Climate Change and its Management in Coastal Areas of Bangladesh

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ABSTRACT

Bangladesh is delta and originated from Ganges-Brahmaputra-Meghna river. It is a low land as well. Here average height is 5 meter from sea level. There are 19 districts of Bangladesh in coastal belt and its length is 580 km (711 km). This region covers about 20% of the country's total land area and over 30% of its cultivable land. It is home to diverse ecosystems, including the world's largest mangrove forest the Sundarbans along with beaches, coral reefs, dunes, and wetlands. These dynamic natural environments provide essential ecological and economic services to millions of people. As a coastal deltaic nation, Bangladesh is one of the most vulnerable countries to climate change. Rising sea levels, increasing cyclones, frequent flooding, erosion, saltwater intrusion, and loss of biodiversity are exacerbating existing environmental and socio-economic challenges. Particularly at risk are coastal ecosystems such as mangroves, tidal deltas, low-lying plains, sandy beaches, wetlands, and coral reefs. The Sundarbans, a critical protective barrier, could be entirely submerged with just a one-meter rise in sea level. To combat these threats, two key approaches are necessary: mitigation and adaptation. However, as mitigation requires global cooperation, Bangladesh must prioritize adaptation strategies at the local level. Implementing sustainable coastal management practices, strengthening disaster resilience and promoting climate-smart agriculture are essential to safeguarding livelihoods and ecosystems. A combination of national adaptation efforts and global mitigation measures is crucial to reducing climate-related risks in Bangladesh.

Keywords: *Climate Change, Management, Coastal Area, Bangladesh*

INTRODUCTION

Climate change is a problem that is continuously affecting people and the environment. Historically, Bangladesh is one of the most susceptible countries of the world to bear the burden of the negative impact of climate change. The coastal areas are worst affected and the coastal population are the sufferers. Climate change refers to any significant change in measures of climate (such as temperature, precipitation, wind, sea level, and natural phenomena), lasting for an extended period of time (decades or longer) that negatively affects the terrestrial and aquatic ecosystems (all living things: plants, animals and organisms, interacting with each other, and also with their non-living environments: weather, earth, sun, soil, climate, and atmosphere). Greater energy efficiency and new technologies hold promise for reducing greenhouse gases (such as Carbon dioxide- CO_2, Methane- CH_4, Nitrous oxide- N_2O, water vapor, while others are synthetic. Those that are man-made include the chlorofluorocarbons-CFCs, Hydro-fluorocarbons-HFCs, Per-fluorocarbons-PFCs, Sculpture- hexafluoride- SF6) and solving this global challenge. Greenhouse gases and certain synthetic chemicals, trap some of the Earth's generated energy, thus retaining heat in the atmosphere. Efforts are being made for reducing, reusing and recycling solid waste to decrease the amount of heat-trapping greenhouse gases released.

Bangladesh is now widely recognised to be one of the countries which are most vulnerable to climate change. Natural hazards that come from increased rainfall, rising sea levels, and tropical cyclones are expected to increase as climate changes, each seriously affecting agriculture, water and food security, human health and shelter. It is believed that in the coming decades the rising sea level alone will create more than 20 million climate refugees. Bangladeshi water is contaminated with arsenic frequently because of the high arsenic contents in the soil. Up to 77 million people are exposed to toxic arsenic from drinking water.

Bangladesh is prone to floods, tornados and cyclones. Also, there is evidence that earthquakes pose a threat to the country. Evidence shows that tectonics have caused rivers to shift course suddenly and dramatically. It has been shown that rainy-season flooding in Bangladesh, on the world's largest river delta, can push the underlying crust down by as much as 6 centimetres, and possibly perturb faults.

The extreme variations in the meteorological phenomena, pose a threat to the coastal zones. The observable weather events are primarily: Earth's atmosphere: temperature, air pressure, water vapor, mass flow, floods/flash floods, cloud burst, heavy precipitation; tropical cyclones and their associated storm surges; severe convective storms - thunderstorms, hailstorms, tornadoes, lightening, dust storms; heat/cold wave; land-slides; and river/sea erosion. The spatial and temporal scales of these hazards vary widely from short-lived, violent phenomena of limited extent (e.g. severe thunderstorms), through large systems (e.g. tropical cyclones). These events can subject large regions to disastrous weather phenomena like strong winds, heavy flood-producing rains, storm surges and coastal flooding, and extreme hot or cold temperature conditions for periods of several days. With this wide variety of the scales of weather phenomena, the requirements of meteorological and hydrological forecasting for effective early warning of these hazards also vary spanning over a very broad spectrum. These can range from very short range forecasts of less than one hour in the case of severe thunderstorms and flash floods; through short and medium range forecasts of - from a few hours to days for tropical cyclones, heavy rains, extreme temperatures and high winds. According to the 3rd assessment report of IPCC, South Asia is the most vulnerable region of the world to climate change impact (Mc Cathie, et.al-2001). Bangladesh ranks high in respect of vulnerability due to its topography and other factors such as hydro-geological and socio-economic factors mentioned below:

1. Its Geographical location in South Asia
2. The Ganga-Brahmaputra-Meghna Catchments area includes a great diversity of Physical environment
3. Its flat deltaic topography with very low elevation
4. Its extreme climate variability droughts; cyclones; and the monsoon season, when much of the country is routinely inundated

Bangladesh is called the land of six seasons. It has a temperate climate because of its physical location. Though the climate of Bangladesh is mainly sub-tropical monsoon, i.e. warm and humid; Bangla calendar year is traditionally divided into six seasons:

