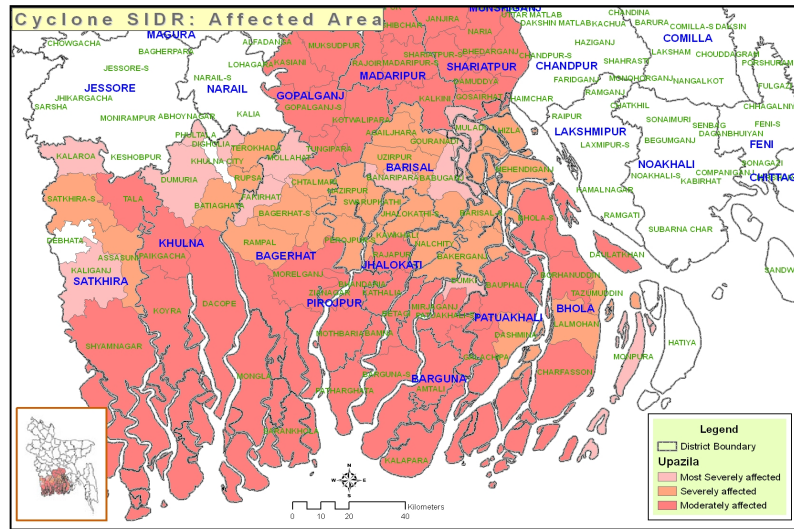


Figure 4.1.2: ‘Worst affected’ and ‘badly affected’ upazilas at 12 districts at time of SIDR (Source: SCS, 2008)

On the Basis of Cyclonic storm track and cyclone affected area Patuakhali, Noakhali and Cox,s Bazar are the most cyclone affected area. Galachipa and Kalapara upazila under Patuakhali district, Noakhali sadar and Companigang upazila under Noakhali district and Ukhia and Teknaf upazila under Cox’s Bazer district are selected as the study area in the coastal belt of Bangladesh. Most of the vulnerable cyclones hit this six upazilas and which are in High Risk Areas (HRAs) but they have inadequate cyclone shelters. Figure 4.1.3 shows the study area and figure 4.1.4 shows the cyclonic storm track with study area.

4.2 Classification of coastal zone

Considering physiographic and hydro-geo-morphological characteristics and the process by which it has been formed, the study area has been delineated in three major zones. These are: Ganges Tidal Plain, Meghna Deltaic Plain and Chittagong Coastal Plain. Brief description of the three zones and the Thanas falling within the zones (fully or partially) are given below (BUET-BIDS, 1993).

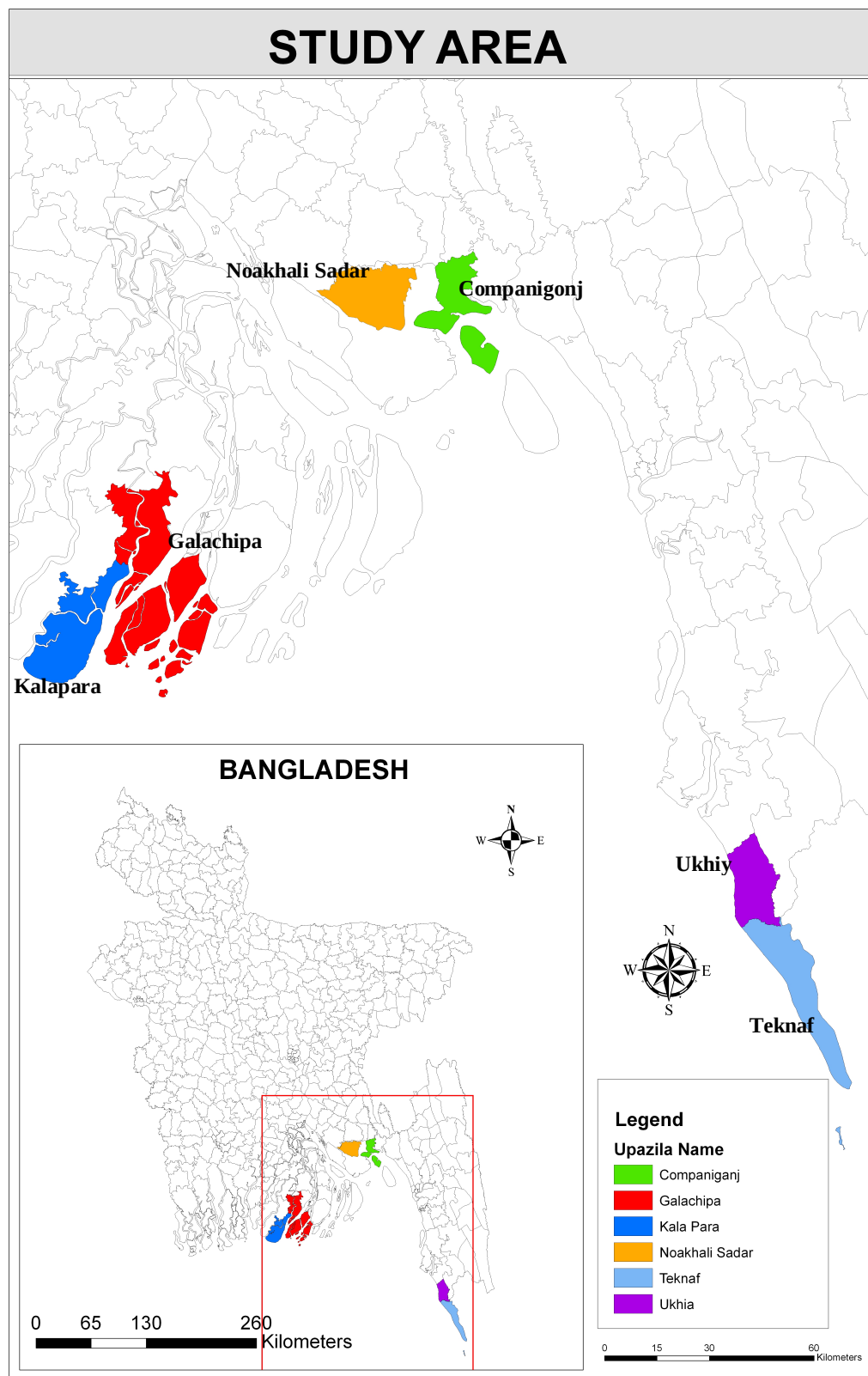


Figure 4.1.3: Selected study area of this project work

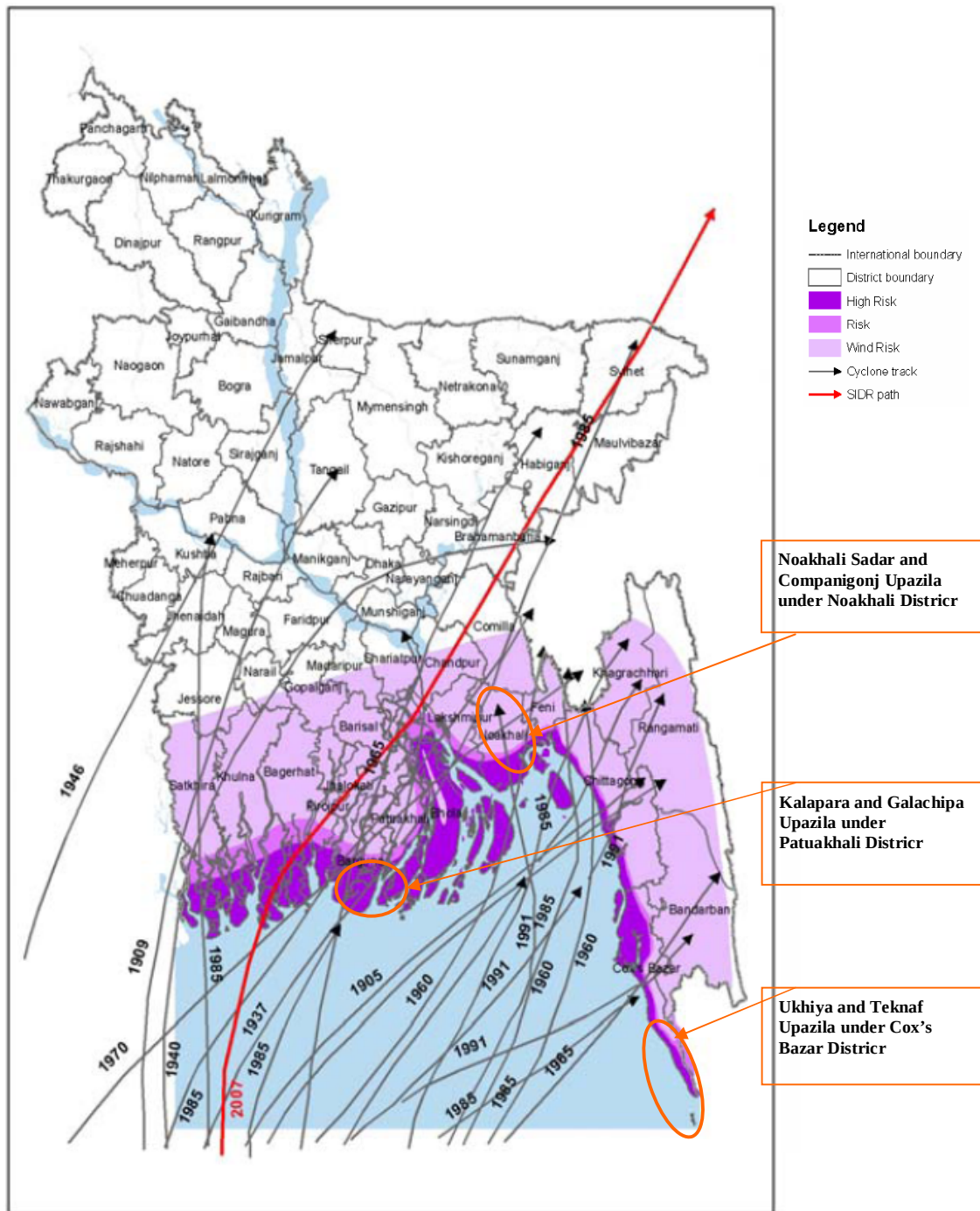


Figure 4.1.4: Cyclonic track with study area (Source: CEGIS, 2009)

Ganges Tidal Plain (West Zone)

This Zone, Located on the southwest of the coastal region, is characterized by large and interconnected network of tidal rivers and creeks, with relatively stable land mass. Rivers in the region carry relatively small quantity of sediments, and land erosion and land accretion rates are relatively low. The largest mangrove forest in the world, the Sunderbans, is located to the western part of the region. Thanas include in the zone are Dacope, Koyra, Morrelganj, Mongla, Sharankhola, Shyamnagar, Matbaria, Amtali, Barguna, Betagi, Bamna, Patharghata and Kalapara (13 Thanas) (BUET-BIDS, 1993).

Kalapara upazila under Patuakhali district is fall in this zone.

Meghna Deltaic Plain (Central Zone)

This is the deltaic region of the Ganges-Brahmaputra-Meghna rivers. The river system in the region carries massive volume of discharge and sediments into Bay of Bengal causing large scale land erosion and land accretion. Thanas include in this zone are Bakerganj, Barisal Sadar, Hizla, Mehendiganj, Bhola, Burhanuddin, Char Fasson, Daulatkhan, Lalmohan, Monpura, Tazumuddin, Bauphal, Dasmina, Galachipa, Sonagazi, Lakshmipur, Raipur, Ramgati, Companiganj, Hatiya, Sudharam (Noakhali Sadar) and Sandwip (22 Thanas) (BUET-BIDS, 1993).

Galachipa Upazila under Patuakhali district and Companigonj and Noakhali Sadar Under Noakhali District are fall in this zone.

Chittagonj Coastal Plain (East Zone)

This zone comprises of land masses along the Chittagong and Cox's Bazar coast. The coastal plain includes the Matamuhuri delta and the Karnaphuli estuary. This zone is formed by the narrow strip of land between the coastline and the hills on the east. Thanas included in the area are Mirsarai, Sitakunda, Pahartali and Bandar, Anwara, Chandanaish, Banskali, Patiya, Chakaria, Cox's Bazar, Kutubdia, Maheshkhali, Ramu, Teknaf and Ukhia (14 Thanas) (BUET-BIDS, 1993).

Teknaf and Ukhia Upazila Under Cox's Bazar district are fall in this zone.

Figure 4.2.1: shows the major three coastal zones.

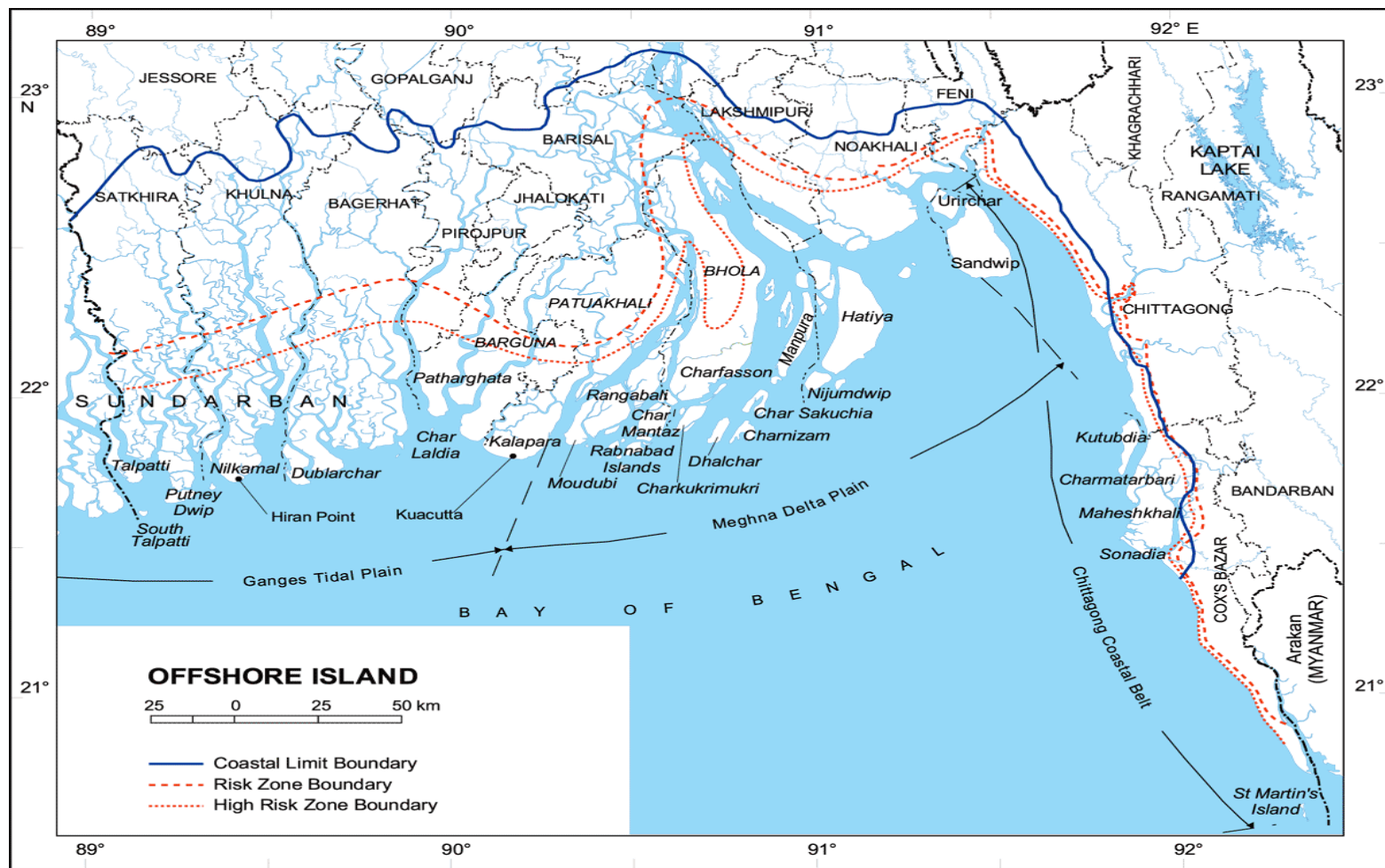


Figure 4.2.1: Three Major Coastal zone (Source: Banglapedia, 2006)

4.3 Tropical Cyclones, Storm Surges and Inundation risk

Cyclonic storm surge forms in the deep sea. The surge is in part due to pressure drop and in part due to blowing wind. It moves towards the coast as a long wave. It may be pointed out that a tidal bore is a phenomenon completely different from a cyclonic storm surge. A bore is a moving wave front with almost phenomenon completely different from a cyclonic storm surge. A bore is a moving wave front with almost vertical wall of water. If the bore is the result of tidal action then it is termed as a tidal bore. Tidal bore forms when a tide with large range approaches a region of very shallow depth. Tidal bores, locally known as ‘baan’ occur in shallow parts at the entrance of the Meghna Delta during spring tides. Table 4.3.1 shows the inundated area under study upazila and figure 4.3.1 shows inundation risk map.

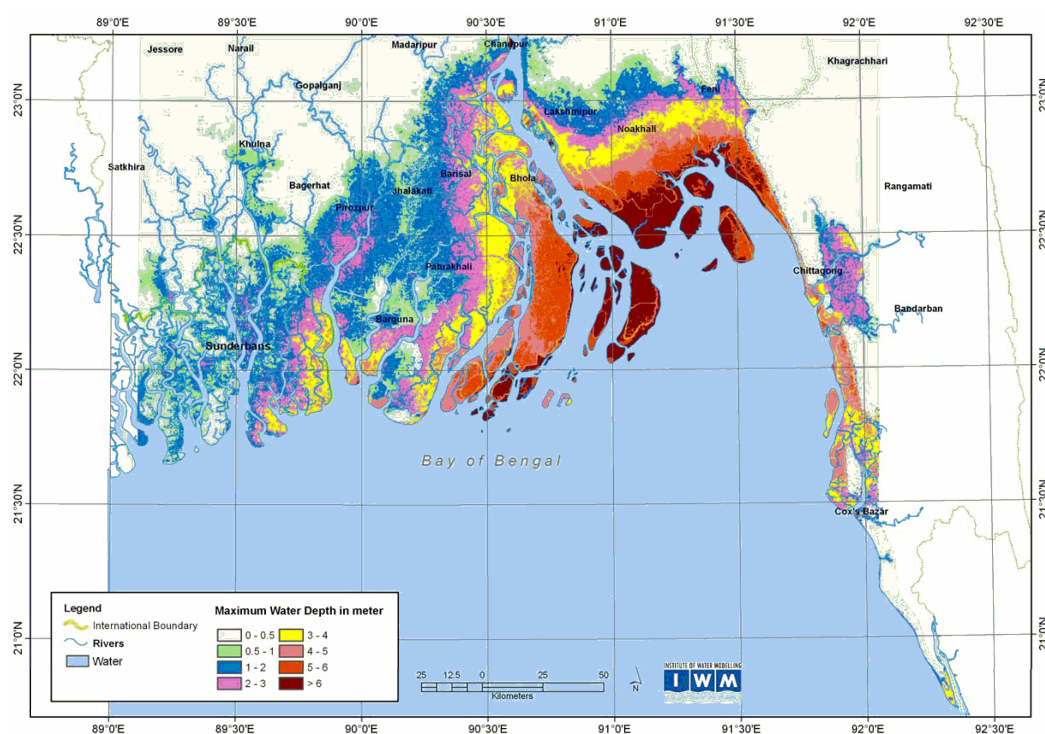


Figure 4.3.1: Inundation risk map generated from 18 cyclones from 1960-2007 to prepare useable Tsunami and storm surge inundation risk (Source: IWM, 2009)

The unions under the study area in High Risk Area (HRA) are shows in table 4.3.2.

Table 4.3.1: Inundated area under study upazila

Sl No.	Name of Upazila	Area (excluding river)	Inundation							
			d*≤1m		1m>d*≤3m		3m>d*≤6m		d*>6m	
			Area	%	Area	%	Area	%	Area	%
1	Galachipa	79580	264	0	17588	22	53044	67	8684	11
2	Kalapara	42672	10292	24	16316	38	15928	37	136	0
3	Noakhali Sadar	91800	4	0	4080	4	63980	70	23736	26
4	Companiganj	28564	0	0	216	1	16384	57	11964	42
5	Cox's Bazar Sadar	11564	4260	37	5284	46	1988	17	32	0

d* is the depth of inundation, all area are in ha.

