Capacity Assessment of Public Institutions for Climate Change Adaptation: Evidence from Coastal Districts in Bangladesh

Doctor of Philosophy

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April 2026

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A Dissertation Submitted to the University of Dhaka (DU) for the Degree of Doctor of Philosophy in Public Administration

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Session: 2020-2021

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April 2026

Certificate of Supervisor

This is to certify that AISHA JAHAN (Reg: 141/2020-2021) have completed this PhD dissertation entitled "Capacity Assessment of Public Institutions for Climate Change Adaptation: Evidence from Coastal Districts in Bangladesh" under my supervision. To the best of my knowledge, this thesis has not been previously submitted, either in whole or in part, to any other university or institution for the award of any degree, diploma, or its equivalent.

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Declaration

I hereby declare that this PhD dissertation, entitled ‘Capacity Assessment of Public Institutions for Climate Change Adaptation: Evidence from Coastal Districts in Bangladesh’, was completed under the guidance of Professor Dr. Naznin Islam, Department of Public Administration, University of Dhaka, for the degree of Doctor of Philosophy. The intellectual content of this thesis is the product of my own work, and this is not submitted elsewhere for any other degree or academic purpose.

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Acknowledgements

First and foremost, I am obliged to the Almighty Allah (SWT), the Most Beneficent, the Most Merciful, for His kind blessings in enabling me to complete my research pleasantly.

I would like to express my deepest gratitude to my supervisor, Professor Dr. Naznin Islam, Department of Public Administration, University of Dhaka, for her invaluable guidance, monitoring, and support throughout the entire period of my research. Her constant encouragement, attention to detail and constructive advice motivated me to work hard, boosted my confidence and helped me to produce a robust research output. Her expertise and insightful feedback have been instrumental in shaping this thesis.

I am also grateful to the members of my PhD thesis committee for their insightful comments and suggestions. I would like to thank the faculty members of the Department of Public Administration, University of Dhaka, for their valuable recommendations during the presentations of my research work at two seminars organised by the department in 2023 and 2025, respectively.

I am especially thankful to the Director General and all the assigned officers of the thirteen (13) institutions under the Ministry of Agriculture (MoA), the Ministry of Environment, Forest and Climate Change (MoEFCC), and Bangladesh Krishi Bank, for their support. I am also grateful to the Deputy Directors in the districts, the Agricultural Scientific Officers, and the field-level Officers I consulted during my study for their steadfast cooperation and support, which facilitated the completion of my job. I am grateful to all the respondents who provided their valuable feedback.

This research work is funded by the University Grants Commission of Bangladesh (UGC) under the UGC PhD Fellowship 2021-2022 program. I would like to acknowledge the financial assistance and tremendous support provided by the University Grant Commission of Bangladesh (UGC), in particular, the Research Support and Publication Department, for granting me the prestigious PhD Fellowship to pursue my research.

Finally, I am deeply indebted to my family, especially my Parents, my sister Mridula, and my son Hamim, for their unwavering love, support and encouragement. Without all of you, this achievement would not have been possible. Thank you all!

Aisha Jahan

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List of Abbreviations

BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BCCRF	Bangladesh Climate Change Resilience Fund
BCCTF	Bangladesh Climate Change Trust Fund
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BDP	Bangladesh Delta Plan
BRRI	Bangladesh Rice Research Institute
CBAA	Community-Based Agricultural Adaptation
CC	Climate Change
CCA	Climate Change Adaptation
CCU	Climate Change Unit
CSO	Civil Society Organisation
DAE	Department of Agricultural Extension
DOE	Department of Environment
DPP	Detailed Project Proposal
FAO	Food and Agriculture Organisation of the United Nations
FGDs	Focus Group Discussions
GCMs	Global Climate Model
GoB	Government of Bangladesh
HYV	High-Yielding Variety
ICA	Index-based Capacity Assessment
ICI	Institutional Capacity Index
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute

LGED	Local Government Engineering Department
MoA	Ministry of Agriculture
MoEFCC	Ministry of Environment, Forest and Climate Change
MoWR	Ministry of Water Resources
NAEP	National Agricultural Extension Policy
NEMAP	National Environmental Management Action Plan
NAgP	National Agricultural Policy
NAPA	National Adaptation Programme of Action
NARS	National Agricultural Research System
NGOs	Non-Governmental Organisations
NWP	National Water Policy
SAAO	Sub-Assistant Agricultural Officer
SDG	Sustainable Development Goals
SLR	Sea Level Rise
SSI	Semi-structured Interview
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

Abstract

The government of Bangladesh has introduced a wide range of climate change adaptation programmes to reduce vulnerability and tackle the impacts of climate change on agriculture, fisheries, livestock, and health in coastal areas. It also emphasises capacity building of the relevant public institutions. Assessing the capacity of institutions to meet the challenges in terms of knowledge and perception, resource availability, coordination, and collaboration requires understanding the impacts and vulnerabilities of climate change. In this context, this research examines key sectoral impacts of climate change, especially on agricultural production in coastal areas in Bangladesh, to address climate change-induced challenges such as sea level rise, salinity intrusion, flooding, coastal erosion, temperature rise, changing precipitation, and coastal waterlogging. Furthermore, it aims to evaluate the capacity of the public institutions and the challenges for agricultural adaptation strategies in the coastal areas in terms of knowledge and perception, resource availability, coordination, and collaboration, training obtainability and information access. A number of policies exist on paper, but there is a gap in understanding how well these policies are implemented and whether institutions have the actual capacity, such as resources, coordination, and skills, to carry them out.

The study has been conducted on the thirteen public institutions working under the Ministry of Agriculture, the Ministry of Water Resources, and the Ministry of Environment, Forest and Climate Change in two coastal districts, Cox's Bazar and Patuakhali, due to their vulnerability to climate change and their distinct agricultural production. Drawing on the policy and document analysis, key informant interviews and focus group discussions, the research identifies both progress and limitations of the institutions' responses to climate issues. The research methodology was a mixed-methods approach, and data were collected through semi-structured interviews with officials and stakeholders from the

Upazila to the district level. This study draws on a range of theoretical approaches to produce a comprehensive assessment of institutional adaptive capacity.

The findings indicate that the impacts of climate change are visible in coastal agricultural production. The public institutions have mandates to adapt to address the challenges of climate change in coastal production. Decrease in production, crop yield loss, insect infestation, a decrease in soil fertility, drought and excessive water logging, loss of topsoil, are identified by the respondents as significant impacts of the coastal region, directly affecting the harvest quality and production quantity. Although Bangladesh has developed adaptation practices in the coastal areas, the adaptive capacity of public institutions is constrained by limited resources, technical capacities, difficulties in accessing information and weak inter-institutional coordination. The findings of the study showed that public institutions have made significant progress in integrating climate change issues into their plans, programs, and policies, and that there is an adequate level of cooperation amongst them. However, institutional, financial, and technological limitations continue to impede their overall adaptive capacities, which are inconsistent. The study identifies fragmented coordination, insufficient machinery and technical knowledge, and limited financial resources as the main obstacles to efficient coordination. The results show that the public institutions have a moderate level of preparedness and capacities in climate change adaptation and climate risk management.

In conclusion, the research findings provide a distinctive explanation of the variables used in the index assessment framework and emphasise the need for strengthening institutional capacity and improving cross-sectoral collaboration. Mainstreaming the institutional assessment for climate change adaptation in coastal agriculture may consider these research findings to explore the institutional adaptive capacity in the context of a developing country. Finally, the study highlights the necessity of bridging the gaps to enable institutions to

successfully deal with the implications of climate change on the agriculture sector, particularly in coastal Bangladesh.

Keywords: Climate Change Adaptation, Adaptive Capacity, Coastal Districts, Agricultural Adaptation, Public Institutions.

Chapter One

Introduction

"Climate Change is a development, economic and investment challenge"

Robert Zoellick, President, World Bank (2007)

Chapter Summary

This chapter introduces the background of the study, the problem statement, the research rationale, and the significance of the study. It presents the research questions, states the study's objectives, and outlines the study's structure by indicating the direction of subsequent chapters.