1. Grisma (Summer): (Baishakh and Jyaistha): mid-April to mid-June
2. Barsha (Rainy): (Ashar and Shraban): mid-June to mid-August
3. Sharat (Autumn): (Bhadra and Ashwin): mid-August to mid-October
4. Hemanto (Late Autumn): (Kartik and Agrahayan): mid-October to mid-December
5. Sheet (Winter): (Paus and Magh): mid-December to mid-February
6. Bashonto (Spring): (Phalgun and Chaitra): mid-February to mid-April
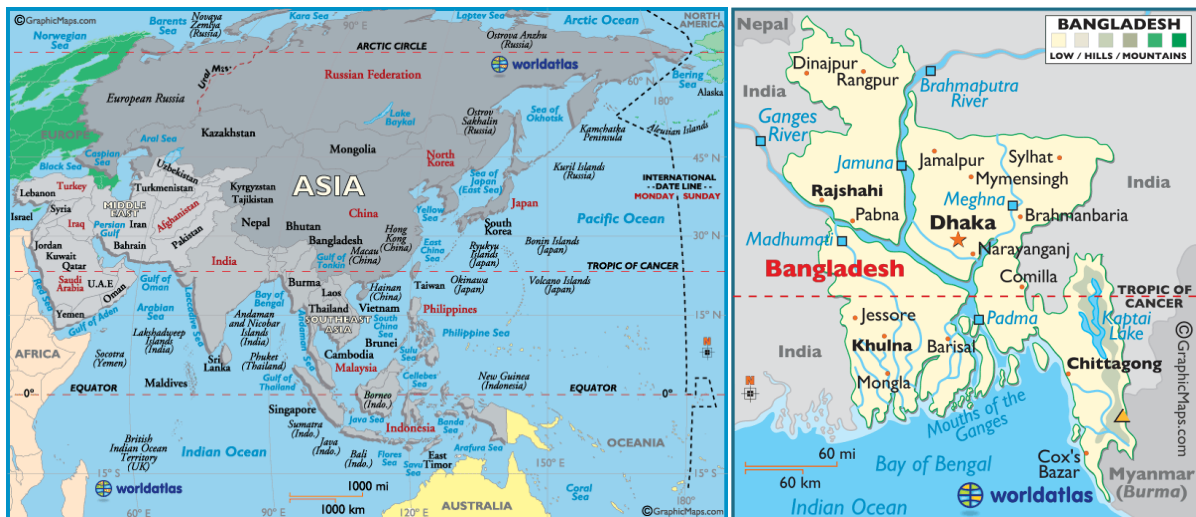
Actually, Bangladesh has three distinct seasons: the pre-monsoon hot season from March through May, rainy monsoon season which lasts from June through October, and a cool dry winter season from November through February. However, March may also be considered as the spring season, and the period from mid-October through mid-November may be called the autumn.

For practical purpose, however, three seasons are distinguishable: summer, rainy, and winter. The pre-monsoon hot season is characterised by high temperature and occurrence of thunderstorms. April is the hottest month in the country when the mean temperature ranges from 27'C in the east and south to 31'C in the west-central part of the country. After April, increasing cloud-cover dampens temperature. Wind direction is variable in this season, especially during its early part rain-fall accounts for 10 to 25 percent of the annual total, which is caused by thunderstorms.

Southerly or south-westerly winds, very high humidity, and heavy rainfall and long consecutive days of rainfall characterise the rainy season, which coincides with summer monsoon. Rainfall of this season accounts for 70 to 85 percent of the annual total. This is caused by the tropical depression that enters the country from the Bay of Bengal. Low temperatures, cool air blowing from the west or northwest, clear sky, and meagre rainfall characterise the cool dry season. Average temperature in January varies from 17'C in the northwest and north-eastern parts of the country to 20'C-21'C in the coastal areas. Minimum temperature in the extreme northwest in late December and early January reaches 3'C to 4'C. The seasons of Bangladesh regulate its economy, communication, trade and commerce, art and culture and, in fact, the entire lifestyle of the people. In the recent past Bangladesh has experienced increased frequency in climate change and increased intensity of natural disasters. These disasters continue to have adverse effect on the society in terms of human casualties, economic and social losses, disruption of livelihoods, and degradation to environment also affecting health and sanitation and availability drinking water.

Table 1: Bangladesh Basic Information

Introduction Background:	The 1971 Bangladesh Liberation War was a war of independence, which resulted in the secession of East Pakistan from the Islamic Republic of Pakistan and established the sovereign nation called Bangladesh. (Peoples Republic of Bangladesh)
Geography location:	Bangladesh is located in South Asia, bordered by India in the north, in the east and west, while Myanmar surrounds it to the south-east and the Bay of Bengal in the south.
Geographic coordinates:	Latitude: 23.8511° N, Longitude: 89.9250° E.
Map references:	Asia
Area:	Total: 147,570 sq. km. Land: 130,170 sq.km. Water: 17,400 sq. km.
Area: Comparative	Slightly smaller than Iowa
Land boundaries:	Total: 4,413 km. Border countries:Burma 271 km, India 4,142 km
Coastline:	580 km
Maritime claims:	Territorial sea:12 nm, Contiguous zone:18 nm, Exclusive economic zone:200 nm, Continental shelf: to the outer limits of the continental margin
Climate:	Tropical; mild winter (October to March); hot, humid summer (March to June); humid, warm rainy monsoon (June to October)
Terrain:	Mostly flat alluvial plain; hilly in southeast
Elevation extremes:	Lowest point: Indian Ocean 0m, highest point: Keokradong 1,230 m
Natural resources:	Natural gas, arable land, timber, coal
Land use:	Arable land: 62.11% , permanent crops: 3.07%, other: 34.82% (2015)
Irrigated land:	38,440 sq. km. (1998 est.) but now 76160 sq.km (2021)
Natural hazards:	Droughts, cyclones; much of the country routinely inundated during the summer monsoon season
Environment – current issues:	Many people are landless and forced to live on and cultivate flood-prone land; water-borne diseases prevalent in surface water; water pollution, especially of fishing areas, results from the use of commercial pesticides; ground water contaminated by naturally occurring arsenic; intermittent water shortages because of falling water tables in the northern and central parts of the country; soil degradation and erosion; deforestation; severe overpopulation
Environment - international agreements:	Party to: Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Desertification, Endangered Species, Environmental Modification, Hazardous Wastes, Law of the Sea, Ozone Layer Protection, Wetlands signed, but not ratified: none of the selected agreements
Geography - note:	Most of the country is situated on deltas of large rivers flowing from the Himalayas: the Ganges unites with the Jamuna (main channel of the Brahmaputra) and later joins the Meghna to eventually empty into the Bay of Bengal