Source: IWM, 2009

Table 4.3.2: List of Unions in the HRA and RZ

Sl. No.	Name of Thana	Unions in HRA		Union in RZ but outside HRA
		Most severely affected areas	Severely affected areas	
1	Teknaf	Baharachhara and sabrang (including St. Martin's isand)	Teknaf Union (western part) and Nhila Union (south)	Nhila Union (north)
2	Ukhiya	-	Jalia Palong and Palong Khali	-
3	Companigonj	Char Fakira (Particularly Char Elahi, Char Lengta, Kachchhapia & Gangchil Mouzas), Musapur (Particularly Daksin and Madhya Muspur (Village) Rampur (Dakshin Rampur) Unions.	Char Fakira (North), Musapur (North), Char Hazari, Char Parbati and Char Kakra Unions.	-
4	Noakhali Sadar (Sudharam)	Char Bata (particularly Char Bata, CHar Majid, Hazipur, Madhya Char Bata Mouzas/villages). Char Clerk, Char Jabbar (particularly East and ZSouth sides) Unions.	Chaprashirhat (Char Mandolia Mouzas-portion Outside the embankment). Sundalpur (Jagadananda Mouza) Union and Ghoshbag (Algi and Sondia Mouzas) Union.	Char Jabbar (N.W side), Chaprashir hat (Mura Amirabad).
5	Galachipa	Rangabali, Bara Baisdia, Chhoto Baisdia, Char Kajal, Panpatty Unions.	Golkhali, Ratandi Taltali, Galachipa Unions, Bakulbaria (east) Union.	Dakua, Chiknikkandi and Bakubaria (west Union)
6	Kalapara	Latachapli, Khaprabhanga Union Lemupara, Char Ershat, Char Habib, Char Bailatali, Bara Bailatali, Sonapara Mouzas of Mithaganj Union and Lalua Union.	Dhankhali, Mithaganj (remaining part) and Nilganj Unions, Tiakhali and Chakamaiya Unions).	-

Source: MCSP (BUET-BIDS, 1993).

4.4 Population in Study area

According to the population census 2001 population statistics of the study area are as follows

Table 4.4.1: Upazila-wise Population and Annual Growth rate on the basis of census 2001

District	Upazila	Area (sq km)	Population	Growth Rate (Annual)
Patuakhali	Kalapara	483.08	202078	1.45
	Galachapa	1267.89	325235	1.28
Noakhali	Noakhali Sadar	335.62	407449	1.65
	Companiganj	305.33	214652	1.59
Cox's Bazar	Ukhia	261.80	155187	2.48
	Teknaf	388.68	200607	2.78

Source: Population census 2001, Community series.

Upazila wise population projection tables are furnished in Annex-(B).

4.5 Cyclone Shelter in Study area

There are 336 number of cyclone shelter in study area (Kalapara and Galachipa upazila under Patuakhali district, Noakhali sadar and Companiganj upazila under Noakhali district and Ukhiya and Teknaf under Cox's Bazar district). Among these 82% (274) are usable and 18% (62) are not usable. A summary of the distribution of cyclone shelters based on their conditions is presented in the following table.

Table 4.5.1: Distribution of cyclone shelter based on their condition

Total cyclone shelter in study area	336
Unusable cyclone shelter	62
Usable cyclone shelter	274

Figure 4.5.1, 4.5.2, 4.5.2, 4.5.4, 4.5.5 and 4.5.6 shows the existing cyclone shelter of kalapara, Galachipa, Noakhali Sadar, Companigonj, Ukhiya and Teknaf upazila respectively.