- *Introduction*
- *Background of the study*
- *Significance of the Study*
- *Research Questions*
- *Research Objectives*
- *Structure of the Thesis*

Introduction

Climate change, a significant global challenge with severe consequences for vulnerable countries like Bangladesh (IPCC 2022, MoEFCC 2012, NAP 2022, Paul and Rashid 2017, Hardy 2003), is now a relatively new field of policy development. Bangladesh is highly exposed to climate-induced risks due to its unique geographical location (Hossain, 2011), low-lying deltaic terrain, poor institutional setup, and dependence on climate-sensitive agricultural sectors like crops, fisheries and livestock (Huq, 2011; Alam et al, 2017). Instead, it is vulnerable to extreme weather events, including floods, sea level rise, erratic rainfall patterns, tropical cyclones with storm surges, river bank and shoreline erosion, saline intrusion, and droughts due to its topographical position and geomorphic landforms (Ali, 1996). Such catastrophes occur frequently and endanger infrastructure, public health, food security, and livelihood (Hossain et al. 2010). These climate-induced challenges reinforce the necessity for effective climate change adaptation strategies and elevating climate change adaptation as a national priority to reduce vulnerability and increase resilience.

Climate change has an influence on everyone throughout the world, but it is widely acknowledged that the poorest people in developing countries are the ones who need the greatest assistance for adaptation (Adger, Huq, Brown, Conway, & Hulme, 2009; Ayers & Dodman, 2010; Burton, 2004; Huq & Ayers, 2007; IPCC, 2007; Schipper, 2007). The coastal zone is being continually attacked by cyclones, sea level rise, and storm surges, which have caused terrible impacts on this low-lying coastal area (Ahmed, 2019). The possible effects of climate change on agriculture, water, fisheries, and livestock include: the loss of productive agricultural land due to saline intrusion; coastal erosion; inundation; sea level rise; increased draught; an increase in the frequency of floods; a decrease in aquaculture production due to floods; a reduction in freshwater fish habitat due to saline water intrusion; a decrease in milk production; a loss of suitable land for livestock; and an increase in cattle mortality due to extreme climate events (Zamudio, 2016). Increasing institutional partnership among public, private and civil society institutions, enhancing institutional capacities, understanding the institutional articulations and access patterns before supporting funds, improving institutional coordination, focusing on territorial strategies and adopting integrated climate risk management will lead towards effective adaptation (Agrawal, 2008).

Bangladesh nowadays is responding to the challenges of climate change through a range of adaptation initiatives. Strong institutional frameworks are the most appropriate prerequisite for Bangladesh to implement national climate change adaptation policies. The initial apprehension about environmental degradation and the impacts of climate change on development potentials is placing tremendous pressure on governments to scrutinise their vulnerabilities as well as their requirement to undertake probable adaptation strategies. The government of Bangladesh has developed national adaptation policies and strategies, including BCCSAP (2009), NAPA (2005, updated 2009), and Delta Plan 2100, identifying the priority areas for crucial and immediate action plans focusing on resilient agriculture, comprehensive disaster management, water resource management, capacity building and infrastructural development.

Despite significant progress in climate change adaptation policies and strategies, adaptation efforts in Bangladesh face substantial challenges and still struggle with resource constraints, coordination gaps, weak institutional support and the need for stronger policy implementation (Bhuiya, 2015; Ragasa et al, 2013; Rahman, 2018; Islam, 2017; Ishtiaque et al, 2021). In addition, the institutional rigidity and non-inclusiveness of bureaucratic institutions undermine the efficiency and effectiveness, while the existing policy obstacles weaken institutional responses to climate change impacts (Rahman and Hickey, 2019). Poor institutional and technical capacities, knowledge gaps, a lack of adequate research, and a lack of attention to developing a capable organisational structure are recognised as the main constraints to adaptive agricultural development (Wang et al., 2017).