OBJECTIVES OF THE STUDY

The overall objective of the research is to suggest to the vulnerable population of the coastal areas - successful strategies for coping with different climate induced disasters through lesson learnt documentation and analyzing national and International actions for achieving sustainable development. However the specific objectives of the study are as follows:

1. To identify adaptation and mitigation strategies used by the coastal population of Bangladesh.
2. To understand climatic hazards faced by the coastal population of Bangladesh.
3. To analyze vulnerability of the areas.

METHODOLOGY OF THE STUDY

The following methodology was used for the study:

Study Design: The study was survey type.

Study Area: The study has been conducted at Samnagar Upazila of Satkhira District, Pathorghata Upazila of Barguna District and Cox's Bazar Sadar Upazila and Moheskhali Upazila of Cox's Bazar District.

Sampling Method: Random sampling method has been used for the study.

Tools for Data Collection: Questionnaire has been used for data collection.

Sources of Data: Data have been collected from the field by face to face interview with the respondents.

Sample Size: 100 respondents have been interviewed for the study. The respondents were elected representatives of the local areas. 7 Chairmen, 23 Councilor, 66 Members, 2 Mayors, and 2 Secretary were interviewed for the study.
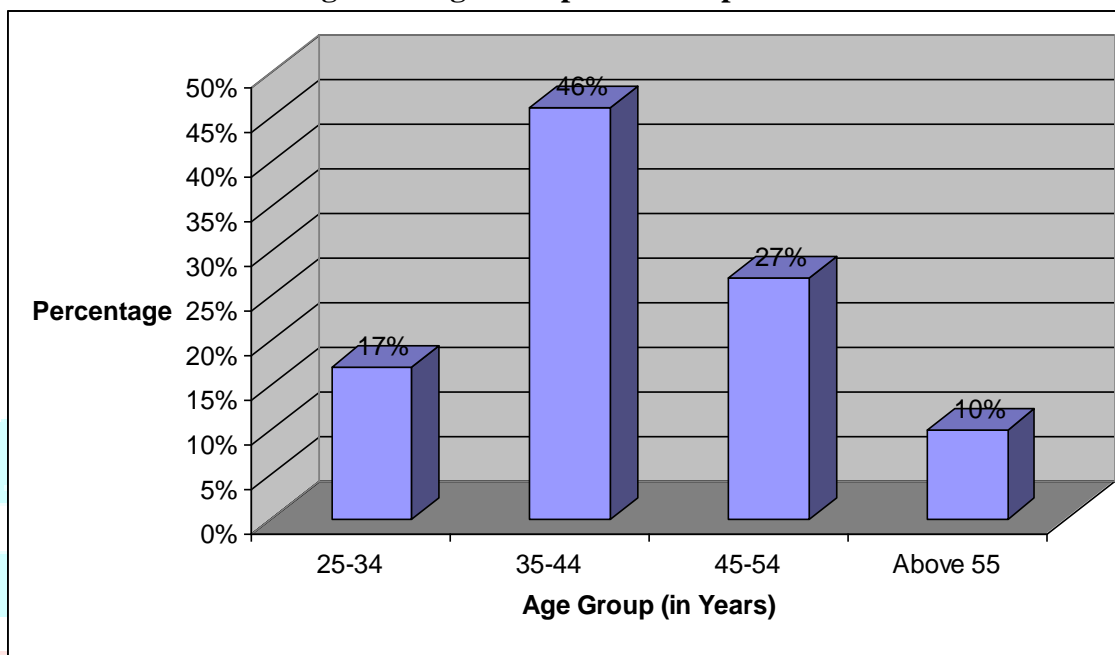
Data Analysis: The collected data were tabulated and analyzed by using Computer Program Microsoft Excel.