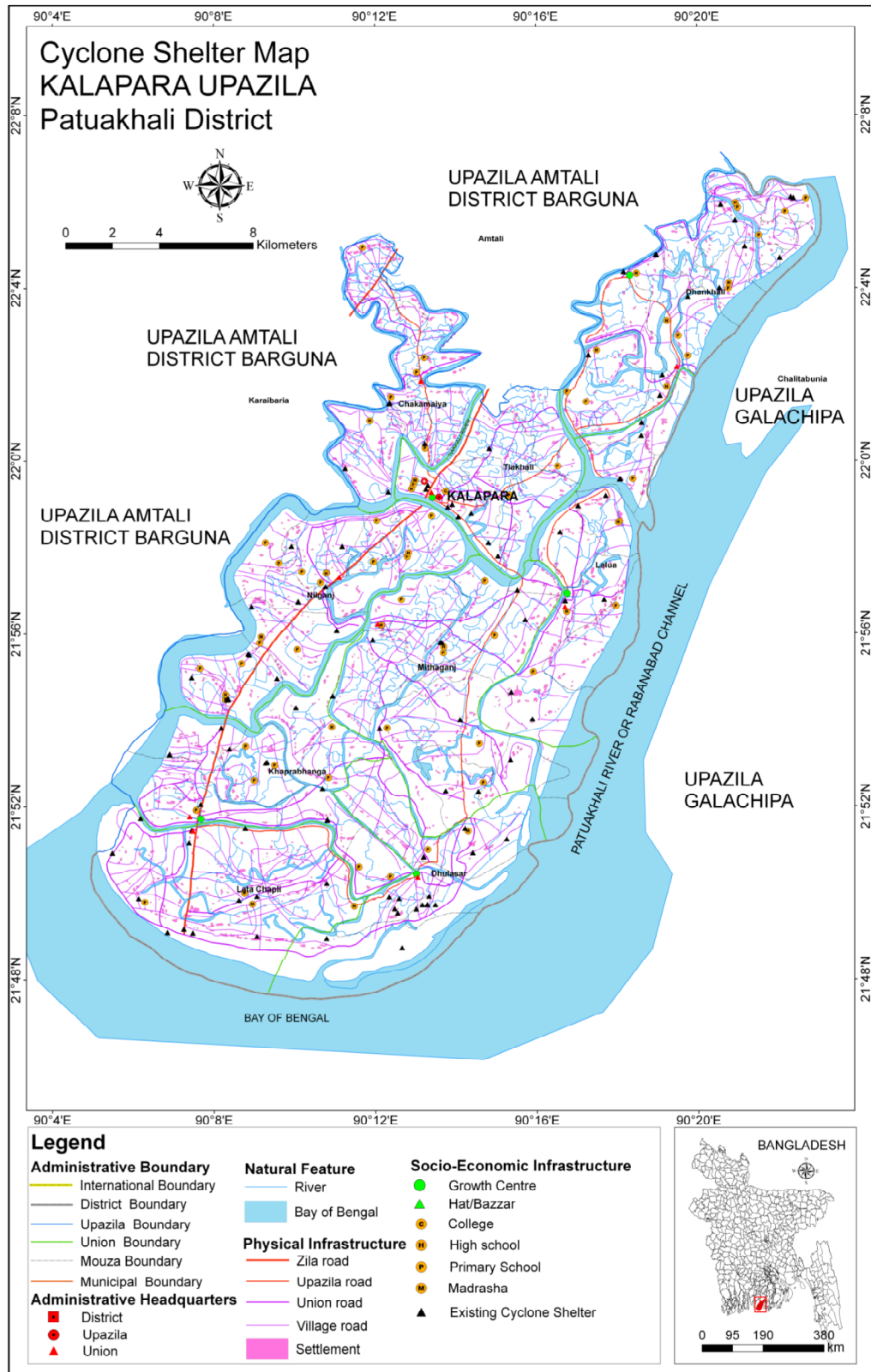


Figure 4.5.1: Existing Cyclone Shelter map of Kalapara upazila

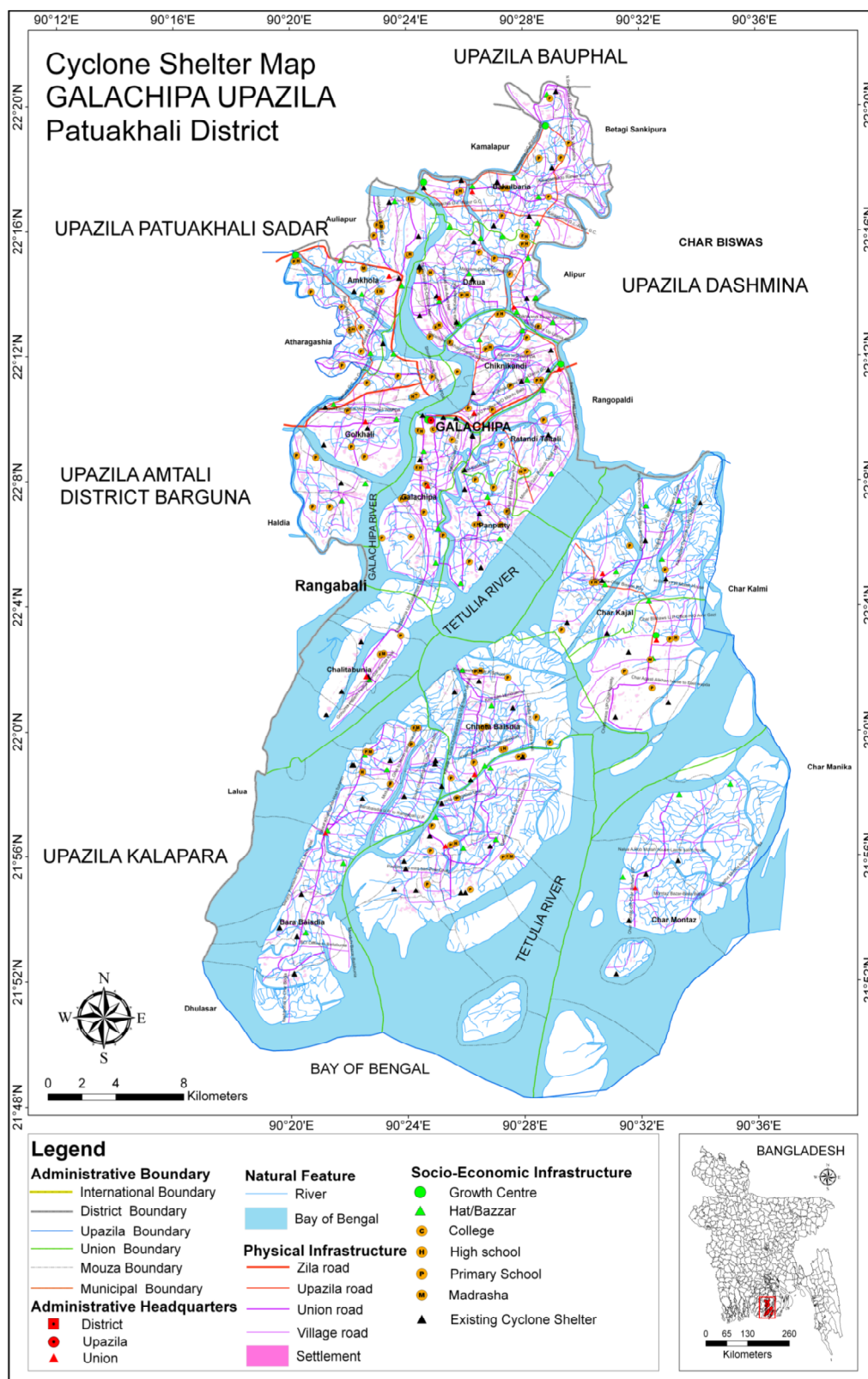


Figure 4.5.2: Existing Cyclone Shelter map of Galachipa upazila

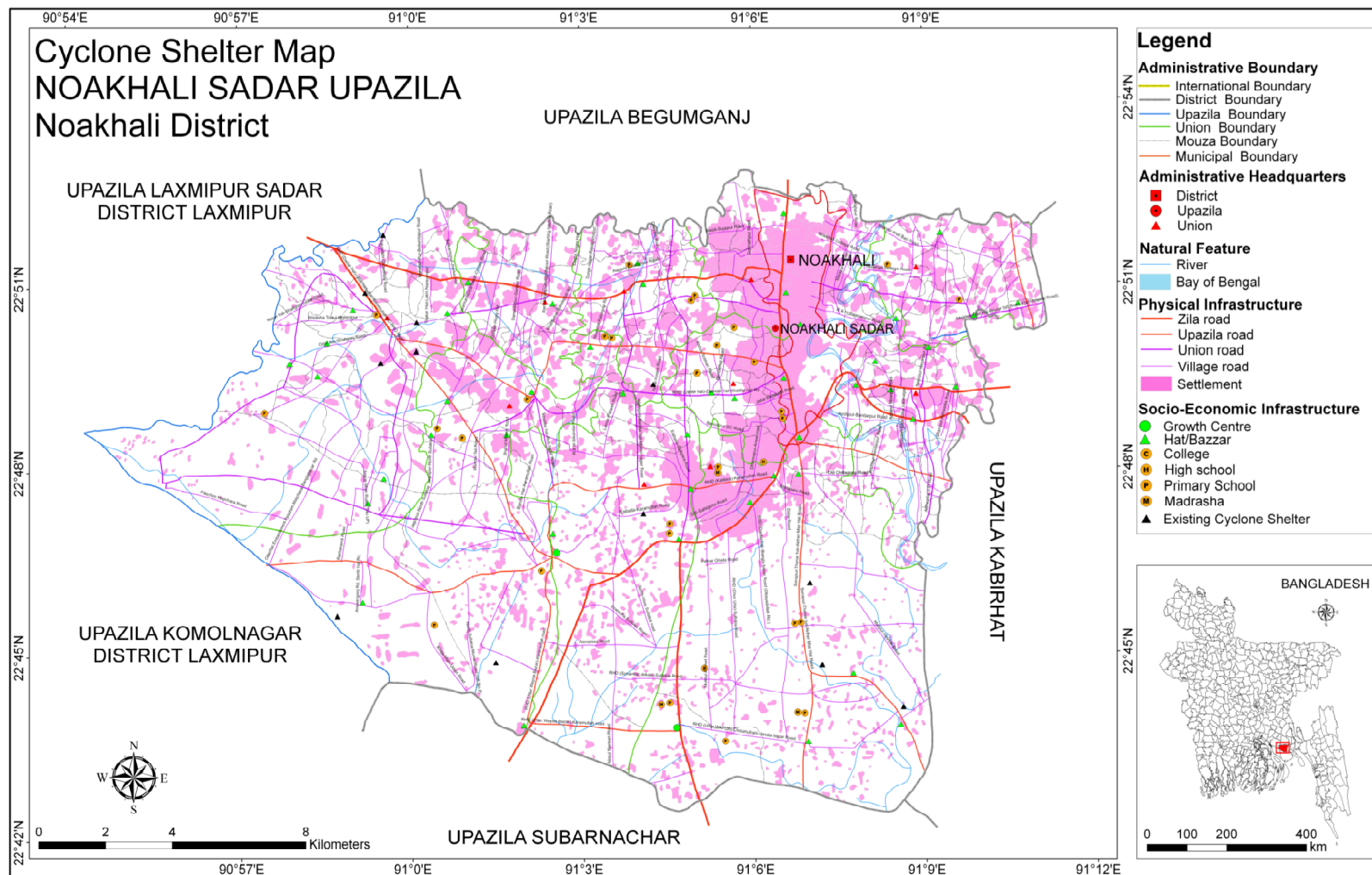


Figure 4.5.3: Existing Cyclone Shelter map of Noakhali Sadar upazila

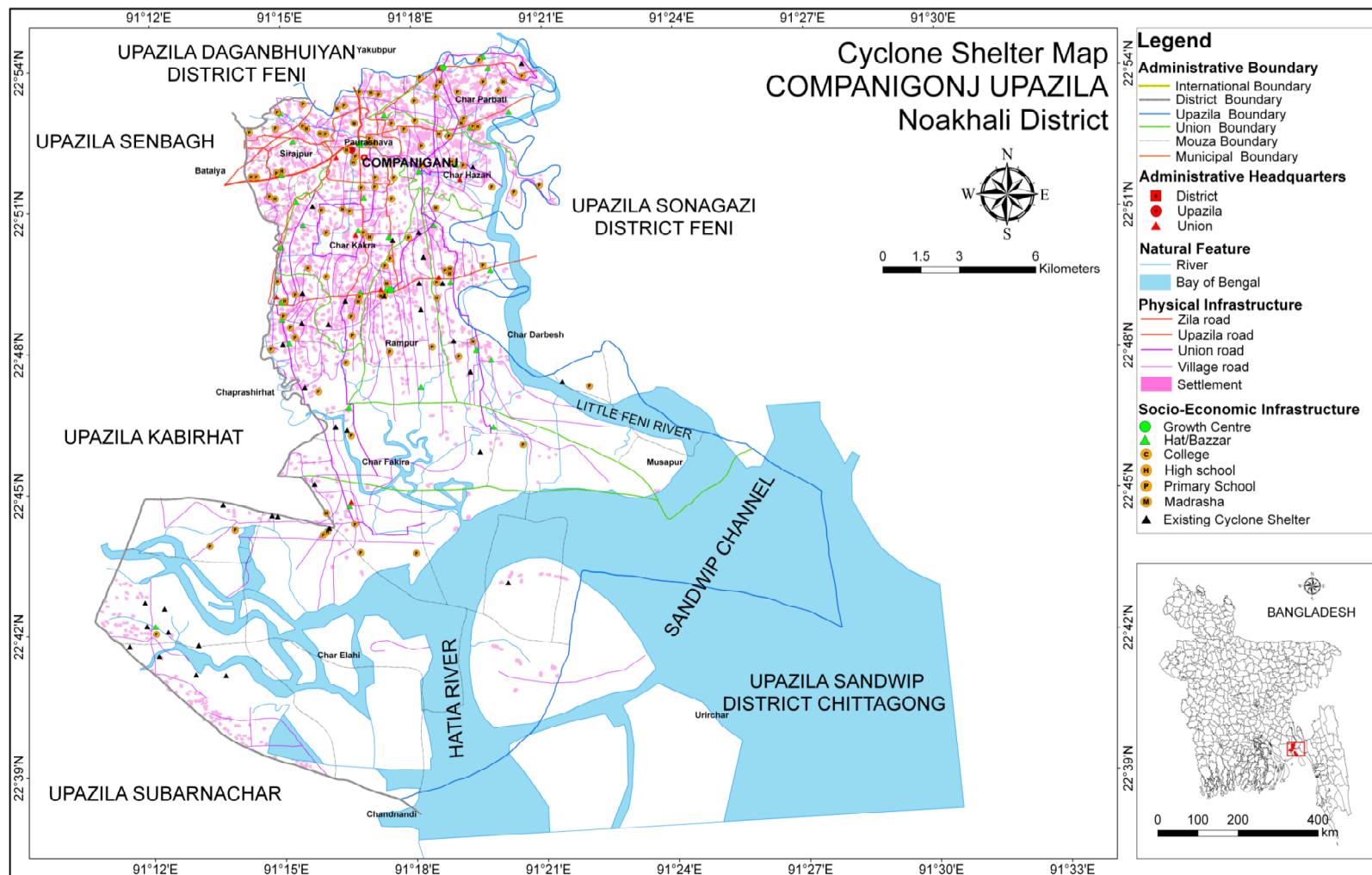


Figure 4.5.4: Existing Cyclone Shelter map of Companigonj upazila

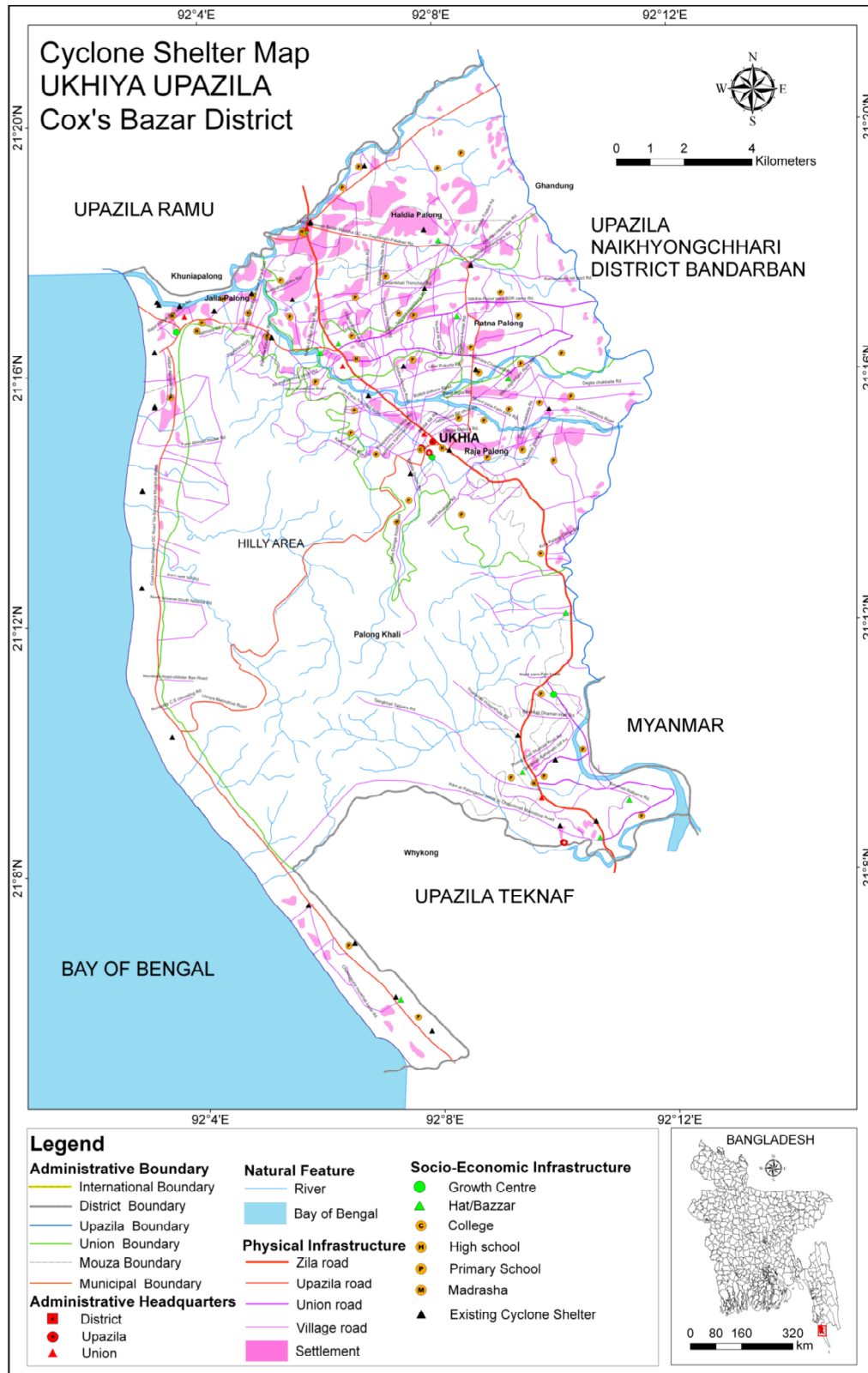


Figure 4.5.5: Existing Cyclone Shelter map of Ukhiya upazila

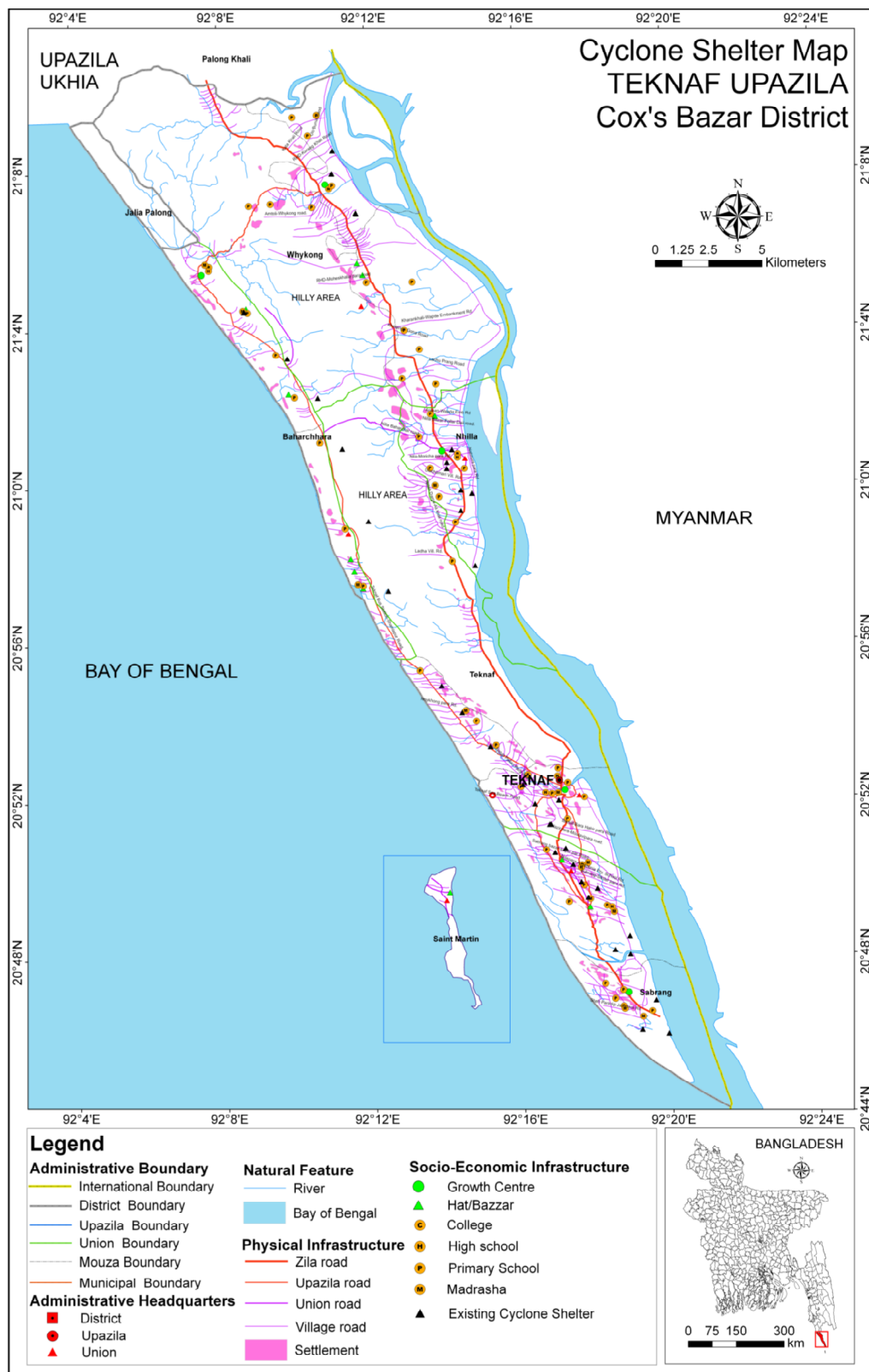


Figure 4.5.6: Existing Cyclone Shelter map of Teknaf upazila

The total area of study area (six upazila) is 2576 sq km. The number of population in this area is 1505208 in 2001 (according to population census), 1796100 in 2011 (projected) 1922996 in 2015 (projected) and 2310481 in 2025 (projected). There are 274 numbers of usable cyclone shelters in this area with their capacity to serve 286039 nos. of people, which is only 15.93% of total study area population in 2011. A upazila wise summary of existing cyclone shelter along with population data is presented in table 4.5.2.

Figure 4.5.7 shows the upazila wise distribution of usable cyclone shelter. From figure it is clear that Kalapara and Galachipa upazila under Patuakhali district have the highest and Noakhali Sadar and Companigonj upazila under Noakhali district and Ukhiya and Teknaf upazila under Cox's Bazar district have the lowest number of cyclone shelter.

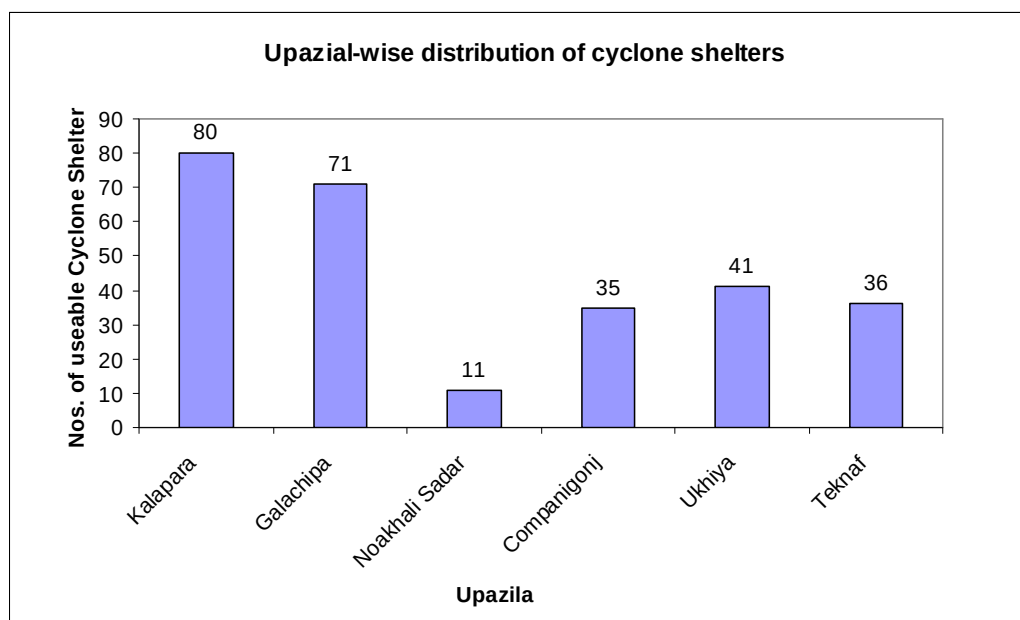


Figure 4.5.7: Upazila wise distribution of cyclone shelter

The figures and tables of union wise distribution of usable cyclone shelters are furnished in Annex-(A) and Annex-(B) respectively.

Table 4.5.2: Upazila wise summary of Cyclone Shelter

District	Upazila/ Thana	Area in Sq Km	Population (Nos.)			Total Cyclone Shelter (Nos.)	Unusable Cyclone Shelter (Nos.)	Usable Cyclone Shelter		Percentage of population can take shelter in 2011
			2001 (Census)	2011 (Projected)	2025 (Projected)			Nos.	Capacity nos. of person	
Patuakhali	Kalapara	476	202078	233366	285472	110	30	80	73975	31.7
	Galachipa	884	325235	369346	441332	99	28	71	66425	17.98
Noakhali	N. Sadar	336	407449	479896	603461	12	1	11	11845	2.47
	Comanigonj	257	214652	251331	313443	38	3	35	34943	13.9
Cox's Bazar	Ukhiya	253	155187	198265	279379	36	0	36	47081	23.75
	Teknaf	371	200607	263896	387394	41	0	41	51770	19.62
Total =		2576	1505208	1796100	2310481	336	62	274	286039	15.93

Cyclone shelters are constructed for multipurpose use. It was found from cyclone shelter information database that among 274 nos. of usable shelter 76% was used as education centres, 4% as offices, 1% as community centres, 1% as health centres and 14% do not have any normal time use. A summary of the use of cyclone shelters during normal time is presented in figure 4.5.8.

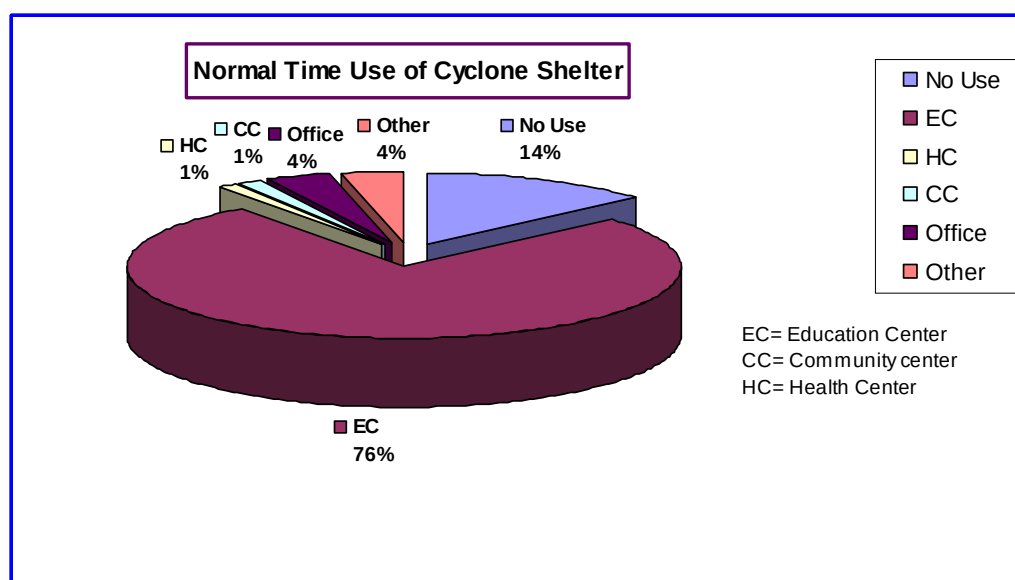


Figure 4.5.8: Normal time use of cyclone shelter

The figures of upazila wise normal time use of cyclone shelters are furnished in Annex-(A)

4.6 Summary

The chapter describes the study area of this study. Kalapara and Galachipa upazila under Patuakhali district, Noakhali Sadar and Companigonj under Noakhali district, Ukhiya and Teknaf upazila under Cox's Bazar district are taken as study area. There are 336 numbers of cyclone shelters were found in the study area. In this chapter also describe the major three zones of the coastal area, demographic information in the study area, existing cyclone shelters information and maps, inundation risk map and other related terms of the study area.

Chapter 5

RESULTS AND DISCUSSIONS

5.1 General

Cyclone shelters are capable of resisting the extreme winds during cyclone with floors raised above the maximum surge levels is necessary for protecting about 1.2 million people immediately who live in the study area in the coastal regions of Bangladesh.

5.2 Results

5.2.1 Kalapara Upazila

With the area of 475.70 square kilometer Kalapara upazila consists of nine unions and one pourashava. The projected population of Kalapara upazila is 2.47 lac in 2015 and 2.85 lac in 2025. Table 5.2.1 shows the union wise calculation for the need of additional cyclone shelters in Kalapara upazila. The union wise results are as follows.

Kalapara Paurashava

The area of Kalapara Paurashava is 3.75 sq-km. This Paurashava is a densely populated area. The population of this paurashava was 16256 in 2001; projected population is 19886 in 2015 and 22962 in 2025. During cyclone, a maximum of 4468 people can take shelter out of 19886 which is really a poor figure. Thus another 15253 people have to accommodate in the newly built cyclone shelter in 2015 and 17870 in 2025. The number of additional new cyclone shelter required in 2015 is seven, four are type1 and three are type2 and in 2025 one more cyclone shelter (type1) is required. According to the settlement pattern and road networks, the tentative locations of proposed new cyclone shelters have been chosen. Due linear type settlement the locations of new shelters are proposed on the river bank or road side.

Chakamaiya Union

The area of Chakamaiya Union is 34.38 sq-km. Chakamaiya union is outside of high risk areas (HRA) where inundation risk less than 1 (one) meter. So no more cyclone shelters are proposed in Chakamaiya union.

Khaprabhanga Union

There are large numbers of interconnected river network in Khaprabhanga union. The total area of this union is 52.73 sq-km and the projected population is 32166 in 2015 and 37147 in 2025. In these circumstances, 15180 numbers of people can take refuge during cyclone in 11 usable cyclone shelters and other public and private buildings. So another 16716 numbers of people are out of the shelter coverage in 2015 and unless new cyclone shelter are constructed there will 20950 numbers of people be out of shelter coverage in 2025. Seven numbers of cyclone shelters are proposed for 2015 and after that, two more cyclone shelters are proposed for 2025. Due to linear settlement pattern locations of new shelters are proposed on the river bank and road side.

Dhulasar Union

Dhulasar union is the most vulnerable area of Kalapara upazila. The area of Dhulasar union is 45.08 sq-km and the projected population is 18593 in 2015 and 21472 in 2025. During cyclone only 10358 people can take shelter in 8 different usable cyclone shelters and other public and private buildings. In 2015 there are 8079 numbers of people are under the vulnerability of cyclone and storm surges and this number will be 10526 in 2025. Three cyclone shelters are proposed for 2015 and after that, two more cyclone shelters are proposed for 2025 to overcome cyclone vulnerability. The settlement pattern of Dhulasar union is mixed. The locations of proposed cyclone shelters have been allocated on the basis of existing settlement pattern and road network.

Lalua Union

The area of Lalua Union is 52.19 sq-km. The projected population of the union is 22434 in 2015 and 25907 in 2025. The existing capacity in 11 usable cyclone shelters and other public and private buildings is 12827. Thus the capacity needs to be increased is 9419 in 2015 and 12371 in 2025. To fulfill the requirements four numbers of cyclone shelters are proposed for 2015, after that two more numbers of shelters are proposed for 2025. From Google map it found that the settlement pattern of Lalua Union is linear type and lies along the river bank and road side. According to settlement pattern the locations of new shelters have been chosen on the river bank and road side.

Lata Chapli Union

Lata Chapli union is also one of the most vulnerable area of Kalapara upazila and exposed to the Bay of Bangle. The total area of this union is 57.2 sq-km and the projected population is 33034 in 2015 and 38148 in 2025. There are large numbers of interconnected river in Lata Chapli union. During cyclone 13928 people can take refuge in 9 usable cyclone shelters and other public and private building. To protect all the people of Lata Chapli union from cyclonic storm and surges 18829 number of additional shelter places required for 2015 and 23176 by the year 2025. In this circumstance eight cyclone shelters are proposed for 2015 and after that, three more cyclone shelters are proposed for 2025. The settlement pattern of Lata Chapli union is mixed. The locations of proposed cyclone shelters have to be allocated on the basis of existing settlement pattern, road network, avoiding agricultural field and wet land.

Dhankhali Union

There are large numbers of interconnected river network in Dhankhali union. The total area of Dhankhali union is 59.30 sq-km. To protect the people of Dhankhali union from cyclone vulnerability 13195 numbers of additional shelter places required in 2015 and 16852 in 2025. Six numbers of cyclone shelters are proposed for 2015 and after that, two more numbers of cyclone shelters are proposed for 2025. The

settlement pattern of Dhankhali union is linear so the locations of new shelters have to be fixed on the river bank and road side.

Mithaganj Union

Mithaganj is the biggest union under Kalapara upazila. The total area of Mithaganj union is 74.85 sq-km and projected population is 29315 in 2015 and 33854 in 2025. The existing safe shelter places in this union are 10951 and needs to increase the places to protect people from cyclone vulnerability is 18118 for 2015 and 21976 for 2025. There are eight numbers of new cyclone shelters are proposed for 2015 and after that, more two numbers of cyclone shelters are proposed for 2025. There are large numbers of rivers in Mithaganj union. Due to linear settlement pattern the locations of proposed shelters have been chosen on the river or road side.

Nilganj Union

The projected population of Nilganj union is found 31259 in 2015 and 36099 in 2025. The total area is 63.33 sq-km. The capacity of existing shelter is 14927 and needs additional capacity 16070 for 2015 and 20184 for 2025. Six numbers of cyclone shelters proposed in this union in 2015 and additional two numbers of cyclone shelters are proposed within 2025. Due to linear settlement pattern the locations of proposed shelter has been chosen on the river or road side.

Tiakhali Union

The capacity of existing shelters is 6835 in five usable cyclone shelters and other public and privet building. Required additional capacity of safe shelter in Tiakhali union is 7592 at 2015 and 9506 at 2025. There are three numbers of cyclone shelters have proposed at 2015 and additional one shelter have proposed at the period of 2025. Select the locations of proposed shelter on the river or road side due to linear settlement pattern.

Figure 5.2.1 shows the cyclone shelter planning map up to the period of 2025 and table B13 shows the detail information and locations of all proposed cyclone shelter in Kalapara upazila.

5.2.2 Galachipa Upazila

Galachipa upazila is under the coastal zone of Meghna Deltaic Plain (Central Zone). Galachipa upazila combines mostly nucleated and linear patterns. The total area of Galachipa upazila is 884.30 square kilometer. Galachipa upazila consist of sixteen unions and one pourashava. The projected population of Galachipa upazila is 3.88 lac in 2015 and 4.41 lac in 2025. Table 5.2.2 shows the union wise calculation for need for additional cyclone shelter in Galachipa upazila. The union wise results are as follows.

Galachipa Paurasava

The area of Galachipa paurasava is 3.40 sq-km and projected population is 20759 at 2015 and 23573 at 2025. Galachipa paurasava is the densely populated area. The existing capacity of shelter is 2960 and required additional capacity which is use as shelter places during cyclone is 17645 in 2015 and 20036 in 2025. There are eight numbers of cyclone shelters are proposed to protect the people from cyclone, storm surges and also tsunami. According to the settlement pattern select the locations of proposed cyclone shelter.

Amkhola Union

There are large numbers of interconnected river network in Amkhola union. The total area of Amkhola Union is 47.24 sq-km. To protect the people of Amkhola Union from cyclone vulnerability there are 23698 numbers of additional shelter place required in 2015 and 27573 in 2025. Ten numbers of cyclone shelters are proposed for 2015 and after that additional two numbers of cyclone shelter will propose for 2025. The settlement pattern of Amkhola union is linear so the locations of new shelters are proposed on the bank of river and road side.

Bakulbaria Union

The total area of Bakulbaria union is 51.77 sq-km and the projected population is 33250 in 2015 and 37760 in 2025. During cyclone 7665 numbers of people can take refuge in 4 numbers of usable cyclone shelters and other public and private building. To protect all the people of Bakulbaria union from cyclonic storm and surges 25337 numbers of additional shelter place required in 2015 and 29171 in 2025. In this situation 10 (ten) numbers of cyclone shelters are proposed for 2015 and after that more 2 (two) numbers of cyclone shelter will proposed for 2025. The settlement pattern of Bakulbaria union is mixed. The locations of proposed cyclone shelters are fixing on the basis of existing settlement pattern, road network and avoid agricultural field and wet land.