With the increasing impacts of climate change, the mandate for existing governance structures to restructure and perform more effectively is also increasing nowadays. International consideration and financial support for climate change adaptation endow the opportunity for strengthening organisational, institutional and human capacity. Assessments of impacts and vulnerability constitute the foundation for adaptive capacity assessment in climate change research (Fussel and Klein 2006). Evaluating adaptive capacity to climate change is essential for understanding vulnerability and developing effective strategies. Building institutional capacity is a crucial component of climate change adaptation (CCA), and developing such capacity is extremely challenging in a developing country like Bangladesh, where resources are inadequate (Burton 2009, Willems 2004). There is a dichotomy between the need for strategies for climate resilience and the capability of the government to do so. The policy gap and imprecise climate fund distribution get in the way of effectively addressing the problem of climate change. Though the institutions are considered the focal point for policy formulation and implementation for climate change adaptation, they are not capable of having enough resources to match their mandates.

The study is structured around three three-tiered frameworks. At first, this research illustrates the recent trends of climate change and the key sectoral impacts of climate change on coastal areas are identified. The most vulnerable sectors with the highest adaptation priorities are classified according to the level of susceptibility. Secondly, it explores the capacities of institutions as well as the challenges in dealing with climate adaptation strategies. The study tries to find out the roles and responsibilities of public institutions, as well as the coordination and collaboration to involve NGOs and community-level organisations in climate resilience under the changing climate scenario.

Different studies have found that a lack of skilled human resources and technical support slows down the effective implementation of adaptation strategies. The coordination gaps among the institutions are hampering the adaptation process. Finally, an in-depth assessment of the institutional adaptive capacity in terms of resource availability and institutional cooperation is conducted.

Background of the study

Climate change is no longer something that will happen in the future; it is here and now. With notable fluctuations in the average global temperature across geological time, Earth's climate is constantly changing due to a combination of natural causes like volcanic eruptions, changes in orbit, and variations in solar radiation, as well as human activities like the burning of fossil fuels, deforestation, and the significant rise in greenhouse gas emissions during the Industrial Revolution. It is evident that the world has warmed by about 0.5℃ (Warrick et al. 1994). Since 1850, Earth's temperature has increased by an average of 0.11° Fahrenheit (0.06° Celsius) per decade; since 1982, the pace of warming has increased by more than three times, at 0.36° F (0.20° C) each decade. The surface temperature was 1.87 degrees Fahrenheit warmer than it was before industrialisation and 1.51 degrees warmer than it was on the 20^{th} (NOAA 2024, IPCC 2021). This increase in world temperature induces severe consequences of climate change, including rising sea levels, increased frequency and intensity of natural hazards, unpredictable rainfall patterns, and prolonged periods of flooding and drought, which pose significant threats to food security, public health, and the livelihoods of millions, particularly in coastal and rural areas (IPCC, 2014, MoEF, 2012). Bangladesh has experienced more susceptible circumstances in precise ways compared to global climate change. Bangladesh is one of the largest deltas in the world, which is highly vulnerable to climate change (NAP, 2023-2050).

River and rainwater flooding affect almost two-thirds of the land area, while storm surges and tidal floods can occur along the coastline. Sea level rise, increased monsoon precipitation, and glacial retreat are the most likely consequences for the country due to these factors. According to the National Adaptation Plan of Bangladesh (2023-2050), the main impacts and vulnerabilities of climate change on coastal areas in Bangladesh are: 1) excessive rainfall with potential impacts on water resources, agriculture, wetlands and biodiversity resources, 2) extreme heat with loses in crop production, a decrease of perennial water bodies and wetlands, loses in fisheries production, 3) increased salinity with impacts on groundwater availability, crop damage, unfavourable habitat for freshwater fishes, disappearance for biodiversity, 4) sea level rise with inundation of potential land area, low crop yields and habitable lands etc. Bangladesh's coastal areas and water resources are very susceptible to the detrimental impacts of climate change, attributable to the country's extensive coastline, low-lying landscape, and numerous river basins. Besides, agriculture, fisheries, livestock, ecosystem, human health and infrastructure are anticipated to be seriously aggravated by climate change. Hundreds of thousands of people could be forced to leave coastal communities and relocate to urban areas as a result of rising sea levels, river bank erosion, and coastal saltwater intrusion (MOEF, 2012). In the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC), experts suspected that due to global warming, 10-15% of Bangladesh’s land could be inundated by 2050, resulting in over 27 million climate refugees from the coastal districts (IPCC, 2014). The number of climate refugees will increase, trigger conflict among different social groups and break down the food and habitation security both at the national and local levels (The Daily Star, 2019).