RESULTS AND DISCUSSION

Table 2: Age Group of the Respondents

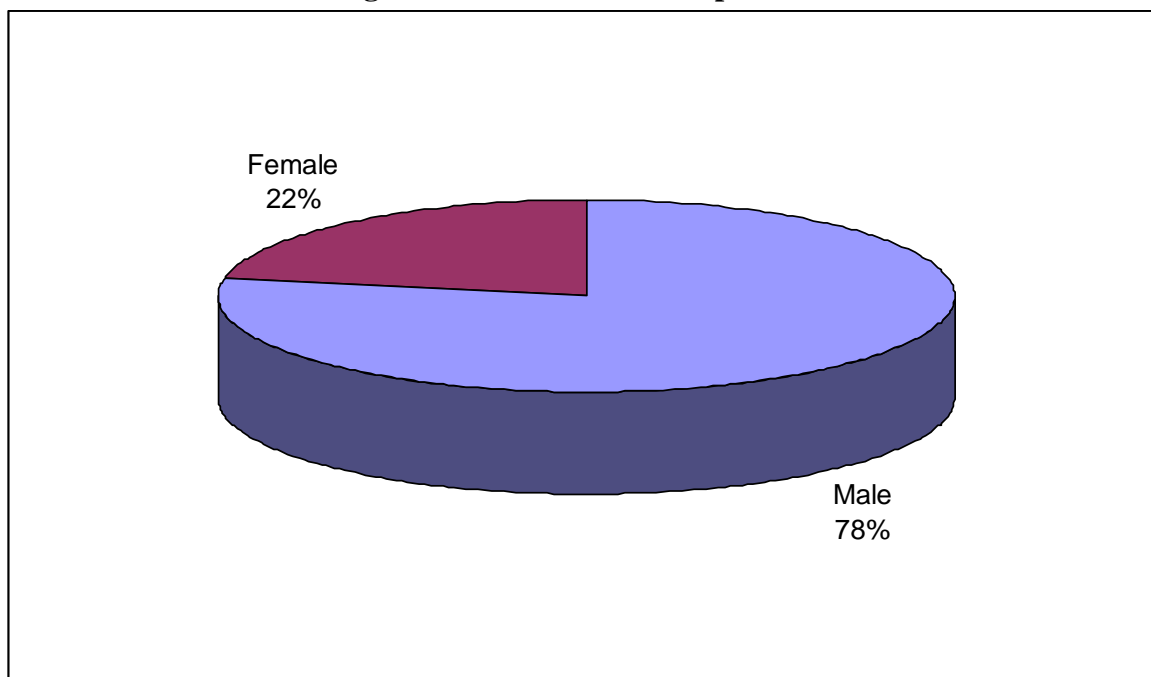| Sl. No.	Age Group	Percentage
1	25-35	17%
2	35-44	46%
3	45-54	27%
4	Above 55	10%
Total		100%

Figure 1: Age Group of the Respondents

Age groups of the respondents are described in the above graph. From the graph it was found that age group 35-44 is 46 % which is the maximum and age group above 55 is 10 % which is the minimum. Age group 25-34, 45-54 years is 17% and 27 % respectively. The selection of the participants was done randomly. It indicates that most of the elected representatives are from 35-44 age group. On the other hand, there are very little number of participants is elected from this above 55 age group.
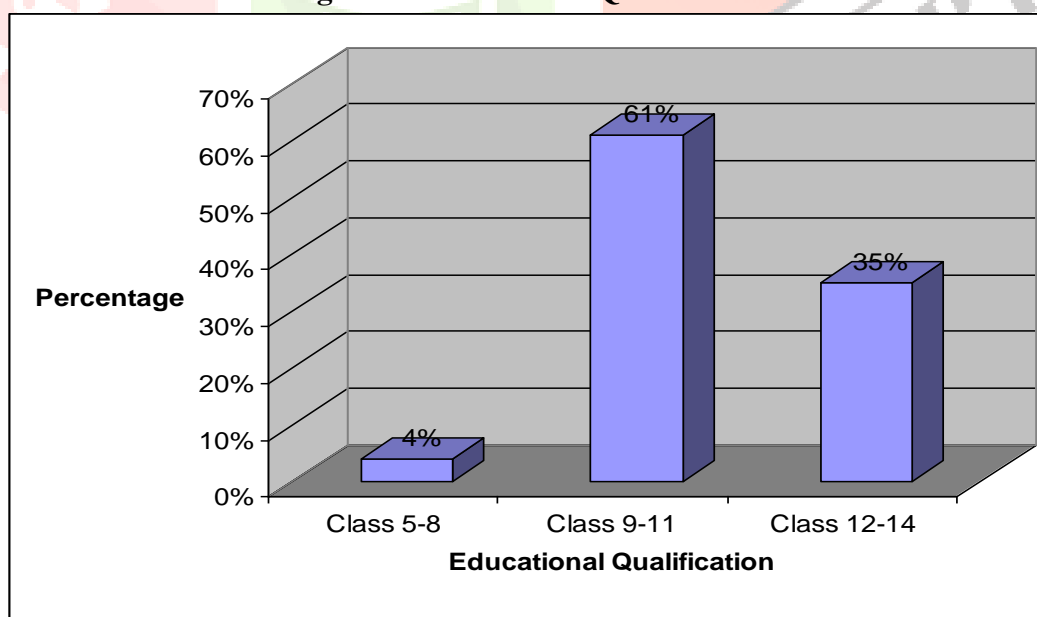
Table 3: Gender of the Respondents

Sl. No.	Gender	Percentage
1	Male	78%
2	Female	22%
Total		100%

Figure 2: Gender of the Respondents

Gender of the respondents is described above. From the graph it was found that out of 100 respondents, 78% respondents were male and 22% respondents were female.
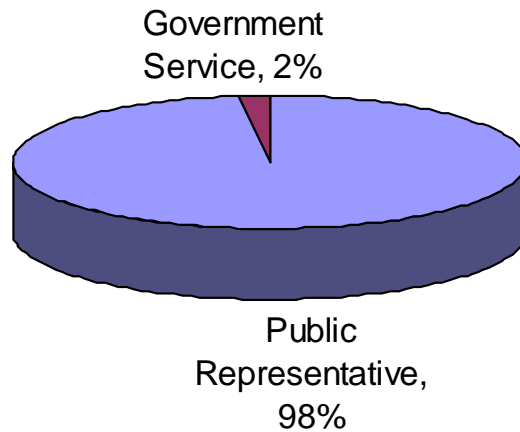
Table 4: Educational Qualification