Bara Baisdia Union

Bara Baisdia union is a newly formed char area. The total area is 96.47 sq-km and projected population 27628 in 2015 and 31376 in 2025. The existing safe shelter places in this union are 10439 and required additional capacity to protect people in this union from cyclone vulnerability is 16984 for 2015 and 20170 for 2025. Seven numbers of new cyclone shelters are proposed for 2015 and after that more two numbers of cyclone shelters are proposed for 2025. Settlement pattern of Bara Baisdia union is mixed type scattered and linear. On the basis of settlement pattern select the locations of proposed cyclone shelter.

Chalitabunia Union

Chalitabunia union is a 27.35 sq-km char area. Existing shelter capacity of this union is 5331 and required additional capacity 3068 in 2025. One cyclone shelter is proposed to protect the people of Chalitabunia union.

Char Montaz Union

Char Montaz union is a newly formed char area. The area of Char Montaz union is 56.65 sq-km and projected population is 17859 in 2015 and 20281 in 2025. During

cyclone 2546 numbers of people can take refuge in public and private building. The union has no cyclone shelter. To protect the people of Char Montaz union from cyclonic storm and surges 15180 numbers of additional shelter place required in 2015 and 17239 in 2025. In this situation six numbers of cyclone shelters are proposed for 2015 and after that more one numbers of cyclone shelter will proposed for 2025. The settlement pattern of Char Montaz union is scattered. The locations of proposed cyclone shelters are fixing on the basis of existing settlement pattern, road network and avoid agricultural field and wet land.

Char Biswas Union

Char Biswas union is a 38.07 sq-km newly formed char area. The projected population is 20441 in 2015 and 23214 in 2025. Existing safe shelter capacity during cyclone is 2914. The union has no cyclone shelter. To protect the people of Char Biswas union from surges 17375 numbers of additional shelter place required in 2015 and 19732 in 2025. Seven numbers of cyclone shelters are proposed for 2015 and after that more one number of cyclone shelter will proposed for 2025. The settlement pattern of Char Biswas union is scattered. The locations of proposed cyclone shelters are fixing on the side of rural road.

Char Kajal Union

Char Kajal union is a 38.07 sq-km newly formed char area. There are five numbers of usable cyclone shelters in this union with capacity 5100. Six numbers of new cyclone shelters are proposed to construct in 2015 and after that more two numbers of cyclone shelters will propose to construct within 2025. In these eight numbers of cyclone shelters there are 19534 numbers of people can be sheltered.

Chhota Baisdia Union

Chhota Baisdia union also a char area. There are nine numbers of usable cyclone shelters in this union with capacity 10825. Three numbers of new cyclone shelters are proposed to construct in 2015 and after that more one cyclone shelter will proposed to

construct within 2025. In these four numbers of cyclone shelters there are 19534 numbers of people can be sheltered. Due to scattered settlement pattern the locations of proposed shelter may be on the rural road side.

Chiknikandi Union

There are a numbers of interconnected river network in Chiknikandi union. The total area of Chiknikandi union is 49.32 sq-km. To protect the people of Chiknikandi union from cyclone vulnerability there are 16159 numbers of additional shelter place are required in 2025. Six numbers of cyclone shelters are proposed for 2015 and after that additional one number of cyclone shelter will propose for 2025. The settlement pattern of Chiknikandi union is linear so the locations of new shelters are proposed on the bank of river and road side.

Dakua Union

There are also a numbers of interconnected river network in Dakua union. The total area of Dakua union is 32.44 sq-km. To accommodate all the people of Dakua union there are 17515 numbers of additional shelter places are required in 2025. Six numbers of cyclone shelters are proposed for 2015 and after that additional one number of cyclone shelter will propose for 2025. The settlement pattern of Dakua union is linear so the locations of new shelters are proposed on the bank of river and road side.

Galachipa Union

In Galachipa union there are 11195 numbers of people should be accommodate in cyclone shelters during cyclone. To accommodate all the people there are four numbers of cyclone shelters are proposed in 2015 after that more one cyclone shelter is proposed for 2025.

Gazalia Union

In Gazalia union there are 12046 numbers of people should be accommodate in cyclone shelters during cyclone. To accommodate all the people there are four numbers of cyclone shelters are proposed in 2011 after that more one cyclone shelter is proposed for 2025.

Golkhali Union

The capacity of existing shelters is 8864 in four numbers of usable cyclone shelters and other public and privet building. Required additional capacity of safe shelter in Golkhali union is 26392 at 2015 and 30486 at 2025. There are ten numbers of cyclone shelters have proposed at 2015 and additional two shelters have proposed at the period of 2025. The locations of proposed shelter has been chosen on the river or road side due to linear settlement pattern.

Panpatty Union

Panpatty union is a 29.08 sq-km char area. There are three numbers of usable cyclone shelters in this union with capacity 3100. Six numbers of new cyclone shelters are proposed to construct in 2015 and after that more one cyclone shelter will proposed to construct within 2025. In these seven numbers of cyclone shelters there are 16781 numbers of people can be sheltered. Due to scattered settlement pattern the locations of proposed shelter has been chosen on the rural road side.

Rangabali Union

Rangabali union is a 108.06 sq-km biggest char area in Galachipa upazila. There are eleven numbers of usable cyclone shelters in this union with capacity 8050. Seven numbers of new cyclone shelters are proposed to construct in 2015 and after that additional one cyclone shelter will proposed to construct within 2025. In these eight numbers of cyclone shelters there are 20745 numbers of people can be sheltered. Due

to scattered settlement pattern the locations of proposed shelter has been chosen on the rural road side.

Ratandi Taltali Union

The capacity of existing shelters is 4403 in two numbers of usable cyclone shelters and other public and private building. Required additional capacity of safe shelter in Ratandi Taltali union is 15636 at 2015 and 17963 at 2025. There are six numbers of cyclone shelters have proposed at 2015 and additional one shelter have proposed at the period of 2025. Select the locations of proposed shelter on the river or road side due to linear settlement pattern.

Figure 5.2.2 shows the cyclone shelter planning map up to the period of 2025 and table B14 shows the detail information and locations of all proposed cyclone shelter in Galachipa upazila.

5.2.3 Noakhali Sadar Upazila

335.62 square kilometer Noakhali Sadar upazila consist of ten unions and one pourashava. The projected population of Noakhali Sadar upazila is 4.79 lac in 2011 and 6.03 lac in 2025. Table 5.2.3 shows the union wise calculation for need for additional cyclone shelter in Noakhali Sadar upazila. The union wise results are as follows.

Noakhali Paurashava

The area of Noakhali paurasava is 15.88 sq-km and projected population is 95514 at 2015 and 112496 at 2025. Population density of Noakhali paurasava is very high. The existing capacity of public and private building is 13419 and required additional capacity which is use as shelter places during cyclone is 81187 in 2015 and 95621 in 2025. There are thirty nine numbers of cyclone shelters are proposed to protect all the people from cyclone, storm surges and also tsunami. According to the settlement pattern and road networks select the locations of proposed cyclone shelter.

Ashwadia Union

In Ashwadia union there are 35179 numbers of people should be accommodate in cyclone shelters during cyclone. To accommodate all the people there are twelve numbers of cyclone shelters are proposed in 2015 after that, two more numbers of cyclone shelters is proposed for 2025.

Binodpur Union

The capacity of existing shelters is 4959 in two numbers of usable cyclone shelters and other public and private building. Required additional capacity of safe shelter in Binodpur union is 18372 at 2015 and 21932 at 2025. There are eight numbers of cyclone shelters have proposed at 2015 and additional two shelters have proposed at the period of 2025. The location of proposed shelters has been chosen on the river or road side due to linear settlement pattern.

Char Matua Union

Char Matua union is a 91.98 sq-km biggest area in Noakhali Sadar upazila. There are three numbers of usable cyclone shelters in this union with capacity 3450. Twenty seven numbers of new cyclone shelters are proposed to construct in 2015 and after that additional five numbers of cyclone shelters will proposed to construct within 2025. In these thirty two numbers of cyclone shelters there are 80606 numbers of people can be sheltered. Due to scattered settlement pattern the locations of proposed shelter may be on the rural road side.

Dadpur Union

The total area of Dadpur union is 13.85 sq-km and the projected population is 26937 in 2015 and 31726 in 2025. During cyclone 3785 numbers of people can take refuge in public and private building. To protect all the people of Dadpur union from cyclonic storm and surges 22896 numbers of shelter place required in 2015 and 26967 in 2025. In this situation ten numbers of cyclone shelters are proposed for 2015 and

after that more two numbers of cyclone shelter will proposed for 2025. The settlement pattern of Dadpur union is linear. The locations of proposed cyclone shelters are fixing on the basis of existing settlement pattern, road network and avoid agricultural field and wet land.

Ewazbalia Union

The area of Ewazbalia union is 29.35 sq-km. Fifteen numbers of new cyclone shelters are proposed to construct in 2015 and after that additional three numbers of cyclone shelters will proposed to construct within 2025. In these eighteen numbers of cyclone shelters there are 44304 numbers of people can be sheltered. The settlement pattern of Ewazbalia union is mixed. The locations of proposed cyclone shelters are fixing on the basis of existing settlement pattern, road network and avoid agricultural field and wet land.

Kadir Hanif Union

Kadir Hanif union is a densely populated area. In Kadir Hanif union there are 31050 numbers of people should be accommodate in cyclone shelters during cyclone. To accommodate all the people there are eleven numbers of cyclone shelters are proposed in 2015 after that more two numbers of cyclone shelters is proposed for 2025. Select the locations of proposed shelter on the river or road side due to linear settlement pattern.

Kaladaraf Union

The area of Kaladaraf Union is 47.86 sq-km. The projected population of this union is 37160 in 2015 and 43767 in 2025. The existing capacity in two numbers of usable cyclone shelters and other public and private building is 7846. The required additional capacity of cyclone shelters is 28960 in 2015 and 34577 in 2025. To fulfill the requirements there are twelve numbers of cyclone shelters are proposed for 2015, after that more two numbers of shelters are proposed for 2025. From Google image it

found that the settlement pattern of Kaladaraf union is mixed type. According to settlement pattern choose the locations of new shelters are on the river or road side.

Niazpur Union

Niazpur union is a densely populated area. In Niazpur union there are 32832 numbers of people should be accommodate in cyclone shelters during cyclone. To accommodate all the people there are twelve numbers of cyclone shelters are proposed in 2015 after that more two numbers of cyclone shelters is proposed for 2025. Select the locations of proposed shelter on the river or road side due to linear settlement pattern.

Noakhali Union

The total area of Noakhali union is 61.61 sq-km and the projected population is 69167 in 2015 and 81465 in 2025. During cyclone 13838 numbers of people can take refuge in four numbers of usable cyclone shelters and other public and private building. To protect all the people of Noakhali union from cyclonic storm and surges 54672 numbers of additional shelter places required in 2015 and 65125 in 2025. In this situation twenty two numbers of cyclone shelters are proposed for 2015 and after that more four numbers of cyclone shelter will proposed for 2025. The settlement pattern of Noakhali union is both linear and scattered. The locations of proposed cyclone shelters are fixing on the basis of existing settlement pattern.

Noannai Union

The total area of Noannai union is 15.52 sq-km and the projected population is 32866 in 2015 and 38709 in 2025. During cyclone 4617 numbers of people can take refuge in public and private building. To protect all the people of Noannai union from cyclonic storm and surges 27936 numbers of additional shelter places required in 2015 and 32903 in 2025. In this situation twelve numbers of cyclone shelters are proposed for 2015 and after that more two numbers of cyclone shelter will proposed for 2025. The settlement pattern of Noannai union is both linear and scattered. The

locations of proposed cyclone shelters are fixing on the basis of existing settlement pattern.

Figure 5.2.3 shows the cyclone shelter planning map up to the period of 2025 and table B15 shows the detail information and locations of all proposed cyclone shelter in Noakhali Sadar upazila.

5.2.4 Companigonj Upazila

Companigonj upazila is under the coastal zone of Meghna Deltaic Plain (Central Zone). The human settlement pattern in this Zone is mostly of scattered type because of existence of a high proportion of char lands- both settled and newly formed. The area of Companigonj upazila is 256.81 square kilometer. Companigonj upazila consist of eight unions and one pourashava. The projected population of Companigonj upazila is 2.68 lac in 2015 and 3.13 lac in 2025. Table 5.2.4 shows the union wise calculation for need for additional cyclone shelter in Companigonj upazila. The union wise results are as follows.

Basurhat Paurashava

The area of Basurhat paurasava is 6.50 sq-km and projected population is 26310 at 2015 and 30806 at 2025. Basurhat paurasava is a densely populated area. The existing capacity of public and private building is 3706 and required additional capacity which is use as shelter places during cyclone is 22363 in 2015 and 26186 in 2025. There are eleven numbers of cyclone shelters are proposed to protect all the people from cyclone, storm surges and also tsunami. According to the settlement pattern and road networks select the locations of proposed cyclone shelter.

Char Elahi Union

Char Elahi union is a 70.68 sq-km biggest newly formed char area in Companigonj upazila. There are thirteen numbers of usable cyclone shelters in this union with capacity 13593. Four numbers of new cyclone shelters are proposed to construct

In 2015 and after that more two numbers cyclone shelters will propose to construct within 2025. In these six numbers of cyclone shelters there are 14110 numbers of people can be sheltered.

Char Fakira Union

Char Fakira union is a 33.05 sq-km char area. The projected population of Char Fakira union is 27996 in 2015 and 32779 in 2025. During cyclone 10743 numbers of people can take refuge in eight numbers of usable cyclone shelter and other public and private building. To protect the people of Char Fakira union from cyclonic storm and surges 16997 numbers of additional shelter places required in 2015 and 21062 in 2025. In this situation seven numbers of cyclone shelters are proposed for 2015 and after that more two numbers of cyclone shelter will propose for 2025. The settlement pattern of Char Fakira union is scattered. The locations of proposed cyclone shelters are fixing on the basis of existing settlement pattern, road network and avoid agricultural field and wet land.

Char Hazari Union

Char Hazari union is a 15.42 sq-km char area. The projected population is 27519 in 2015 and 32222 in 2025. Existing safe shelter capacity during cyclone is 4825. To protect the people of Char Hazari union from surges 22441 numbers of additional shelter place required in 2015 and 26439 in 2025. Nine numbers of cyclone shelters are proposed for 2015 and after that more two numbers of cyclone shelter will propose for 2025. The settlement pattern of Char Hazari union is scattered. The locations of proposed cyclone shelters are fixing on the side of rural road.

Char Kakra Union

In Char Kakra union there are 41326 numbers of people should be accommodate in cyclone shelters during cyclone. To accommodate all the people there are fourteen numbers of cyclone shelters are proposed in 2015 after that more three numbers of

cyclone shelters is proposed for 2025. The locations of proposed shelter has been chosen on the river or road side due to linear settlement pattern.

Char Parbati Union

The area of Char Parbati union is 16.28 sq-km. Eleven numbers of new cyclone shelters are proposed to construct in 2015 and after that additional two numbers of cyclone shelters will proposed to construct within 2025. In these thirteen numbers of cyclone shelters there are 31514 numbers of people can be sheltered. The settlement pattern of Char Parbati union is mixed. The locations of proposed cyclone shelters are fixing on the basis of existing settlement pattern, road network, avoiding agricultural field and wet land.

Musapur Union

In Musapur union there are 19104 numbers of people should be accommodate in cyclone shelters during cyclone. To accommodate all the people there are six numbers of cyclone shelters are proposed in 2015 after that two more numbers of cyclone shelters is proposed for 2025.

Rampur Union

The total area of Rampur union is 18.90 sq-km and the projected population is 22589 in 2015 and 26449 in 2025. During cyclone 6981 numbers of people can take refuge in four numbers of usable cyclone shelters and other public and private building. To protect all the people of Rampur union from cyclonic storm and surges 15401 numbers of additional shelter places required in 2015 and 18682 in 2025. In this situation six numbers of cyclone shelters are proposed for 2015 and after that more two numbers of cyclone shelter will propose for 2025. The settlement pattern of Rampur union is both linear and scattered. The locations of proposed cyclone shelters have been chosen on the basis of existing settlement pattern.

Sirajpur Union

In Sirajpur union there are 33062 numbers of people should be accommodate in cyclone shelters during cyclone. To accommodate all the people there are twelve numbers of cyclone shelters are proposed in 2015 after that more one number of cyclone shelter is proposed for 2025.

Figure 5.2.4 shows the cyclone shelter planning map up to the period of 2025 and table B16 shows the detail information and locations of all proposed cyclone shelter in Companigonj upazila.

5.2.5 Ukhiya Upazila

Ukhiya upazila is under the coastal zone of Chittagonj Coastal Plain (East zone). This zone comprises of land masses along the Chittagong and Cox's Bazar coast. Human settlement patterns are both linear and scattered/nucleated forming along the sides of the roads, highways and foot hills, and along the banks of rivers and canals in the region. The area of Ukhiya upazila is 252.66 square kilometer. Ukhiya upazila consist of five unions. The projected population of Ukhiya upazila is 1.38 lac in 2011 and 2.79 lac in 2025. Table 5.2.5 shows the union wise calculation for need for additional cyclone shelter in Ukhiya upazila. The union wise results are as follows.

Haldia Palong Union

The area of Haldia Palong union is 35.27 sq-km. Haldia Palong union is outside of high risk areas (HRA) where inundation risk less than 1 (one) meter. So no more cyclone shelters are proposed in Haldia Palong union.

Jalia Palong Union

Jalia Palong union is the most cyclone and tsunami vulnerable area of Ukhiya upazila. The area of Jalia Palong union is 22.04 sq-km. There are existing eighteen numbers of usable cyclone shelters and other public and private building with total capacity 29815. To protect all the people of Jalia Palong union from cyclonic storm surges and tsunami there are 29341 numbers of shelter places are required. To fulfill the requirements there are seven numbers of new cyclone shelters are proposed in 2015 and after that additional five cyclone shelters required within the period of 2025. The settlement pattern of Jalia Palong union is linear so new shelters are proposed on the road side in map.

Raja Palong Union

The area of Raja Palong union is 39.34 sq-km. Raja Palong union is outside of high risk areas (HRA) where inundation risk less than 1 (one) meter. So no more cyclone shelters are proposed in Raja Palong union.

Ratna Palong Union

The area of Ratna Palong union is 20.67 sq-km. Ratna Palong union is outside of high risk areas (HRA) where inundation risk less than 1 (one) meter. So no more cyclone shelters are proposed in Ratna Palong union.

Palong Khali Union

Palong Khali union is located on the middle part of Ukhiya upazila and fully hilly area. To protect the people of Palong Khali union nine numbers of cyclone shelters proposed in 2015 and additional three numbers of cyclone shelters are proposed within the period of 2025.

Figure 5.2.5 shows the cyclone shelter planning map up to the period of 2025 and table B17 shows the detail information and locations of all proposed cyclone shelter in Ukhiya upazila.

5.2.6 Teknaf Upazila

Teknaf upazila is under the coastal zone of Chittagonj Coastal Plain (East zone). This zone comprises of land masses along the Chittagong and Cox's Bazar coast. Human settlement patterns are both linear and scattered/nucleated forming along the sides of the roads, highways and foot hills, and along the banks of rivers and canals in the region. The area of Teknaf upazila is 371.37 square kilometer. Teknaf upazila consist of six unions and one paurashava. The projected population of Teknaf upazila is 2.94 lac in 2015 and 3.87 lac in 2025. Table 5.2.6 shows the union wise calculation for need for additional cyclone shelter in Teknaf upazila. The union wise results are as follows.

Teknaf Paurashava

The area of Teknaf paurashava is 4.04 sq-km. There are existing one number of usable cyclone shelter and other public and private building with total capacity 5286. To protect all the people of Teknaf paurashava from cyclonic storm surges and tsunami there are 27017 numbers of additional shelter places are required. To fulfill the requirements there are eight numbers of new cyclone shelters are proposed in 2015 and after that additional three cyclone shelters required within the period of 2025. The settlement pattern of Teknaf paurashava is linear so new shelters are proposed on the road side in map.

Baharchhara Union

Baharchhara Union is the most cyclone and tsunami vulnerable area of Teknaf upazila. The area of Baharchhara union is 15.31 sq-km. There are existing eight numbers of usable cyclone shelters and other public and private building with total capacity 13759. To protect all the people of Baharchhara union from cyclonic storm surges and tsunami there are 22432 numbers of additional shelter places are required. To fulfill the requirements there are six numbers of new cyclone shelters are proposed in 2015 and after that additional three cyclone shelters required within the period of 2025. The settlement pattern of Baharchhara union is linear so new shelters are proposed on the road side in map.