Around thirty-five million people who are living in nineteen coastal districts of the country are at the highest level of climate risk. The coastal zone of Bangladesh covers an area of 47,201 km^2, 32% of the country’s landmass, and represents about 29% of the population.

It consists of nineteen districts that are Jessore, Narail, Gopalganj, Shariatpur, Chandpur, Satkhira, Khulna, Bagerhat, Pirozpur, Jhalakati, Barguna, Barisal, Patuakhali, Bhola, Lakshmipur, Noakhali, Feni, Chittagong, and Cox's Bazar, comprising 147 Upazila. The coastline is 710 km long and is composed of the interface of various ecological and economic systems, including mangroves (the world's largest mangrove forest covers 6,017 km^2) and tidal flats. Estuaries, sea grass, about 70 islands, accreted land, beaches, a peninsula, rural settlements, urban and industrial areas, and ports. Many of the coastal inhabitants are poor, and the populations are exposed to both climate-induced natural disasters and man-made hazards (Ahmad, 2019). The coastal district presents a range of vulnerabilities which cause loss of life, damage to infrastructure and economic assets, and adversely impact lives and livelihoods, especially of poor people. Therefore, there is experience in managing climate risks, including those that will be exacerbated by a changing climate.

Table 1: Comparison of Global Climate Change with Bangladesh (Source: Global Climate Highlights by ECMWF, 2024; World Bank Group Climate Data)

Region	**Annual Mean Temperature (1940-2024) JRA3Q**	**Sea Surface Temperature (1991-2020) ERA5**	**Annual Mean Precipitation (1991-2024)**
Global	+1.57	0.66	Increase over land of 30°N & decrease in the tropical region
Bangladesh	+1.1	0.76	5.45%

Mitigation through the reduction of greenhouse gases and adaptation through necessary adjustments to cope better with climate stresses in the long term represent two areas of human responses to the consequences of climate change (Brooks, 2003; Fussel, 2005; IPCC, 2007; Preston & Stafford-Smith, 2009; Jahanzad et al., 2020). The average temperature has been gradually increasing over the past few decades, with increases of 0.39°C from 1991–2000, 0.53°C from 2001–2010, and 1.06°C from 2011–2019 (CEGIS, 2022). Bangladesh will be 0.5% to 2.0% warmer by the year 2030 (IPCC, 1990), and 2013 to 2023 were found to be the 10 warmest years. Alongside global efforts to mitigate greenhouse gas emissions, adaptation is essential. As the consequences of climate change continue to intensify, effective adaptation remains more crucial compared to before. If the world becomes successful in reducing greenhouse gas emissions, climate change will continue to impact our lives for over a century, since it persists due to current emission levels. Addressing the detrimental effects of climate change and adopting the necessary steps to prevent or lessen the impact requires adaptation measures. However, adaptation is still receiving less attention and is seen as a passive reaction rather than mitigation, even if it is given priority by international players (Raman et al. 2012; Smit et al. 1999; Paavola and Adger 2006; Adger 2007). A significant agreement to address climate change was established in 2015 by the Paris Agreement (COP 21), which focused on increasing resilience, decreasing vulnerability to climate change, and enhancing adaptive capacity. The agreement aims to engage all parties globally in adaptation, including by formulating and implementing the National Adaptation Plan (NAP) describing the priorities, needs, plans and actions for effective climate resilience (UNCC, 2015).

Adaptation has become crucial in social research in order to correctly assess the impacts or risks of climate change and to respond directly (Fankhauser, 1996; Pittock & Jones, 2000; Smit et al., 1999; Tol et al., 1998; UNEP, 1998; Yohe et al., 1996; Smit & Pilifosova, 2001, p. 881 Kane & Shogren, 2000; Pielke, 1998; Smith, 1996). IPCC describes adaptation as the *'…adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices and structures to moderate potential changes or to benefit from opportunities associated with climate change'* (Smit & Pilifosova, 2001, p. 879). IPCC signifies assessing the impacts of climate change, identifying adaptation options, and enhancing adaptive capacity for effective climate change adaptation. IPCC summarizes adaptive capacity as the potential adaptation variable means the capability of a system, region, or community to adapt to the effects or impacts of climate change to condense vulnerability and promote sustainable development (Goklany, 1995; Burton, 1997; Cohen et al., 1998; Klein, 1998; Rayner and Malone, 1998; Munasinghe, 2000; Smit et al., n.d.).