Sl. No.	Education	Percentage
1	Class 5~8	4.0%
2	Class 9~11	61%
3	Class 12~14	35%
Total		100%

Figure 3: Educational Qualification

Educational qualifications of respondents are described above. From the graph it was found that out of 100 respondents, 61 % respondents completed class 9~11 which is the maximum and 4.0% completed class 5~8 which is the minimum and 35% respondents completed class 12~14.
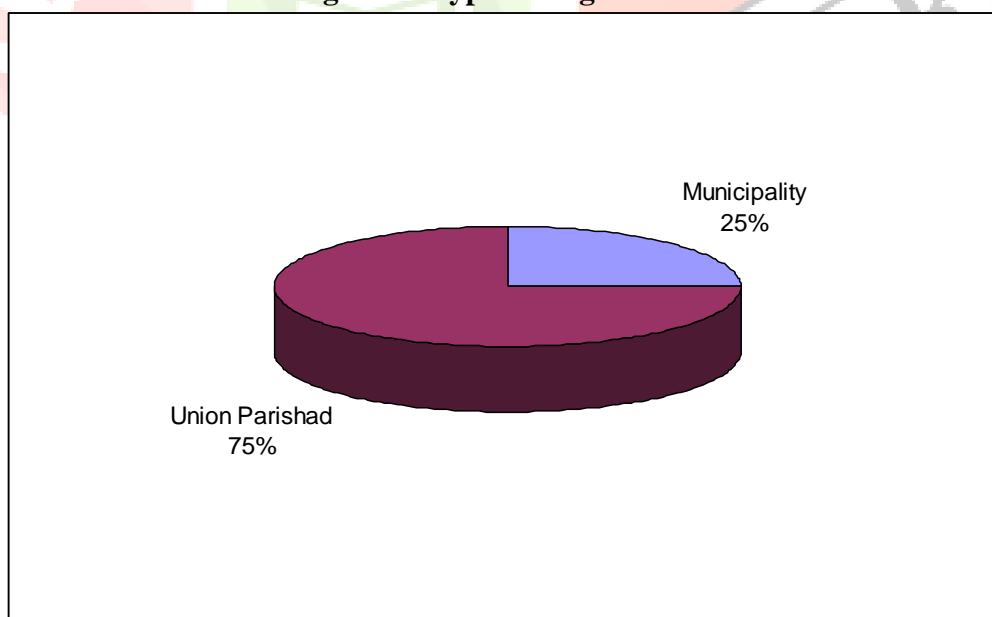
Table 5: Type of Job of the Respondents

Sl. No.	Type of Job	Percentage
1	Government	2.0%
2	Public Representatives	98%
Total		100%

Figure 4: Type of Job of the Respondents

Government Service, 2%

Public Representative, 98%

Job category of the respondents is described above. From the graph it was found that out of 100 respondents 98% respondents are Public Representative and 2.0% respondents are Government Service holder.
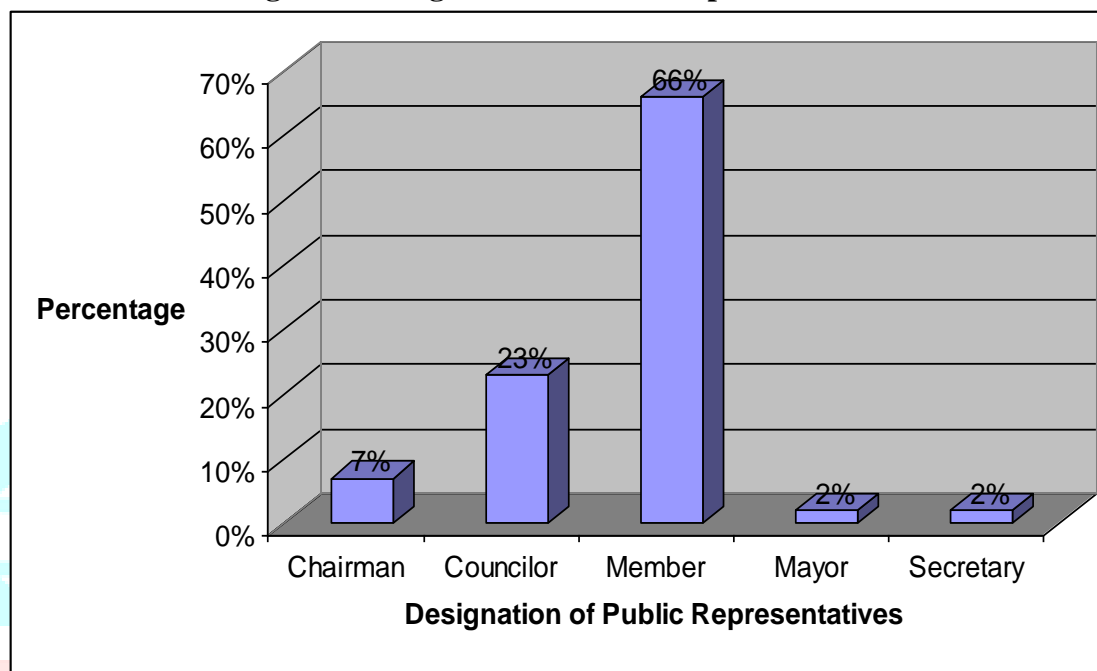
Table 6: Type of Organization