Nhilla Union

Nhilla union situated on the west bank of the Naf river and east side of Teknaf hilly area. There are existing seven numbers of usable cyclone shelters and other public and private building with total capacity of 18504. To protect all the people of Nhilla union from cyclonic storm surges and tsunami there are 51189 numbers of shelter places are required. To fulfill the requirements there are fifteen numbers of new cyclone shelters are proposed in 2015 and after that additional six cyclone shelters required within the period of 2025. The settlement pattern of Nhilla union is linear so new shelters are proposed on the road side in map.

St. Martin Dwip

St. Martin Dwip is the separate island from mainland of Teknaf upazila. It is an important tourism place in Bangladesh. St. Martin Dwip is one of the most cyclone and tsunami vulnerable areas. To protect the people of St. Martin Dwip and also tourist there are two numbers of cyclone shelters are proposed.

Sabrang Union

Sabrang union is vulnerable for cyclone and tsunami. There are existing ten numbers of usable cyclone shelters and other public and private building with total capacity 20928. To protect all the people of Sabrang union from cyclonic storm surges and tsunami there are 64597 numbers of shelter places are required. To fulfill the requirements, nineteen numbers of new cyclone shelters are proposed for 2015 and after that, additional eight cyclone shelters required within 2025. The settlement pattern of Sabrang union is linear so the new shelters are proposed on the road side in map.

Teknaf Union

Most of the areas of Teknaf union are hilly. The area of Teknaf union is 106.16 sq-km. There are eight numbers of existing cyclone shelters with capacity 10375. Thirteen numbers of cyclone shelters are proposed to protect all the people for 2015 and additional six numbers of cyclone shelters are proposed within 2025. Proposed cyclone shelters have to be allocated on the foothill or road side due to linear settlement pattern.

Whykong Union

Whykong union mainly a hilly area in Teknaf upazila. The area of Whykong union is 112.75 sq-km. There are five numbers of existing cyclone shelters with capacity 4225. There are eighteen numbers of cyclone shelters are proposed to protect all the people in 2015 and additional seven numbers of cyclone shelters are proposed within 2025. The settlement pattern of Whykong union is linear type and lies along the foothill or road side therefore the proposed cyclone shelter have to be allocated on the foothill or road side.

Figure 5.2.6 shows the cyclone shelter planning map up to the period of 2025 and table B18 shows the detail information and locations of all proposed cyclone shelter in Ukhiya upazila.

Table 5.2.7 and table 5.2.8 showed that the probable distribution of population in various types of shelter and required additional numbers of cyclone shelters in 2015 and 2025 respectively. The results showed that among 19,22,996 nos. of people (in 2015 projected) only 5,55,458 nos. could take shelter at existing cyclone shelter and other public and private building during cyclone and 13,48,508 nos. of people need to accommodate safe shelter by the year of 2015. In order to protect those people total 549 nos. of cyclone shelter need to construction in first phase considering 40 numbers of type1 shelter (NCS1) with capacity 1,750 person and 509 nos. of type 2 shelter (NCS2) with capacity 2,500 person. The results also showed that more 148 numbers of cyclone shelter should be constructed in second phase within the year 2025 considering 49 numbers of type1 shelter (NCS1) with capacity 1,750 person and 99 numbers of type2 shelter (NCS2) with capacity 2,500 person. The locations of the proposed cyclone shelter were chosen based on population density, settlement pattern, inundation risk etc. spatially to river and road side which have been showed in the proposed GIS map.

5.3 A Comparison of the finding of the this study with that of MCSP

In 1993 Multipurpose Cyclone Shelter Programme (MCSP) was prepared by BUET and BIDS proposed the following number of cyclone shelter in six upazila which is used as the study area in this project work.

Table 5.3.1: Number of proposed cyclone shelter in MCSP report

Sl. No	Upazila	Total Number of MCSP shelter proposed for the year of 2017
01	Kalapara	85
02	Galachipa	93
03	Noakhali Sadar (Sudharam)	66
04	Companigonj	16
05	Ukhiya	26
05	Teknaf	17

Source: MCSP (BUET-BIDS, 1993)

In this project work the calculated cyclone shelters are as follows

Table 5.3.2: Proposed Cyclone Shelter within the period of 2025

Sl. No	Upazila	Total Number of shelters proposed by this study for the year 2025
01	Kalapara	76
02	Galachipa	127
03	Noakhali Sadar (Sudharam)	206
04	Companigonj	96
05	Ukhiya	114
05	Teknaf	78

The MCSP report was prepared in 1993 after the Bhola cyclone in 1991. After 18 years the coastal population has increased at an alarming rate and simultaneously the frequency of cyclonic storm has also increased. Thus coastal people need more shelters to protect themselves from cyclonic storm surges and tsunami.

5.4 Summary

This chapter describes the result of the study. It was found that 697 number of cyclone shelters should be constructed within the year 2025. In the first phase around 500 cyclone shelters should be constructed immediately. The cyclone shelter maps of six study upazila are presented in this chapter.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Analysis of the capacities of existing cyclone shelters and other public and private buildings capable of providing shelter reveals that only about one-third of the total population may be sheltered in these facilities. In order to protect the remaining two-thirds of the vulnerable population, immediate steps must be taken for the constructions of new cyclone shelter. The major findings of this study are stated as follows:

1. In 2011 there are 274 numbers of usable cyclone shelter could be accommodated only 15.93% of the total people in study area. 15 % of the total people can take shelter in existing public and private building. So most of the people in the study area are living under risk from cyclones and storm surges.
2. 549 numbers of new cyclone shelters are proposed by the year of 2015 in which 40 numbers are of type1 with capacity 1750 person and 509 numbers are of type2 with capacity 2500 number of persons.
3. After 2015, 148 numbers of new cyclone shelters are proposed by the year of 2025 in which 49 numbers are of type1 with capacity 1750 person and 99 numbers are of type2 with capacity 2500 number of persons.
4. The locations of proposed cyclone shelter in 2015 and 2025 are shown in cyclone shelter maps which can provide the information about spatial and temporal variations of existing and proposed new cyclone shelter.

The study of the locational plan for future construction of cyclone shelters in the selected study area based on the population density and land use. When any government or non-government organization will construct a new shelter, this study can be used as a model for them to locate a shelter position.

6.2 Recommendations

The recommendations from this study can be summarized as follows:

1. Most of these cyclone shelters would be used as educational institutions in normal time, has been recommended in this study. A small quantity of proposed cyclone shelter could be used as health centre, community centre, office or other uses.
2. Cyclone shelter information (maps, attributes etc.) are very useful for the stakeholders. These needs to be disseminated. This information should be made available both in map and database format at district and upazila level.
3. Regarding the unusable cyclone shelters, a study is needed to assess the possibility and methods to make the shelters usable again.
4. To protect the livestock (bovine and ovine) an initiative should be taken for the construction of cyclone shelters on killas.
5. Improve the accuracy and timing of cyclone warnings by adopting a system of sequenced warnings: first, that a cyclone may strike, secondly, that a change to the waning has occurred as more information about the cyclone is gathered and thirdly, emergency actions to take if the cyclone is near to the area and may strike soon.

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APPENDIX-(A): FIGURES

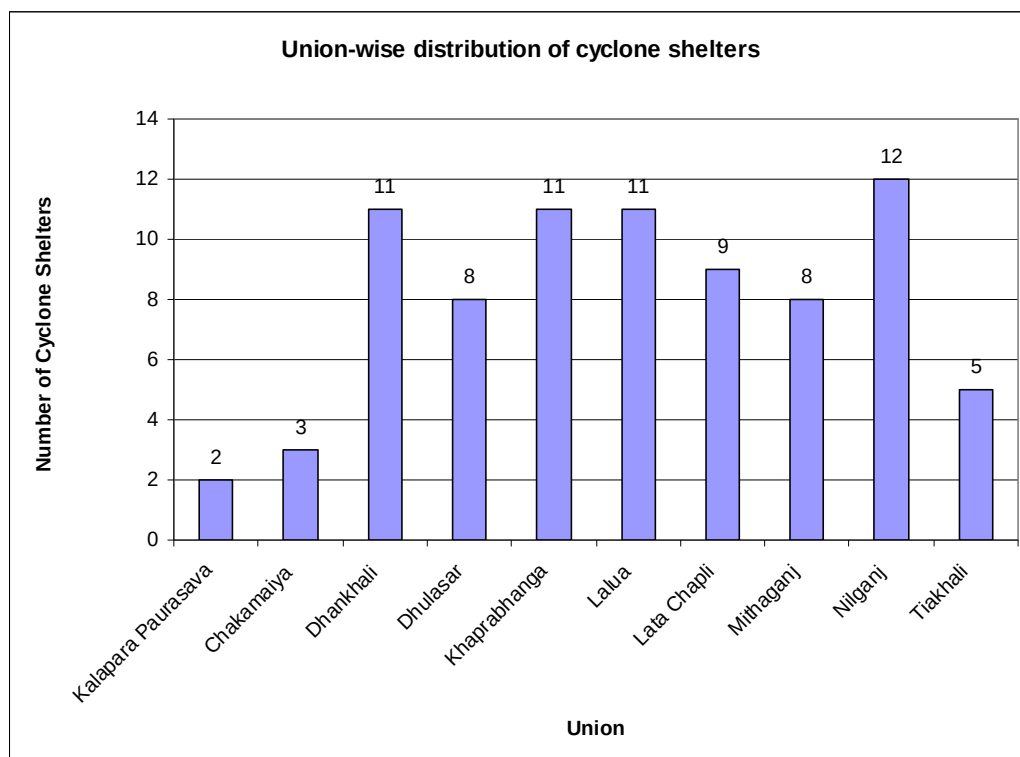


Figure A01: Union-wise distribution of cyclone shelters of Kalapara Upazila

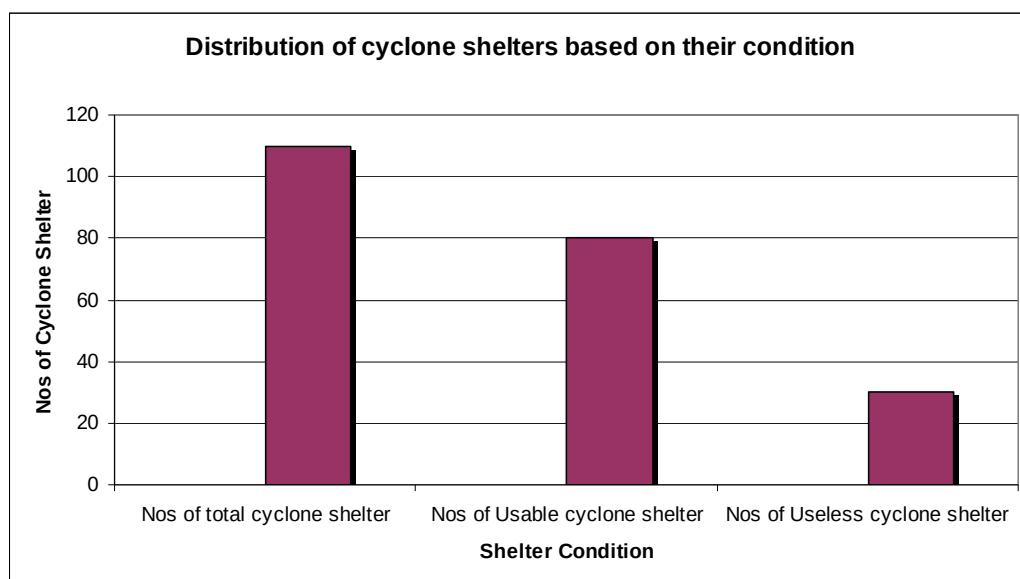


Figure A02: Distribution of cyclone shelters based on their condition of Kalapara Upazila

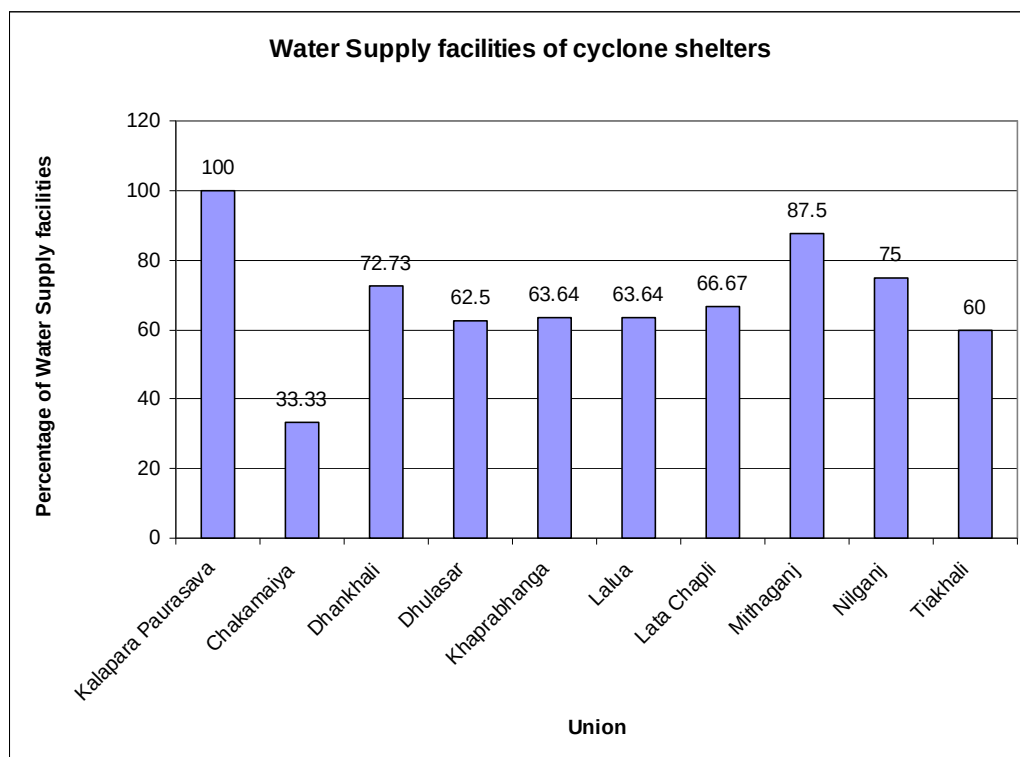


Figure A03: Water Supply facilities of cyclone shelters of Kalapara Upazila

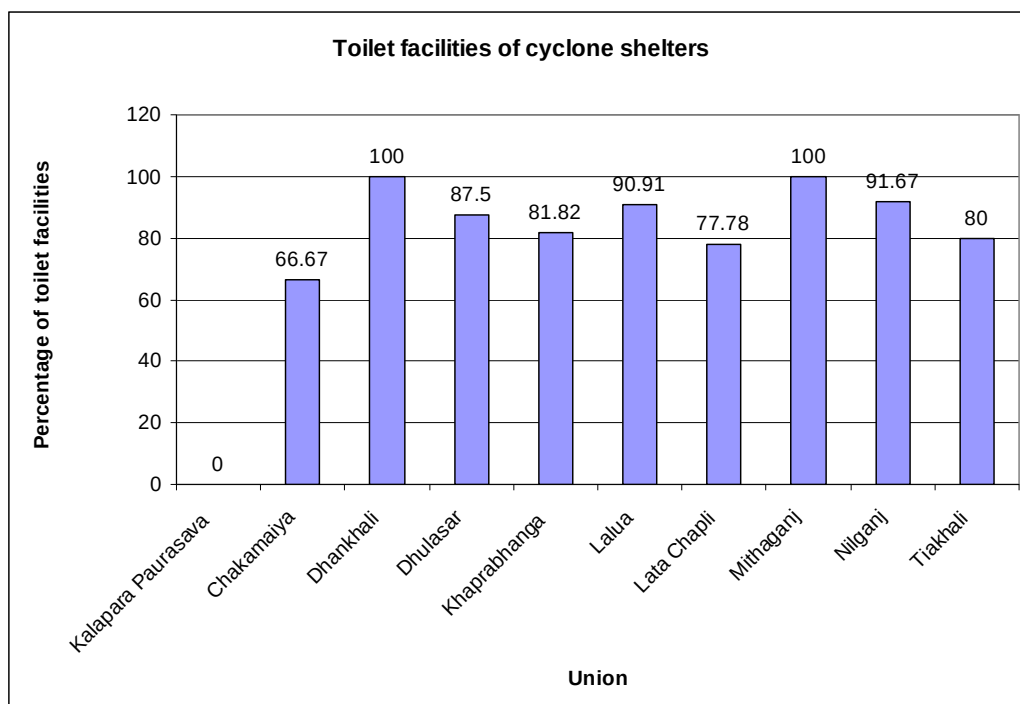


Figure A04: Toilet facilities of cyclone shelters of Kalapara Upazila

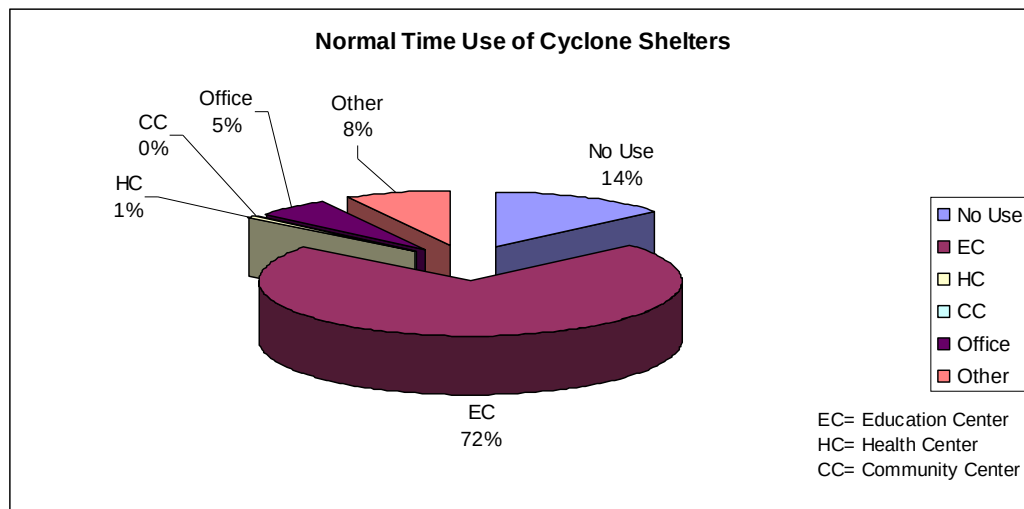


Figure A05: Normal Time Use of Cyclone Shelters of Kalapara Upazila

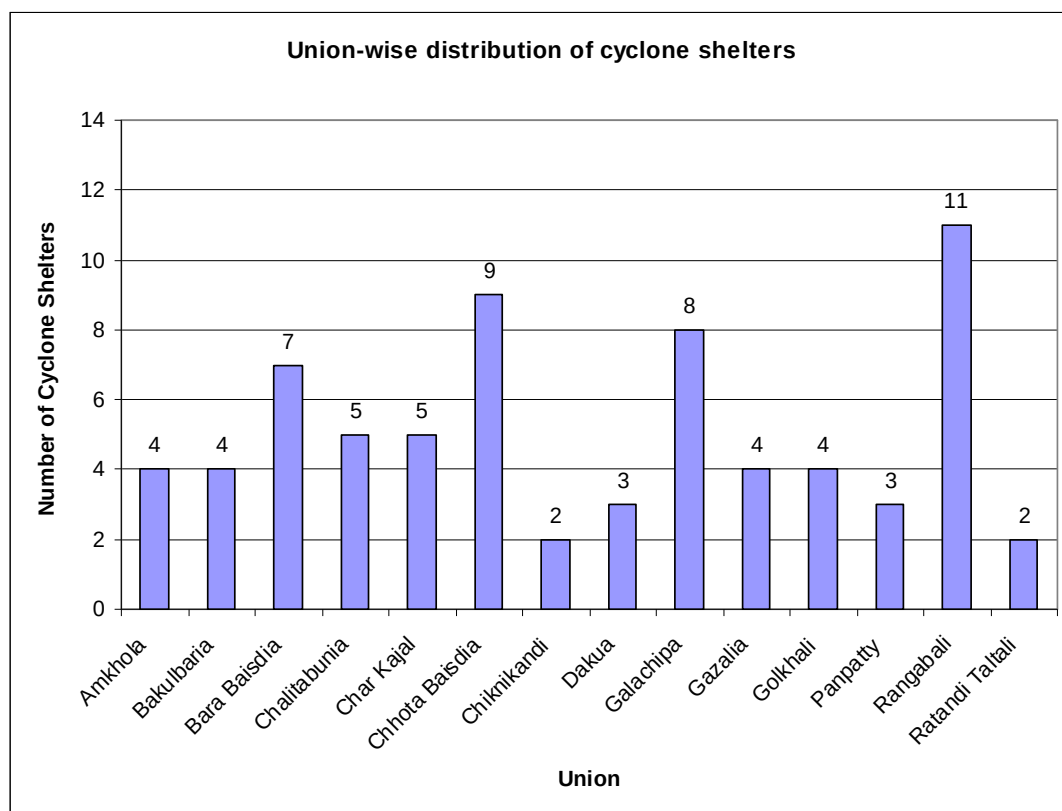


Figure A06: Union-wise distribution of cyclone shelters of Galachipa Upazila

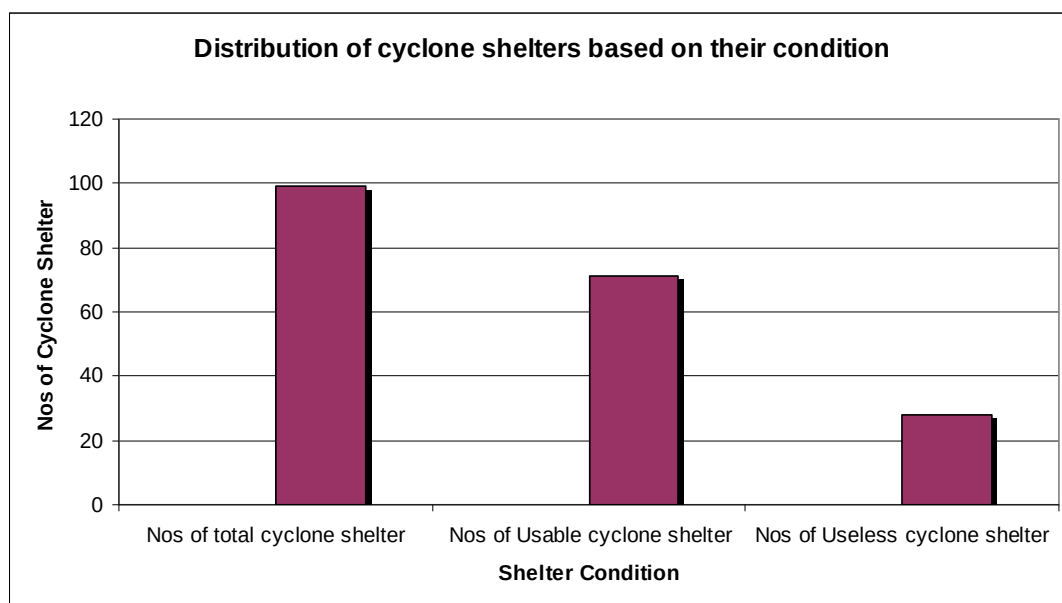


Figure A07: Distribution of cyclone shelters based on their condition of Galachipa Upazila