A number of factors are affecting and encouraging adaptation actions. The degree of adaptive capacity of communities or nations is influenced by several factors, including socio-economic resources, physical and material resources, infrastructure, natural resources, technology, the availability of new technologies, social and economic development, people's willingness to change their behaviour, networks and social capital, governance structures, and the ability of institutions. (Smit and Pilifosova 2003; Berkhout 2005; Adger et al. 2003; Klein et al. 2007; Engle and Lemos 2010).

Some closely interconnected determinants of adaptive capacity include financial resources, technology, information and skills, infrastructure, institutions, social capital and equity, which are substantial to take into account in capacity assessment to adapt to climate change (Smit and Pilifosova 2001, 2003).

Institutions are considered the progressive and proactive determinants in coping with the projected impacts of environmental change. Institutional frameworks are considered the key part of governing human response that organises all forms of repetitive and structured interactions (Ostrom, 2005). Public Institutions can play an important role in addressing the impacts of Climate change. In Bangladesh, the Ministry of Environment, Forest and Climate Change (MoEFCC) is considered the focal point for all work on climate change, including international negotiations. The ministry, along with its different agencies, is mainly concerned with policy strategies and action plan preparation, coordination among the ministries, national and international representation of Bangladesh in climate adaptation, mitigation, technology transfer, financing and public awareness (Annual Report, MOEF, 2012-13). According to the revised Bangladesh Climate Change Strategy and Action Plan 2009 developed by the MoEFCC, the climate change action plan of the government is built on six major pillars i) to ensure food security, social protection and health security for the poorest and most vulnerable in climate change, ii) to compare disaster management system in order to strengthen it for frequent and severe disasters, iii) to maintain and develop urgent infrastructural (coastal and river embankments, cyclone shelter, urban drainage) assets, iv) to develop research and knowledge management to predict impacts, v) to mitigate and emit low carbon and vi) finally, to strengthening and capacity building of national, local, private and civil society institutions to meet the challenges of climate change. Climate change is habitually an extremely localised affair. Areas of close geographical proximity face very different adaptation challenges and thus require very different time and location-specific responses.

Furthermore, the impacts of Climate Change are different for women and children, rich and poor, old and young, and differ among the professions and livelihoods. These confined variations require more knowledge and the ability to mobilise people and resources. As a result, the involvement of institutions as well as people is the prerequisite for adaptation.

The government can interface with climate change via three main instruments: i) planning and regulations, ii) delivering goods and services and iii) fiscal revenues. So, the climate issues can be highly addressed with the involvement of public institutions, people, private organisations, NGOs and civil society also (MOEF, 2012).

In recent years, climate-induced vulnerabilities have exerted enormous pressure on governance structures that are closest to the people, but they lack the capacity to meet the challenges. Bangladesh is among the countries that are expected to be worst affected by climate change (MOEF, 2013). And the coastal districts of Bangladesh are at the highest level of climate risk. The government coerces the risk and takes the policy as well as the institutional arrangements. To address climate change, different policies, strategies, and action plans are in place, but the main challenge remains in the implementation. At the national level, there are a number of climate risk management structures, including a fully-fledged Ministry with agencies and committees right up to the Upazila level. Low adaptive capacity and inadequate institutional access also make the situation more vulnerable. The government has strong mandates but lacks technical resources, limited information, inadequate coordination among actors and a lack of funding are the common challenges to implementing those mandates. Governance is the manner in which power and resources are used towards the realisation of development objectives. Good governance entails efficient and effective use of power and resources to bring about desired developmental outcomes.

Significance of the Study

Bangladesh has been listed as the 7th most vulnerable country in the world due to climate change, based on the vulnerability of the coastal people (IPCC 2014). Southeast Asian mega deltas, particularly the Ganga-Brahmaputra river basin, would be extremely vulnerable to future floods.