Sl. No.	Type of Organization	Percentage
1	Union Parishad	75%
2	Municipality	25%
Total		100%

Figure 5: Type of Organization

Municipality 25%

Union Parishad 75%

Category of the Organization is described above. From the graph it was found that out of 100 respondents, 75% respondents engaged in Union Parishad and 25% respondents are engaged in Municipality.
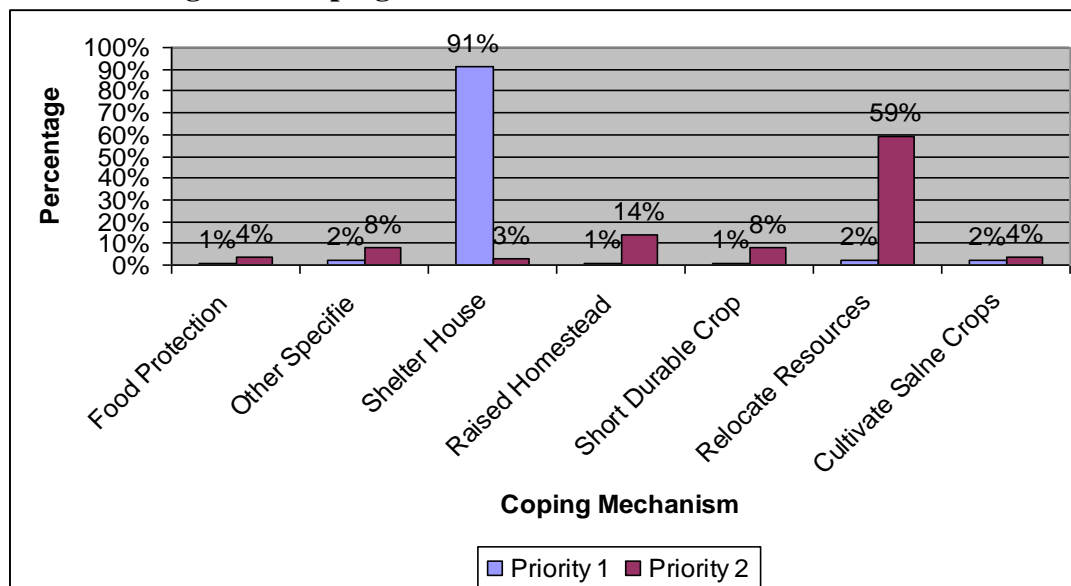
Table 7: Designation of Public Representatives

Sl. No.	Designation	Percentage
1	Chairman	7.0%
2	Councilor	23%
3	Member	66%
4	Mayor	2.0%
5	Secretary	2.0%
Total		100%

Figure 6: Designation of Public Representatives

Designation of the Public Representatives is described above. From the graph it was found that out of 100 respondents, 66% was Member of Union Parishad which is the maximum and 2.0% are Mayor of Municipality and Secretary of Union Parishad. Other representatives are Chairman of Union Parishad, Councilor of Municipality are 7.0% and 23% respectively.

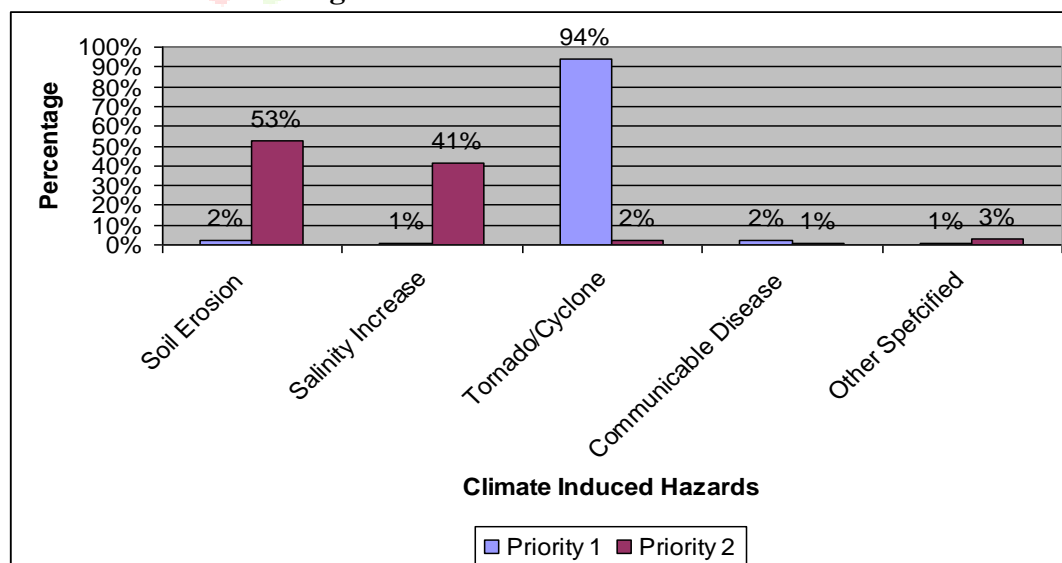**Table 8: Coping Mechanism of Climate Induced Hazard**

Category	Priority 1	Priority 2
Food Protection	1.0%	4.0%
Other Specifie	2.0%	8.0%
Shelter House	91%	3.0%
Raised Homestead	1.0%	14%
Short Durable Crop	1.0%	8.0%
Relocate Resources	2.0%	59%
Cultivate Salne Crops	2,0%	4.0%