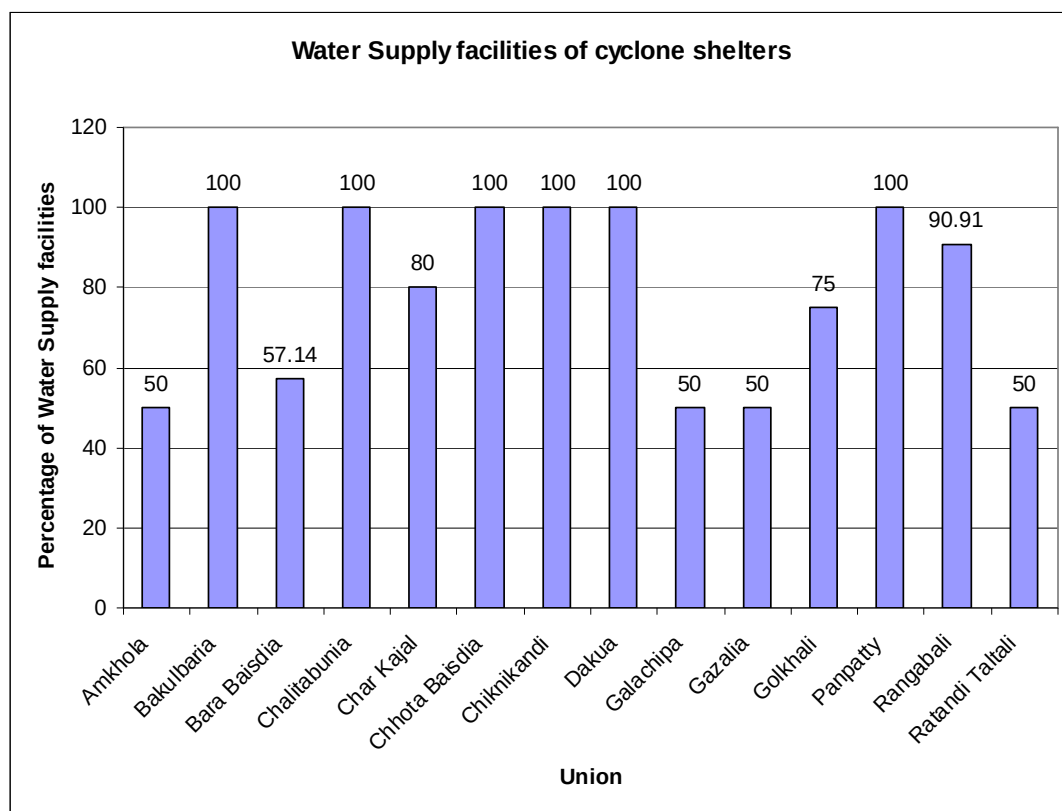


Figure A08: Water Supply facilities of cyclone shelters of Galachipa Upazila

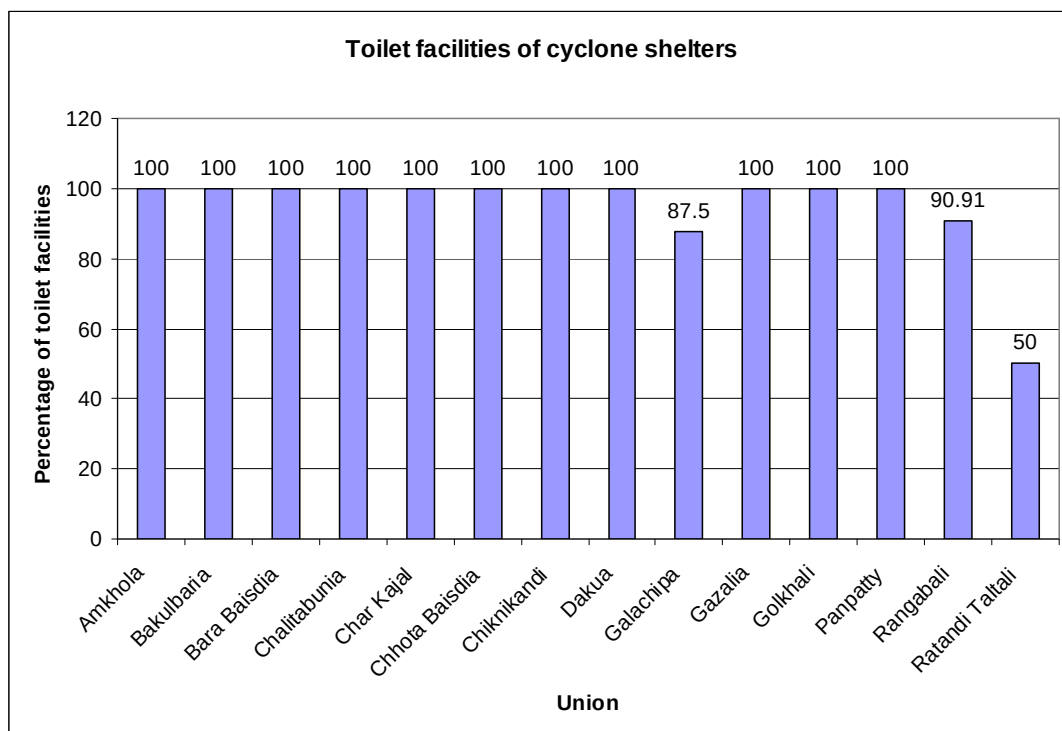


Figure A09: Toilet facilities of cyclone shelters of Galachipa Upazila

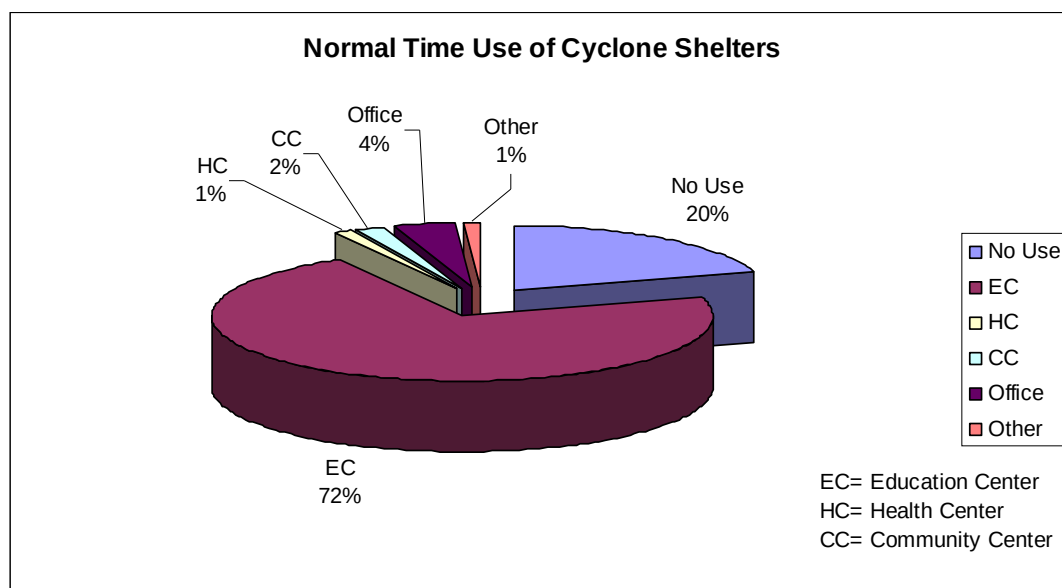


Figure A10: Normal Time Use of Cyclone Shelters of Galachipa Upazila

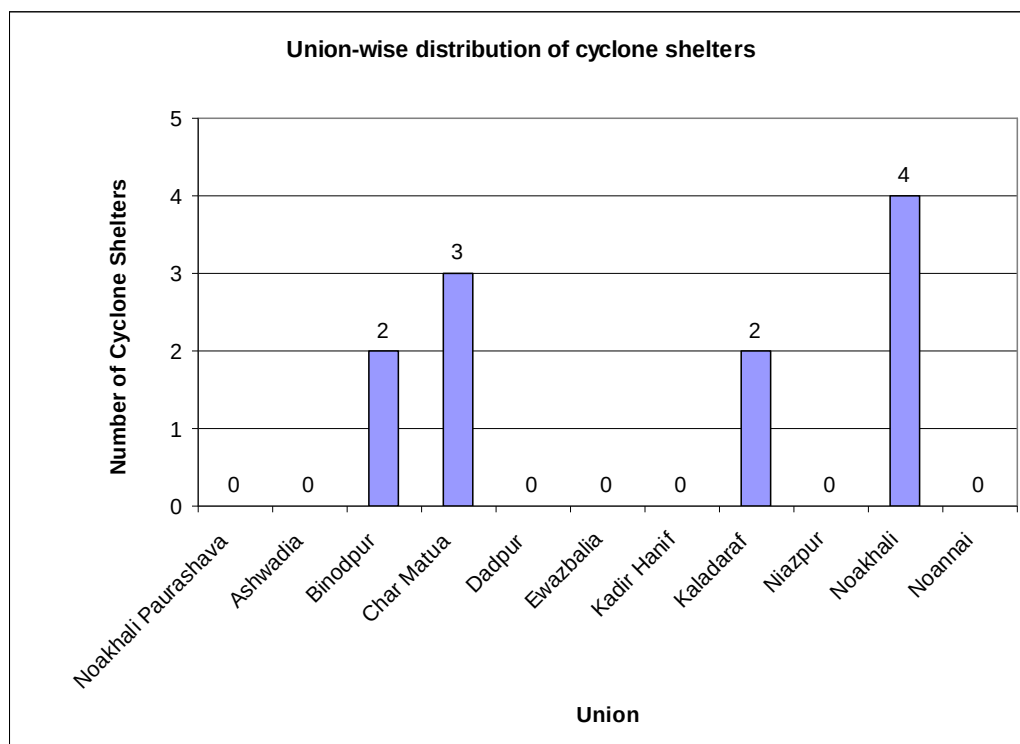


Figure A11: Union-wise distribution of cyclone shelters of Noakhali Sadar Upazila

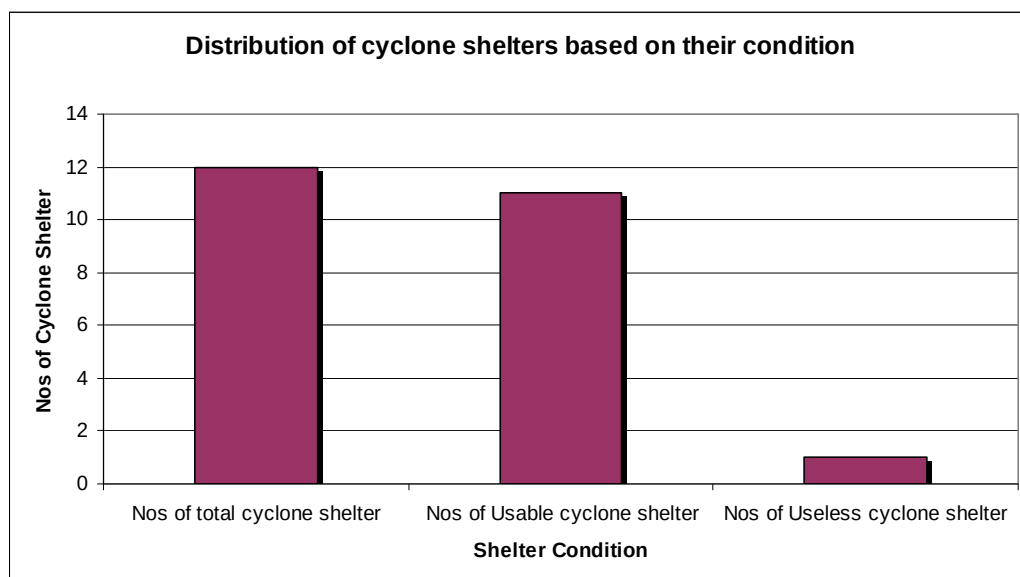


Figure A12: Distribution of cyclone shelters based on their condition of Noakhali Sadar Upazila

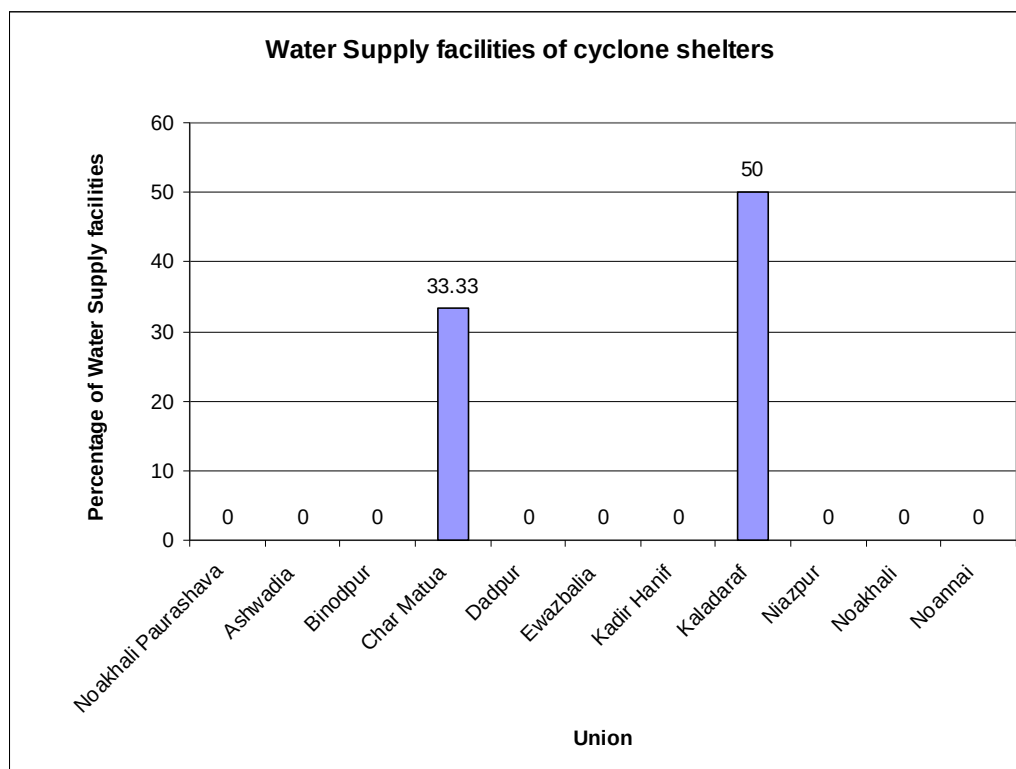


Figure A13: Water Supply facilities of cyclone shelters of Noakhali Sadar Upazila