By the twenty-first century, agricultural yields in East Asia are expected to rise by up to 20%, while in Central and South Asia, they could decrease by up to 30%. (IPCC 2007). Those densely populated and low-lying countries in the South Asian region where adaptive capacities are relatively low are identified as the most vulnerable countries to the effects of climate change by the IPCC.

In recent years, the government of Bangladesh (GOB) highlighted the numerous ways in which water, agriculture, fisheries, livestock, human health, ecosystems and forests, infrastructure, and urban areas are vulnerable to the effects of climate change (MOEF, 2012). Loss of productive agricultural land due to saline intrusion, coastal erosion, inundation, sea level rise, increased draught, increased number of floods, depleted freshwater fish habitats as a result of saltwater intrusion; reduced milk production; decreased access to adequate agricultural land for livestock; and elevated cattle mortality as a result of extreme weather conditions are the likely impacts of Climate Change on agriculture, water, fisheries and livestock. Additionally, damage to highways and railways due to flooding increased urban floods and drainage congestion, increased flash floods and landslides due to urban development, and increased water and air-borne diseases such as malaria, cholera, and diarrhoea are the multiple impacts on human health, infrastructure and urban centres due to climate issues (Zamudio, 2016).

In Bangladesh, the Gross Domestic Product (GDP) per capita is $2551 (World Bank Report, 2023) and based on the report of the Bangladesh Bureau of Statistics (BBS), the contribution of agriculture to the total GDP is 11.89 per cent. According to the Asian Development Bank (ADB), Bangladesh could lose up to 16.2 per cent of its Gross Domestic Product (GDP) by 2070 because of high temperature-driven productivity, 15.4 per cent to rising sea levels and up to 8.2 per cent to river-based flooding (ADB, 2025). The country's average precipitation pattern is projected to increase by 17.1 per cent (Almazroui et al. 2020) and the global annual mean temperature is projected to increase by 1.5°C, 1.8°C, 2.7°C, 3.6°C and 4.4°C under the SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5 scenarios by 2100 respectively (IPCC 6th Assessment Report, 2021).

The climate vulnerabilities in the coastal area are very high due to the combination of sea level rise, an increase in saline intrusion from freshwater sources, and an increase in cyclones and storm surges (BCCSAP, 2009). In addition, the coastal land is exclusively used for agriculture, fisheries, salt production, infrastructure and tourism, which enhances the loss of arable lands, and terrestrial and aquatic habitats such as mangrove forests, wetlands and tidal floods. The susceptibilities of coastal populations in Bangladesh are increased by these losses of arable lands, natural catastrophes brought on by climate change, exposure to the Bay of Bengal, and the precarious socioeconomic status of the coastal communities (Islam, 2004; Mahmood and Mahbub, 2018).

Bangladesh, like several South Asian nations, experiences significant difficulties in effectively addressing the growing threats associated with climate change. The country is working to minimise the consequences by formulating adaptation policies and strategies, enhancing institutional adaptive capacity, and developing international collaboration for technical and financial support. Several studies highlighted the proactive nature of Bangladesh's governance, particularly through the formulation of key policy documents such as the BCCSAP 2009, NAPA, and Delta Plan 2100, highlighting food security, disaster management, and infrastructure resilience in delta regions (GED, 2018), reflecting Bangladesh's commitment to international climate frameworks, including the Paris Agreement (NAPA, 2005).

In order to address the crucial and urgent need for climate change adaptation, a number of adaptation programs were proposed and taken into implementation in response to international policy and financial incentives, as well as to enhance the capacity of the ministries and institutions involved in implementation. BCCSAP is considered the main national planning document for climate change action in Bangladesh that prioritises capacity building and institutional strengthening as obligatory for successful adaptation (BCCSAP, 2009). Two major trust funds, BCCTF, funded by the Government of Bangladesh and BCCRF, funded by several donors, were established to support the implementation of BCCSAP (Pervin, 2014).