Figure 7: Coping Mechanism of Climate Induced Hazard

Coping mechanism of the disaster prone areas are described above. Here opinions of the respondents are categorized into Priority 1 and Priority 2. From the graph it was found that in case of priority 1, out of 100 respondents, 91% respondents were agreed that Shelter House is the most effective coping mechanism against natural disaster and other coping mechanisms are Food Protection, Other Specific adaptation measure like take shelter in embankment/dam during disaster period, Raised Homestead, Short Durable Crop, Relocate Resources and Cultivable Saline Crops are 1.0%, 2.0%, 1.0%, 1.0%, 2,0% and 2.0% respectively. In case of Priority 2, out of 100 respondents, maximum 52% respondents agreed that Relocate Resources is the most effective coping mechanism against natural disaster and other coping mechanisms are Food Protection, Other Specific, Raised Homestead, Short Durable Crop, Relocate Resources and Cultivable Saline Crops are 4.0%, 7.0%, 8.0%, 17%, 8.0%, and 4.0% respectively.

Table 9: Climate Induced Hazards

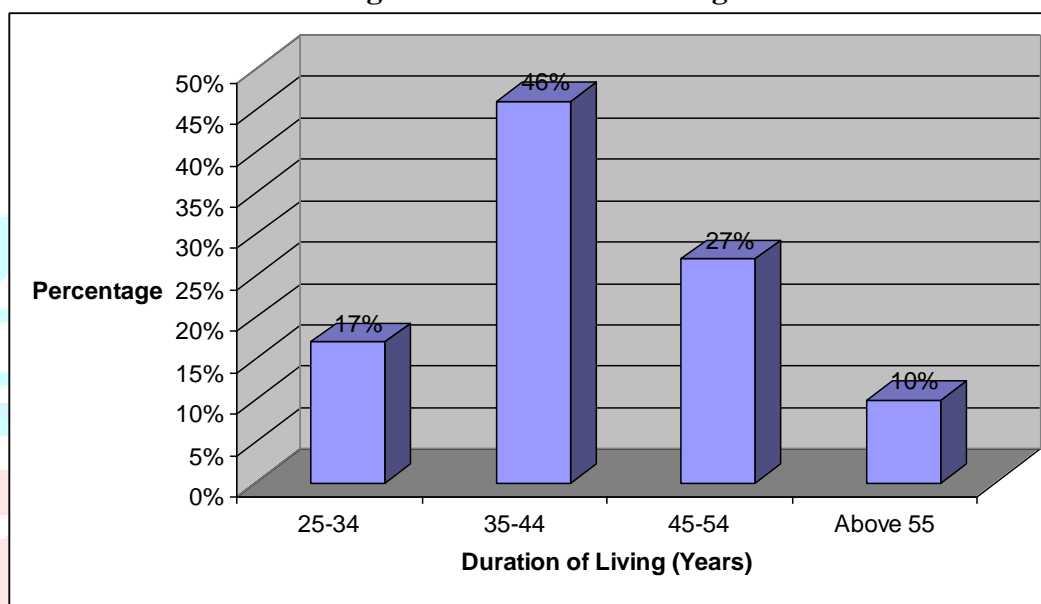| Hazards	Priority 1	Priority 2
Soil Erosion	2.0%	53%
Salinity Increase	1.0%	41%
Tornado/Cyclone	94%	2.0%
Communicable Disease	2.0%	1.0%
Other Spefcified	1.0%	3.0%

Figure 8: Climate Induced Hazards

Climate Induced Hazards are described above. Here opinions of the respondents are categorized into Priority 1 and Priority 2. From the graph it was that in case of priority 1, it was found that out of 100

respondents, maximum 94 % respondents agreed that Tornado/Cyclone is the main climate induced hazards, and other climate induced hazards are Soil Erosion, Salinity Increase, Communicable Disease and Other Specified hazards are 2%, 1%, 2%, and 1% respectively. In case of Priority 2, it was found that out of 100 respondents, maximum 53% respondents agreed that Soil Erosion is the main climate induced natural hazards and other climate induced natural hazards are Salinity Increase, Tornado/Cyclone, Communicable Disease and other Specified hazards are 41%, 2%, 1% and 3% respectively.