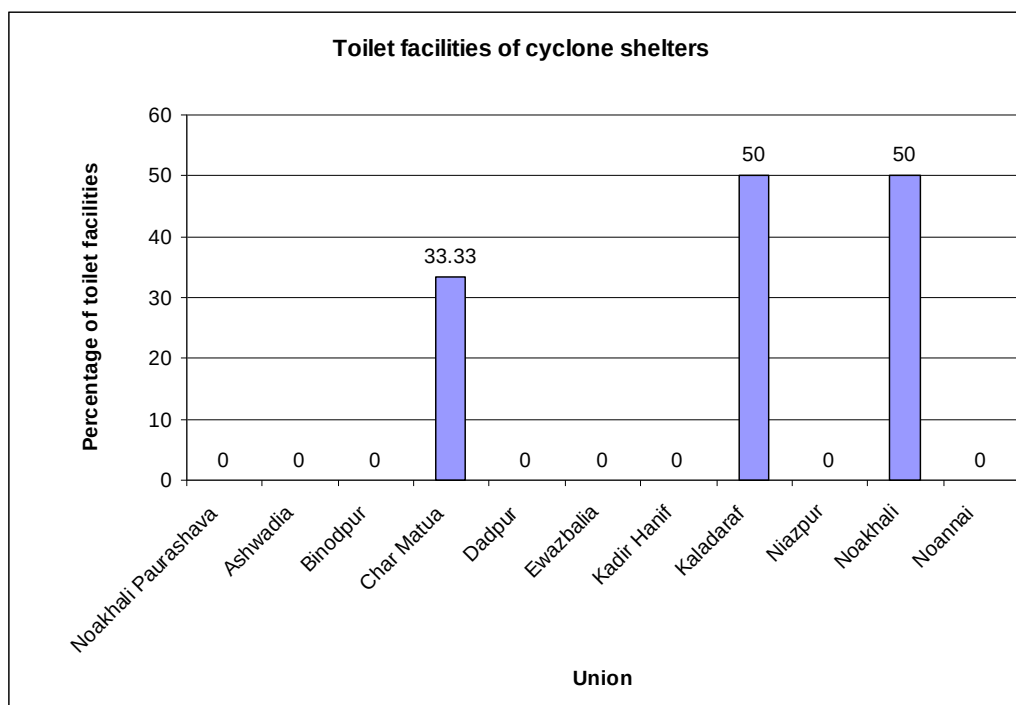


Figure A14: Toilet facilities of cyclone shelters of Noakhali Sadar Upazila

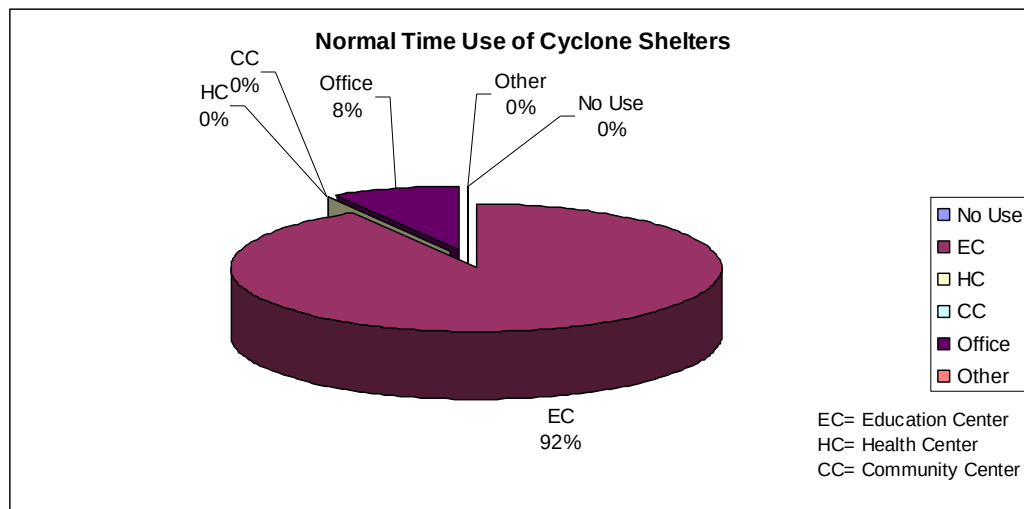


Figure A15: Normal Time Use of Cyclone Shelters of Noakhali Sadar Upazila

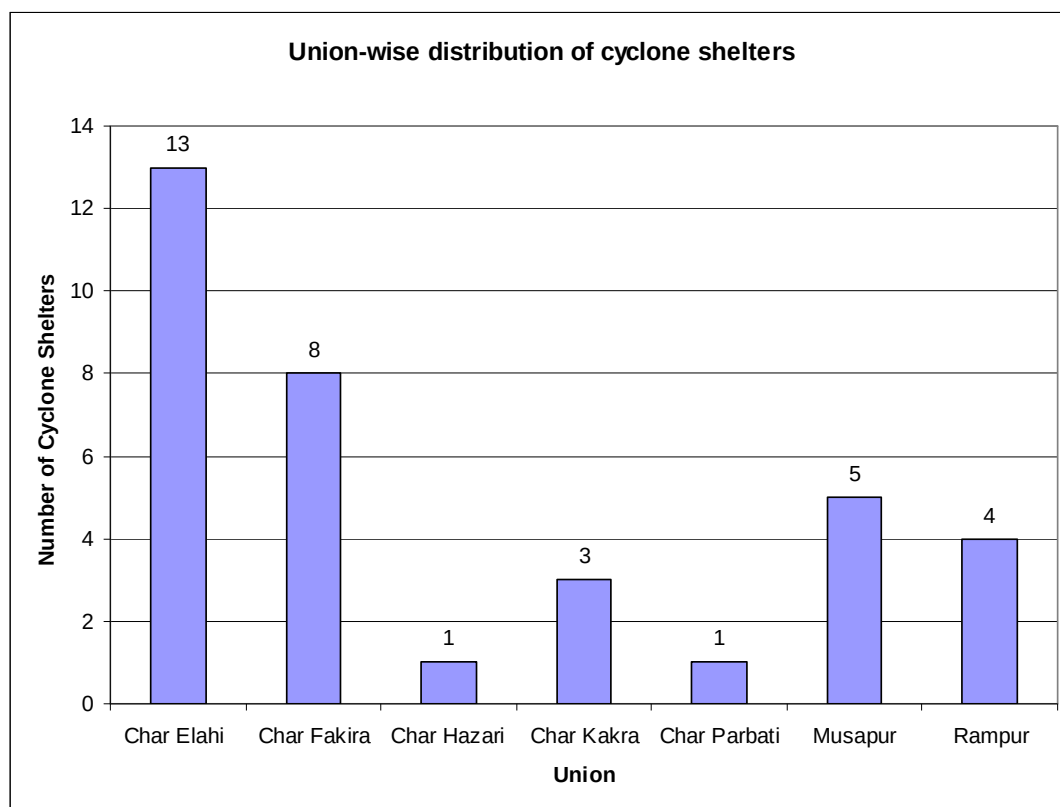


Figure A16: Union-wise distribution of cyclone shelters of Companigonj Upazila

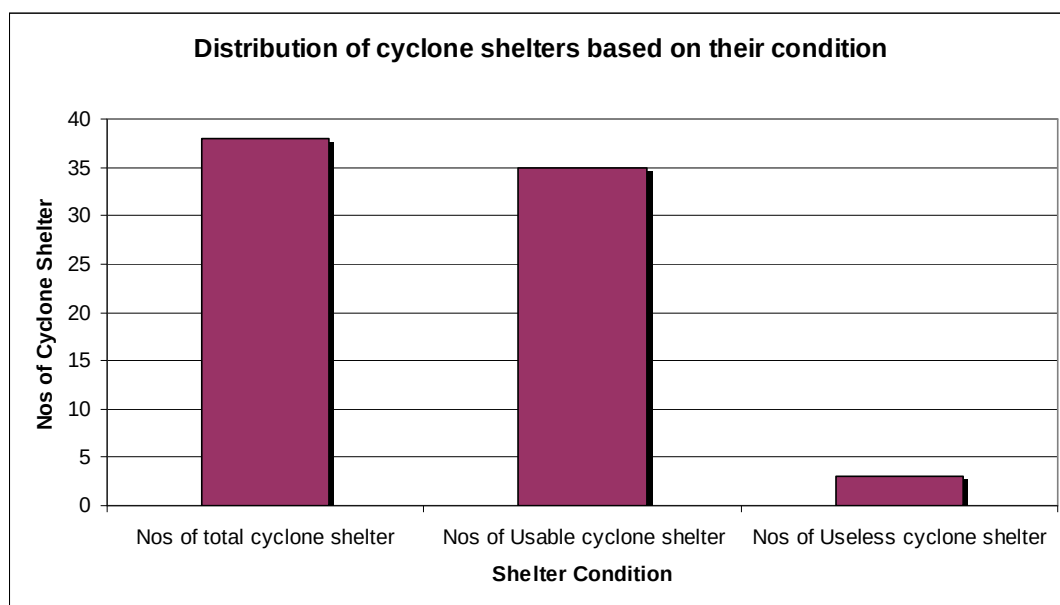


Figure A17: Distribution of cyclone shelters based on their condition of Companigonj Upazila

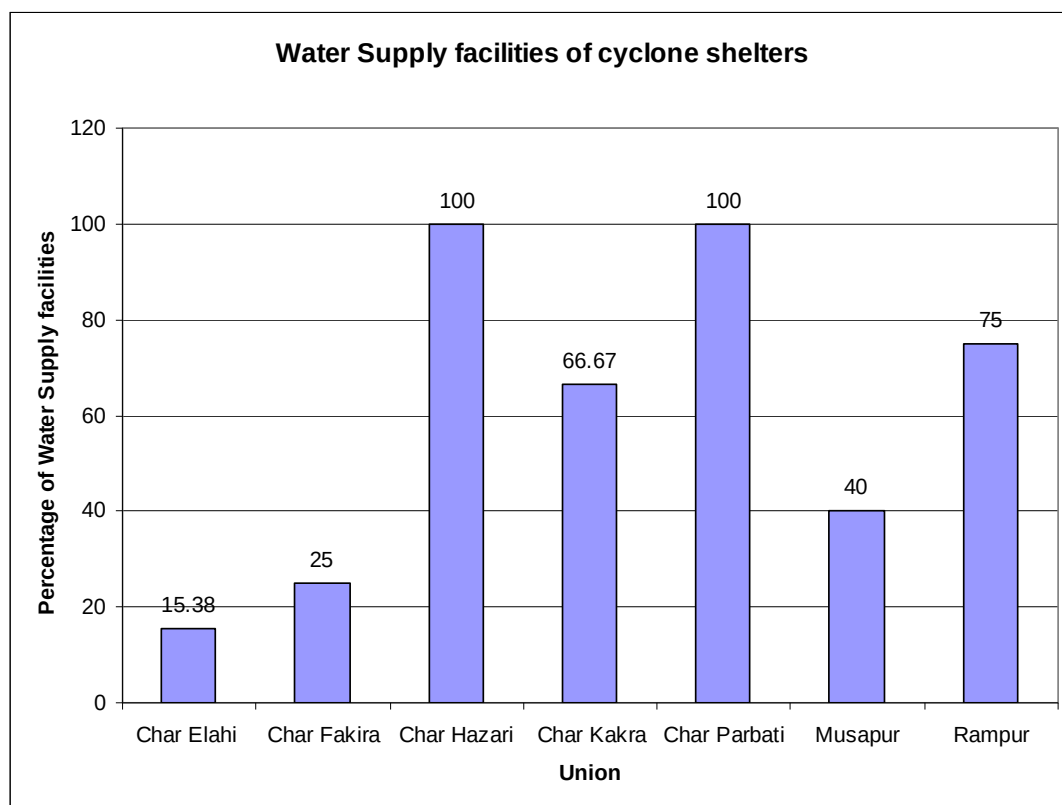


Figure A18: Water Supply facilities of cyclone shelters of Companigonj Upazila

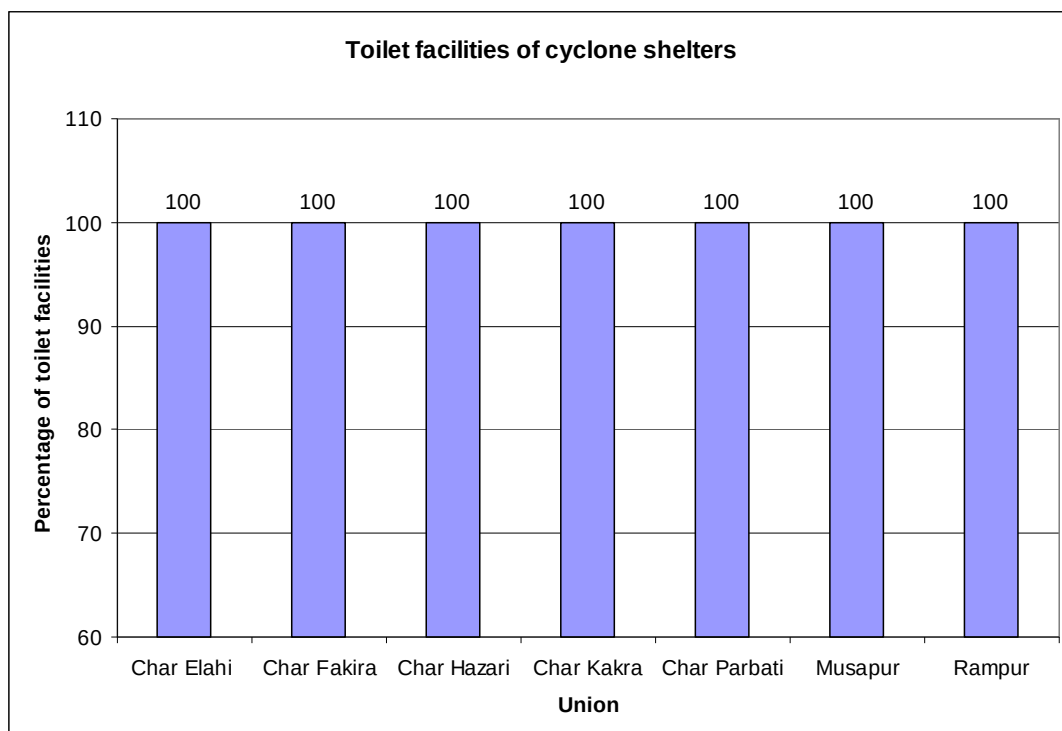


Figure A19: Toilet facilities of cyclone shelters of Companigonj Upazila

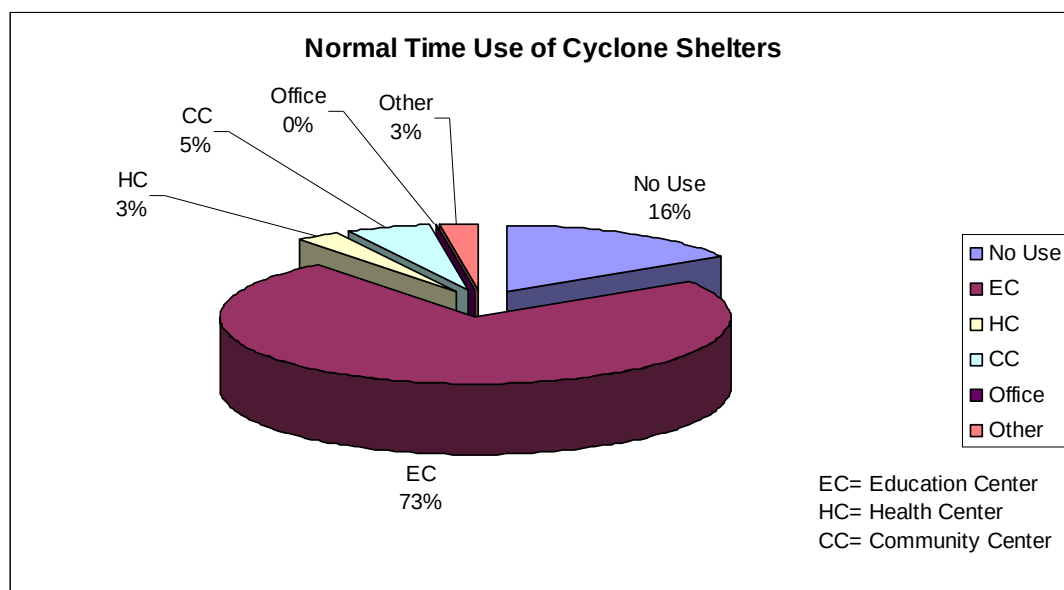


Figure A20: Normal Time Use of Cyclone Shelters of Companigonj Upazila

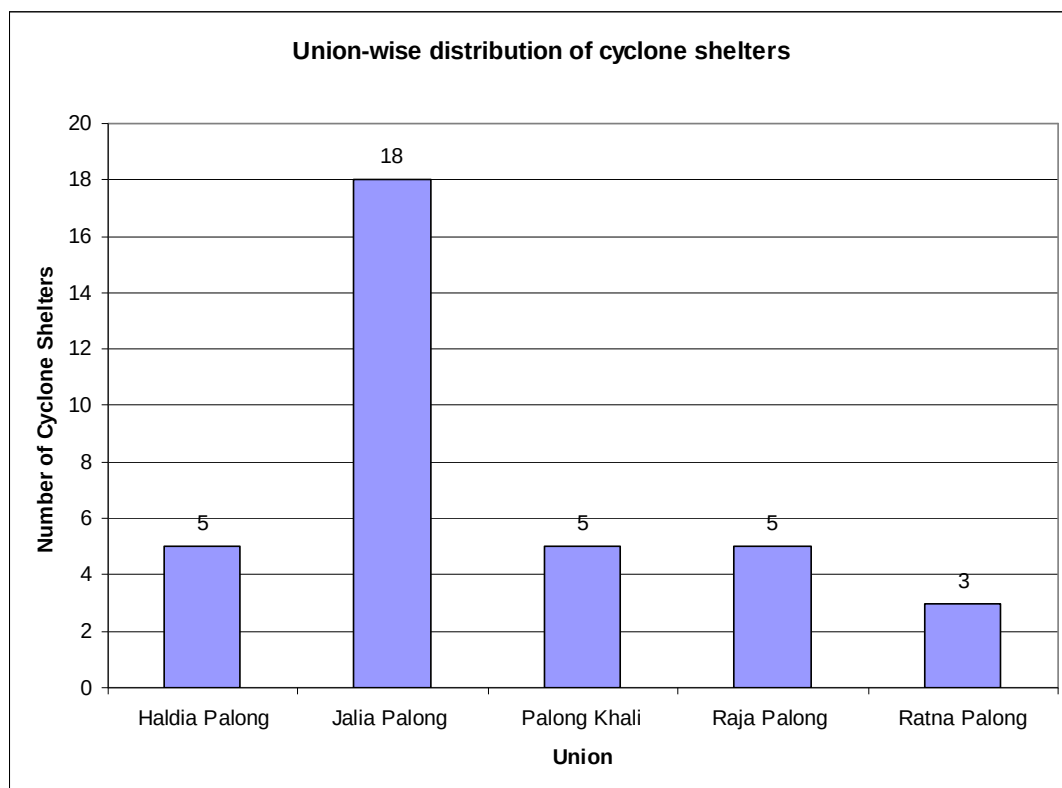


Figure A21: Union-wise distribution of cyclone shelters of Ukhiya Upazila

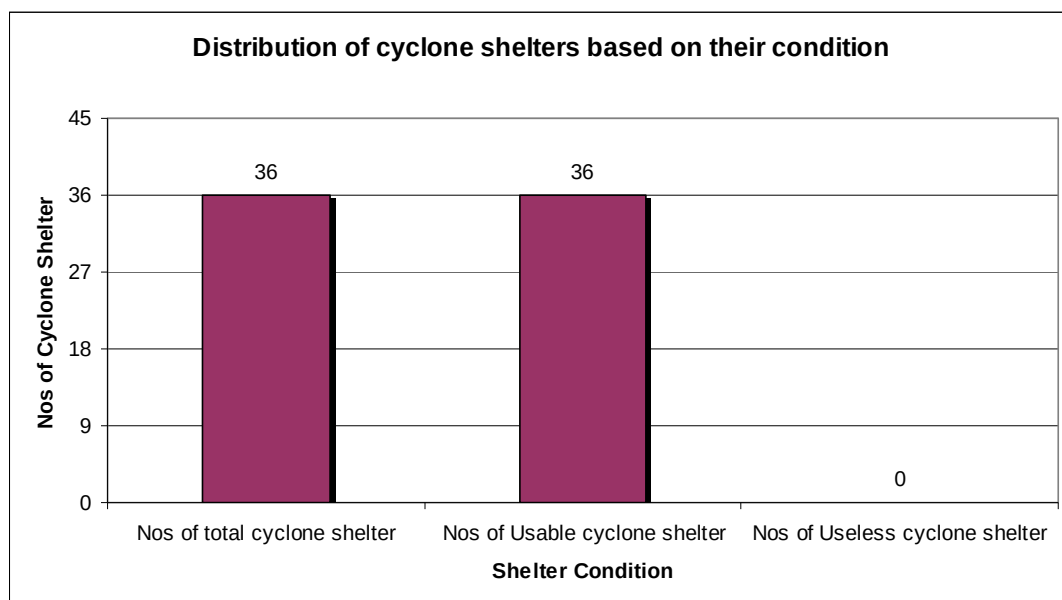


Figure A22: Distribution of cyclone shelters based on their condition of Ukhiya upazila