Table 10: Duration of Living

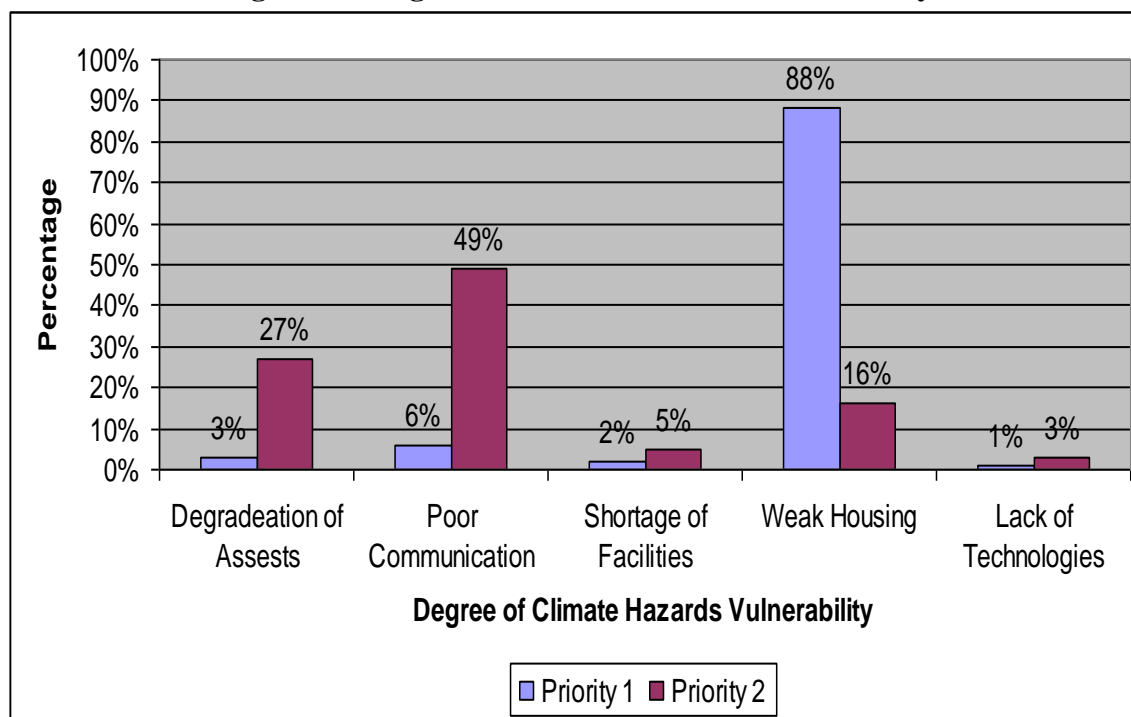| Sl. No.	Duration	Percentage
1	25-35	17%
2	35-44	46%
3	45-54	27%
4	Above 55	10%
Total		100%

Figure 9: Duration of Living

Duration of living of the respondents is described in the above graph. From the graph it was found that duration of living 35-44 years is 46 % which is the maximum and duration of living above 55 years is 10 % which is the minimum. Duration of living 25-34, 45-54 years is 17% and 27 % respectively. The selection of the participants was done randomly.

Table 11: Degree of Climate Hazards Vulnerability

Degree	Priority 1	Priority 2
Degradation of Assets	3.0%	27%
Poor Communication	6.0%	49%
Shortage of Facilities	2.0%	5.0%
Weak Housing	88%	16%
Lack of Technologies	1.0%	3.0%

Figure 10: Degree of Climate Hazards Vulnerability

Degree of Climate Hazards Vulnerability is described above. Here opinions of the respondents are categorized into Priority 1 and Priority 2. From the graph it was that in case of priority 1, out of 100 respondents, 88% respondents agreed that Weak Housing is the effect of natural disaster which is the maximum and lack of technologies is 1% which is the minimum effect of natural hazards. Other effects of natural hazards are Degradation of Assets, Poor Communication, Shortage of Facilities, Weak Housing and Lack of Technologies is 3%, 6%, 2% respectively. In case of priority 2 out of 100 respondents, 49% respondents agreed that Poor Communication is the effect of natural disaster which is the maximum and Shortage of Facilities s 1% which is the minimum effect of natural hazards. Other effects of natural hazards are Degradation of Assets, Weak Housing and lacks of Technologies are 30%, 6% and 4% respectively.

SUMMARY AND RECOMMENDATION

A study was conducted to identify the adaptation and mitigation strategies of climate induced hazards in the coastal areas and understand the climate hazards and degree of vulnerability caused by these disasters in coastal zone in Bangladesh. Adaptation to climate change is a complex topic that presents a number of challenges. This involves a process of sustainable and permanent adjustment in response to new and changing environmental circumstances. So adaptation cannot be treated as a stand-alone issue and should be premised on the following factors:

1. Vulnerability and adaptation assessments should be developed for prioritizing adaptation policies and measures. Adaptation has to be mainstreamed in investment planning both in public and private sector. Governments therefore need to devise policies, incentives, and regulation to public and private initiative toward strengthening adaptation.

2. Capacity needs to be built for both short-term and long-term adaptation planning. Innovative risk sharing mechanisms (insurance) are needed to respond to emerging challenges including biodiversity loss and land degradation.

3. Adaptation, rather than being concentrated in one sector, should essentially be dispersed across all socio-economic sectors including water, health, agriculture, and infrastructure, each of which presents in own challenges, and will involve stakeholders in different if overlapping groups. Adaptation measures are likely to be less capital intensive and more amenable to small scale interventions.

4. More Shelter Centers should be built to give shelter during the natural hazards.

5. Living house should be built in such a way so that the houses can resist the tidal surge and cyclones.

6. Governmental institutions (ministries, governmental organizations and agencies), private entries and NGOs should consider integrating climate change in their planning and budgeting at all levels of decision making and coordinate their actions among themselves.

7. Vulnerability and adaptation assessments should be developed for prioritizing adaptation policies and measures. Adaptation has to be mainstreamed in investment planning both in public and private sector.

Governments therefore need to devise policies, incentives, and regulation to public and private initiative toward strengthening adaptation.

Still many climate change impacts timing and exact magnitude are uncertain. Hence, the strategy and Action Plan will require periodical revision. The following enhancements should be considered by Government of Bangladesh to their policies and programs:

1. Adopt meaningful, achievable climate change targets.
2. Pursue strong, biding emissions targets in international negotiations.
3. Ensure commitment of developing countries fair share to climate change adaptation for Bangladesh.
4. Education, training and public awareness.
5. Seeking more support for climate change mitigation and adaptation research: The Government of Bangladesh should look for increased funding support to research into innovative technologies including renewable energy, understanding climate change dynamics, carbon capture and sequestration, energy efficiency, crop varieties, and other adaptation and mitigation innovations.
6. Encourage environmental solutions in other counties.
7. Collaborate with our neighbors who are victim of climate change.

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