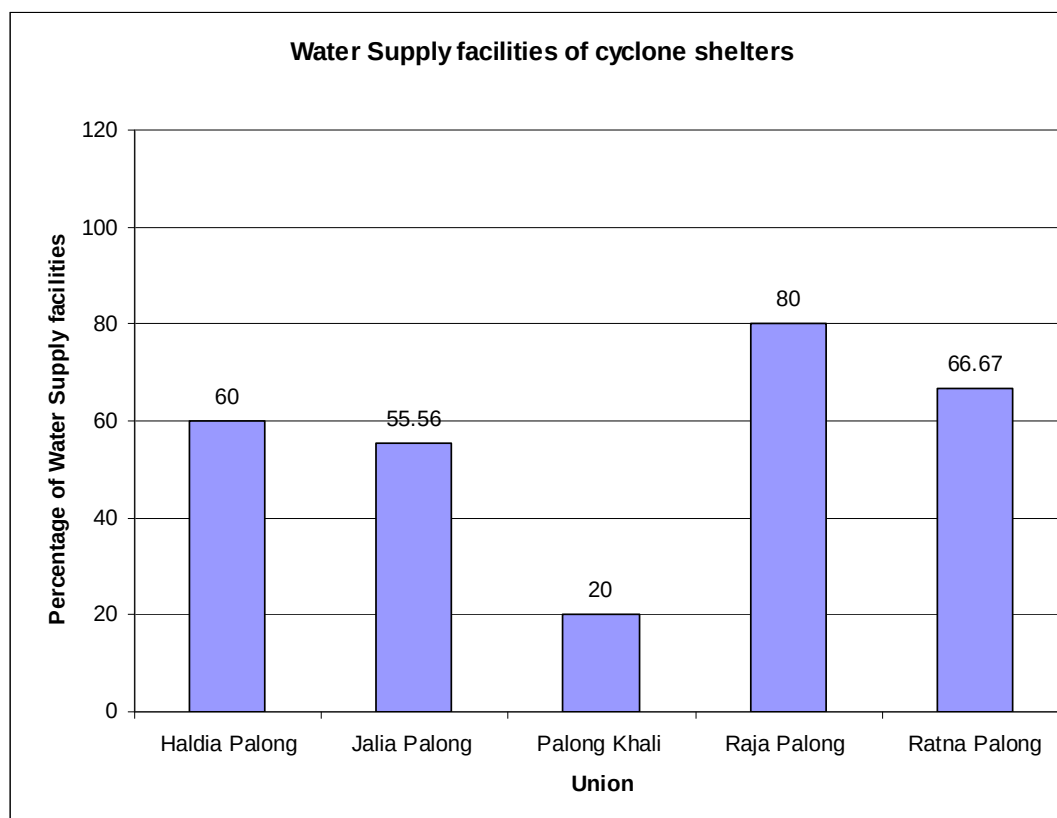


Figure A23: Water Supply facilities of cyclone shelters of Ukhiya Upazila

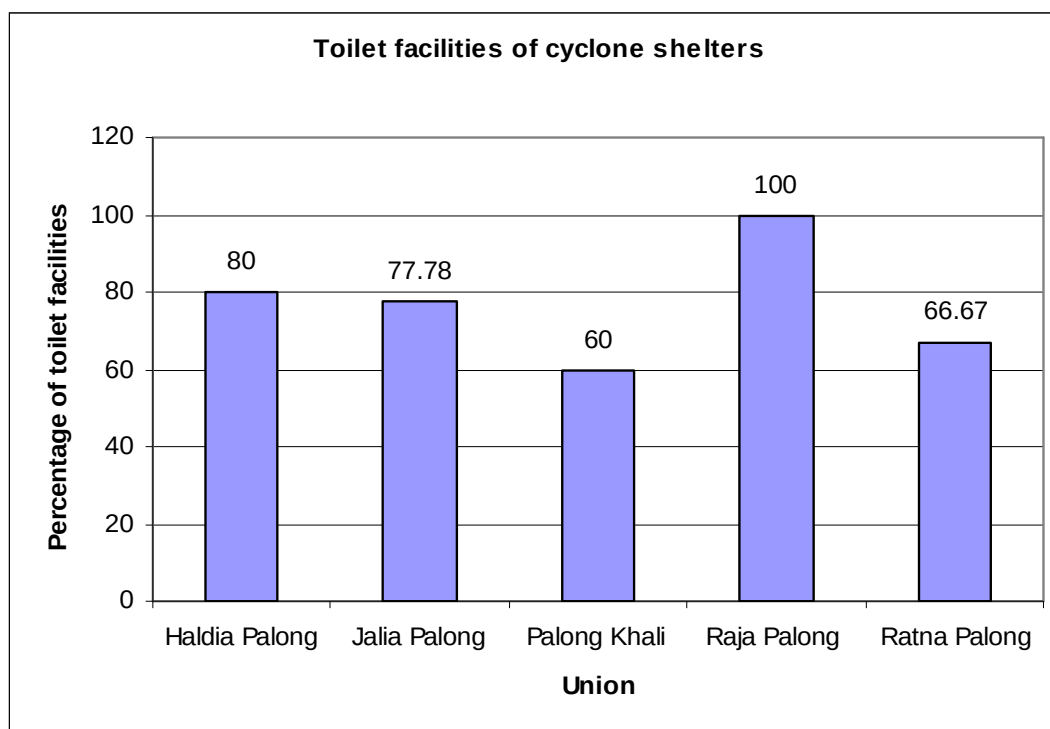


Figure A24: Toilet facilities of cyclone shelters of Ukhiya Upazila

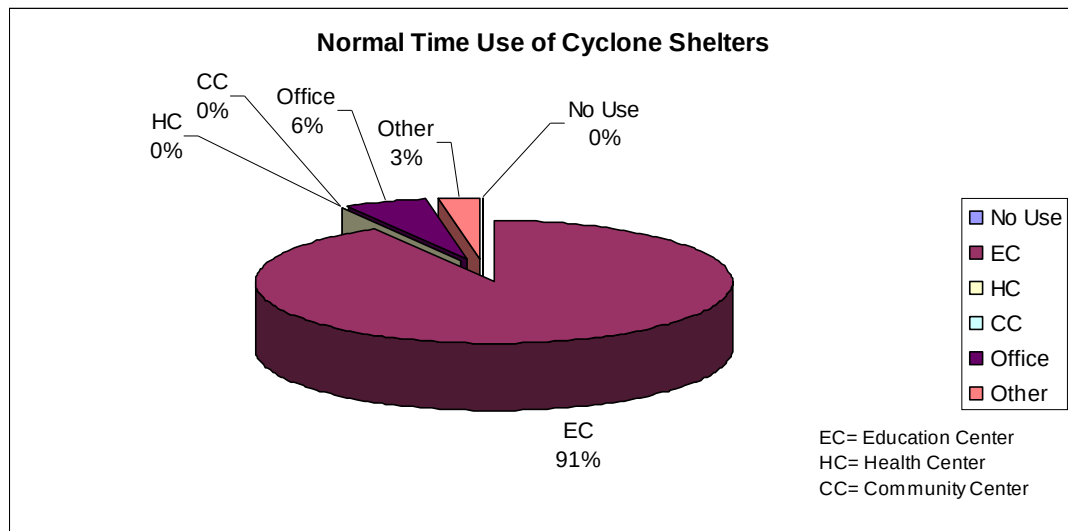


Figure A25: Normal Time Use of Cyclone Shelters of Ukhiya Upazila

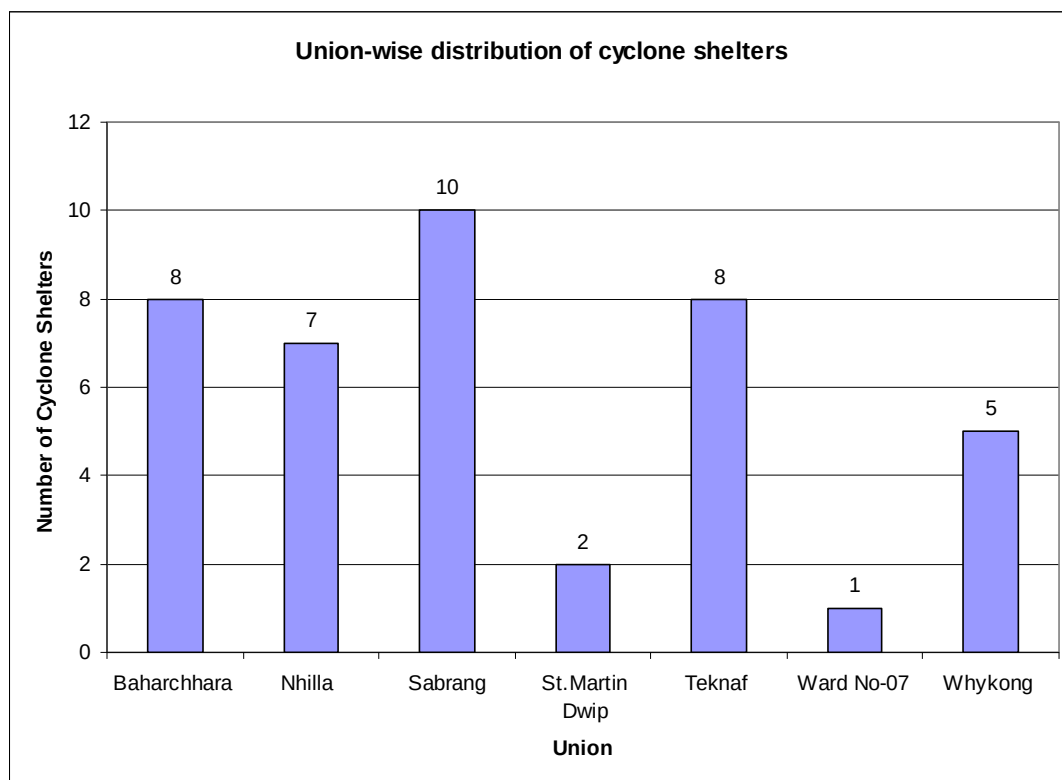


Figure A26: Union-wise distribution of cyclone shelters of Teknaf Upazila

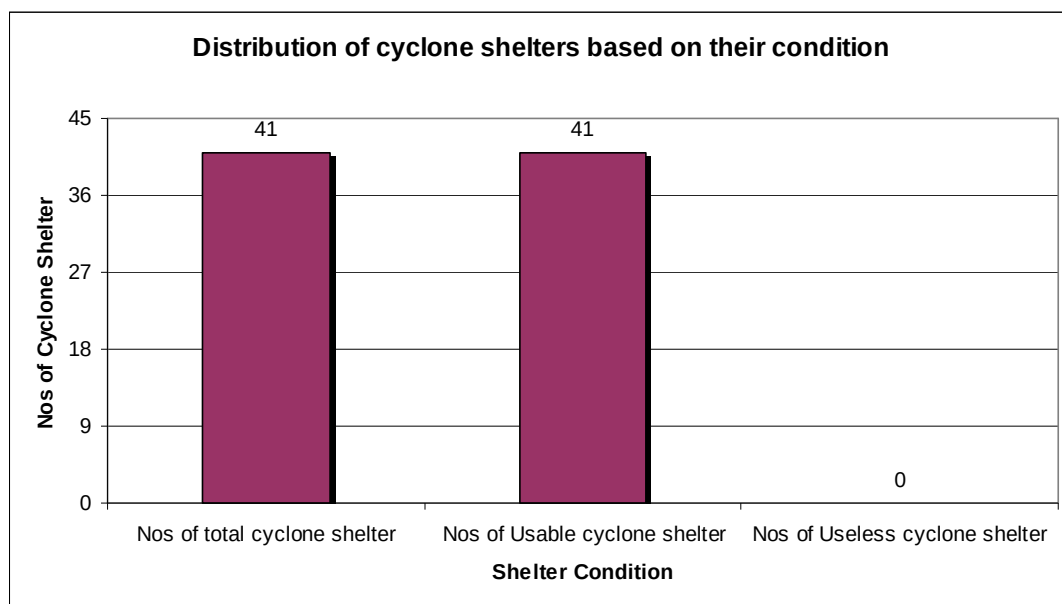


Figure A27: Distribution of cyclone shelters based on their condition of Teknaf Upazila

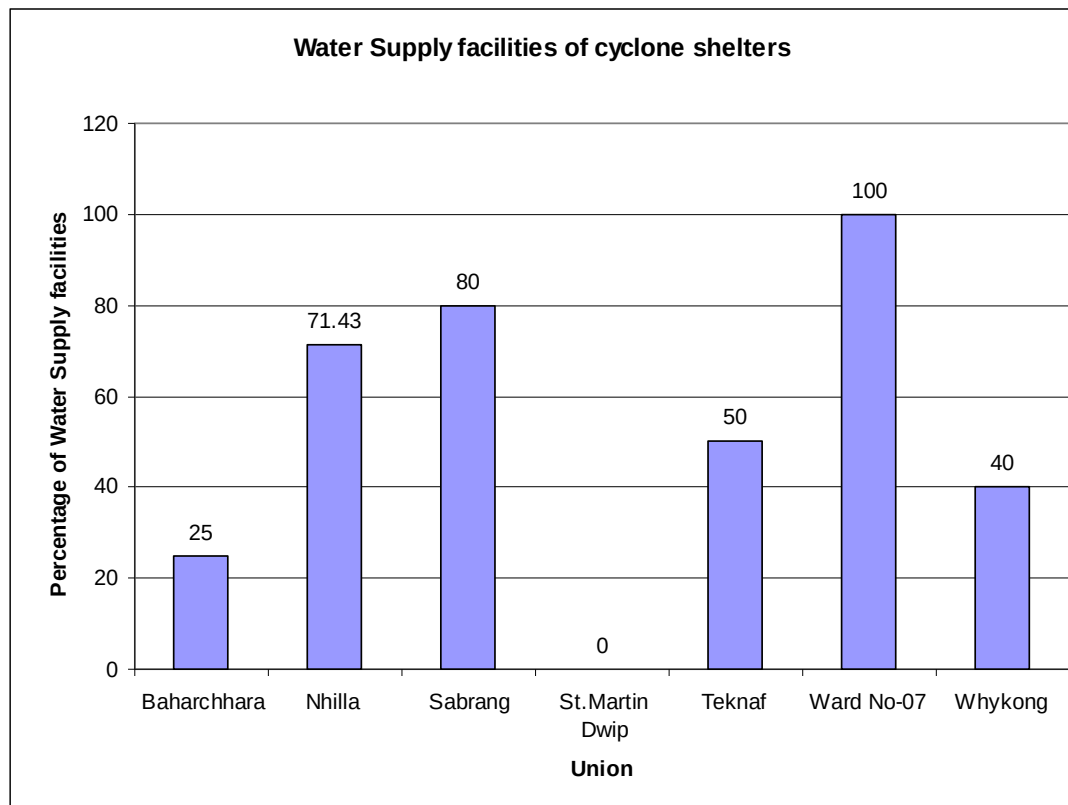


Figure A28: Water Supply facilities of cyclone shelters of Teknaf Upazila

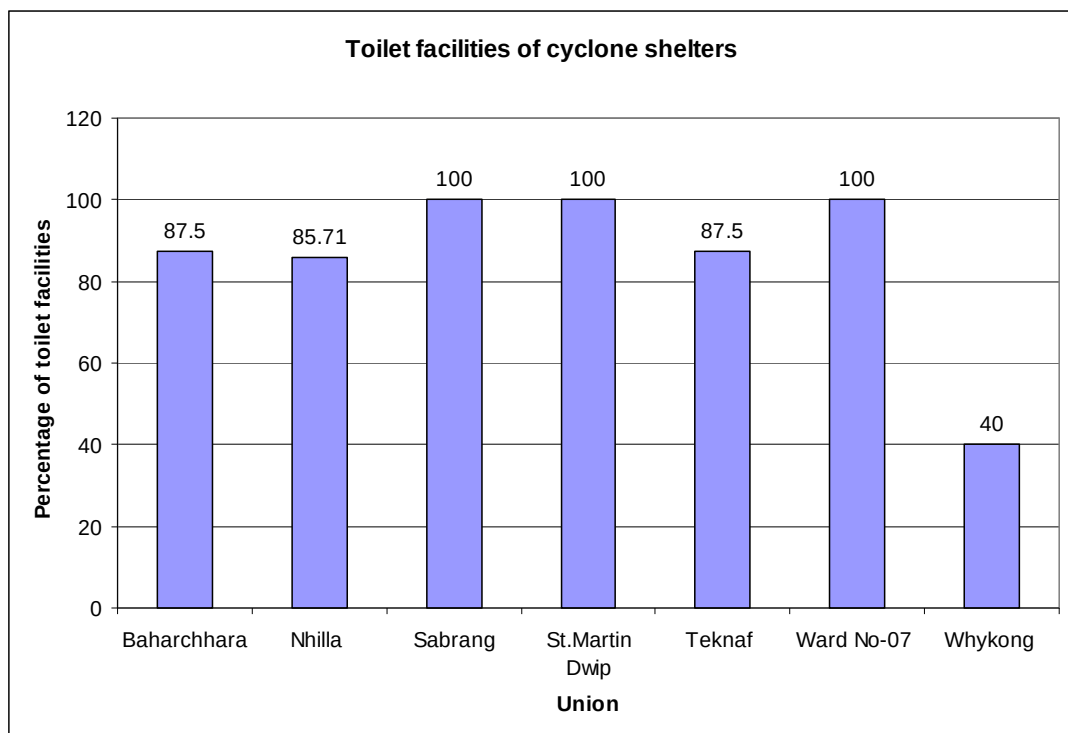


Figure A29: Toilet facilities of cyclone shelters of Teknaf Upazila

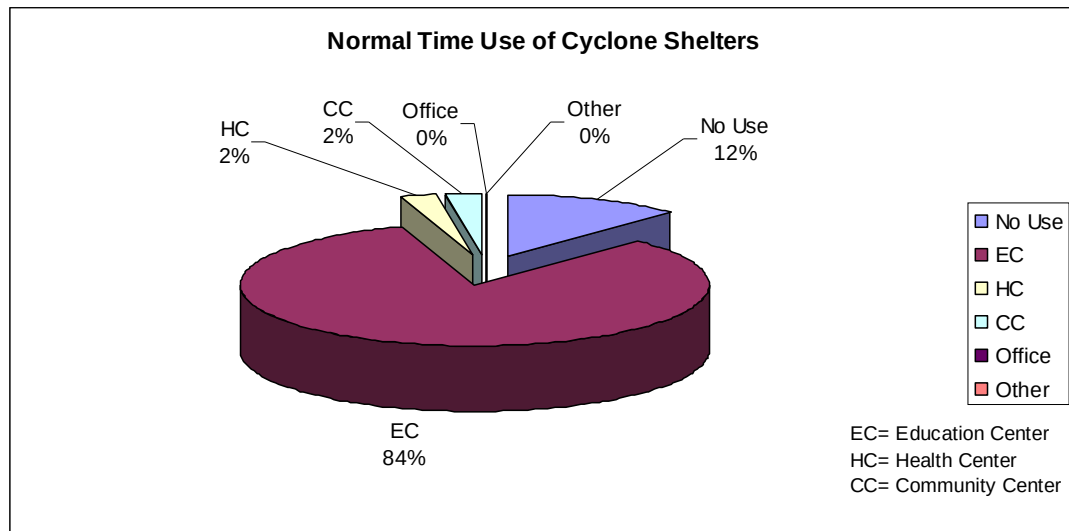


Figure A30: Normal Time Use of Cyclone Shelters of Teknaf Upazila

APPENDIX-(B): TABLES

Table B01: Population Projection of Kalapara upazila under Patuakhali district

Union	Area in Acres	Population (Nos.)		
		2001 (Census)	2015 (Projected)	2025 (Projected)
1	2	3	4	5
Kalapara Paurasava	926	16256	19886	22962
Chakamaiya Union	8496	14859	18177	20991
Khaprabhanga Union	13029	26295	32166	37147
Dhulasar Union	11139	15199	18593	21472
Lalua	12897	18339	22434	25907
Lata Chapli Union	14134	27004	33034	38148
Dhankhali Union	14652	22716	27788	32091
Mithaganj Union	18496	23964	29315	33854
Nilganj Union	15648	25553	31259	36099
Tiakhali Union	8126	11893	14549	16801
Total	117543	202078	247201	285472

Table B02: Population Projection of Galachipa upazila under Patuakhali district

Union	Area in Acres	Population (Nos.)		
		2001 (Census)	2015 (Projected)	2025 (Projected)
1	2	3	4	5
Galachipa Paurasava	839	17373	20759	23573
Amkhola Union	11673	28132	33615	38174
Bakulbaria Union	12792	27827	33250	37760
Bara Baisdia Union	23838	23122	27628	31376
Chalitabunia Union	6758	6344	7580	8609
Char Montaz Union	13997	14946	17859	20281
Char Biswas Union	9408	17107	20441	23214
Char Kajal Union	25159	21357	25519	28981
Chhota Baisdia Union	13492	17442	20841	23668
Chiknikandi Union	12188	15006	17931	20363
Dakua Union	8017	17873	21356	24253
Galachipa Union	11433	15862	18954	21524
Gazalia Union	10760	14020	16753	19025
Golkhali Union	16730	29726	35520	40337
Panpatty Union	7185	17237	20596	23390
Rangabali Union	26843	24965	29831	33877
Ratandi Taltali Union	7396	16896	20189	22927
Total	218508	325235	388622	441332

Table B03: Population Projection of Noakhali Sadar upazila under Noakhali district

Union	Area in Acres	Population (Nos.)		
		2001 (Census)	2015 (Projected)	2025 (Projected)
1	2	3	4	5
Noakhali Paurashava	3924	75956	95514	112496
Ashwadia	4575	27944	35139	41387
Binodpur	2212	18732	23555	27744
Char Matua	22727	66769	83961	98890
Dadpur	3422	21421	26937	31726
Ewazbalia	7253	35192	44253	52122
Kadir Hanif	3943	24664	31015	36529
Kaladaraf	11826	29551	37160	43767
Niazpur	3989	26080	32795	38626
Noakhali	15223	55004	69167	81465
Noannai	3836	26136	32866	38709
Total	82930	407449	512362	603461

Table B04: Population Projection of Companigonj upazila under Noakhali district

Union	Area in Acres	Population (Nos.)		
		2001 (Census)	2015 (Projected)	2025 (Projected)
1	2	3	4	5
Basurhat Paurashava	1606	21096	26310	30806
Char Elahi	17465	22320	27836	32592
Char Fakira	8166	22448	27996	32779
Char Hazari	3809	22066	27519	32222
Char Kakra	5342	35390	44136	51678
Char Parbati	4022	26840	33473	39193
Musapur	14813	19742	24621	28828
Rampur	4670	18113	22589	26449
Sirajpur	3560	26637	33220	38896
Total	63453	214652	267700	313443

Table B05: Population Projection of Ukhiya upazila under Cox's Bazar district

Union	Area in Acres	Population (Nos.)		
		2001 (Census)	2015 (Projected)	2025 (Projected)
1	2	3	4	5
Haldia Palong	8716	36900	51996	66430
Jalia Palong	5446	34356	48412	61850
Raja Palong	9720	43105	60740	77601
Ratna Palong	5107	17778	25051	32005
Palong Khali	33441	23048	32477	41493
Total	62430	155187	218676	279379

Table B06: Population Projection of Teknaf upazila under Cox's Bazar district

Union	Area in Acres	Population (Nos.)		
		2001 (Census)	2015 (Projected)	2025 (Projected)
1	2	3	4	5
Teknaf Paurashava	999	17569	25791	33927
Baharchhara	3782	19682	28893	38008
Nhilla	16486	37902	55639	73193
St. Martin Dwip	824	4531	6651	8750
Sabrang	15582	46512	68279	89820
Teknaf	26233	34537	50700	66695
Whykong	27859	39874	58534	77001
Total	91765	200607	294487	387394