Acknowledging the negative impacts of climate change and promoting sustainable planning for future development, the government of Bangladesh integrated the information, policies, and measures to address climate change into ongoing development planning and decision-making. Moreover, mainstreaming climate change into development planning persuades us to understand the institutional adaptive capacity for successful adaptation in vulnerable regions like Bangladesh (Huq et al., 2004; Klein, 2008; OECD, 2009). Various disparities regarding institutionally effective responses lead towards unstable adaptation outcomes. Institutions with strong adaptive capacity can respond better to risk management, reducing vulnerabilities, and increasing community resilience to climate hazards. The study of integrated sector-wise assessment of institutional adaptive capacity helps to identify gaps in policy, coordination, resources, and governance that need to be addressed to make adaptation strategies more effective and sustainable. It is significant because it highlights the enabling and constraining factors within institutions that affect their ability to respond. It is anticipated that the study will give some policy inputs to increase the institutional capacity. In addition, future researchers will obtain some ideas to carry out research in this relevant field.

The research findings will contribute to the existing institutions in building resilient agriculture in the coastal regions. It will identify the pathways for strengthening governance and promoting resilience. Understanding the institutional strengths and weaknesses supports targeted investments in training, infrastructure, and stakeholder engagement; the findings will help to provide evidence-based insights for designing adaptive policies that are responsive to local contexts and changing environmental conditions. Institutional capacity assessment will help policymakers to design risk reduction strategies and encourage coordination, reducing governance gaps in climate programs. Specifically, it will contribute in the following ways.

Firstly, by obtaining data from thirteen different institutions working on the implementation of agricultural adaptation in two coastal districts, which are highly vulnerable to climate change hazards, this study will attempt to identify and understand how the institutions are responding to address the vulnerability and the strengths and weaknesses of the relevant institutions for designing effective and evidence-based adaptation strategies.

Secondly, by analysing the strengths, limitations, and difficulties within the current institutional framework, the study will provide insight into the factors contributing to the success and failure of adaptation programs.

Thirdly, by analysing the initiatives and strategies of field, research, and credit institutions in the coastal region for agricultural adaptation, this study will provide light on how adaptation strengthens agricultural systems. Thus, it will provide a more comprehensive understanding of how these institutions' capacities impact resilience initiatives on a national and regional scale.

Fourthly, the knowledge gained from this study will give direction to policymakers, practitioners, development partners and future researchers, as the findings of the study will shed light on the major stakeholders and factors that must be strengthened in order to improve climate governance.

Finally, the findings will be useful for other vulnerable developing countries that are also facing similar climate change impacts and could use similar institutional prescriptions for adaptive capacity development.

Research Questions

To attain the objectives of the study, the answers to five research questions are pursued. They are:

1. What are the major impacts of climate change on the coastal agricultural sector in Bangladesh?
2. What is the existing institutional and policy framework for supporting agricultural adaptation in coastal areas?
3. Do the institutions have any adaptive measures to increase their capacity for climate change adaptation?
4. How far are the institutions capable enough to address these climate change issues?
5. What are the barriers to Climate Change Adaptation (CCA) in coastal districts in Bangladesh?

Research Question 1: What are the major impacts of climate change on the coastal agricultural sector in Bangladesh?

To answer the question, numerous pieces of literature regarding the impacts of climate change on agriculture are studied. Based on the existing studies of climate change and its impacts on agriculture in coastal Bangladesh (for example, IPCC 2012, Islam, N. 2003, Warrick, Bhuiya and Mirza, 1993, Islam and Ahmed 2004, I. Hossain and A. R. Mullick, 2020, Ali, 1999, Haque and Ayers, 2008, Jalonski, 2002; Ainsworth 2005, Mensah et al. 2019, Nunez, 2019, Yang, Ray, Brown, Khalil, & Yu, 2015) a list of climate change indicators (rise of temperature, declining rainfall, variation in cropping calendars, change in precipitation patterns) are identified. The research then investigates whether the changes in the indicators have a negative impact on crop production and searches for the most notable changes in coastal climate patterns in the study area.

Research Question 2: What is the existing institutional and policy framework for supporting agricultural adaptation in coastal areas?

In response to the question, both the national and international legal contexts, public policies and government actions, as well as institutional arrangements assisting Bangladesh to address the current problems and the future risks of climate change and variability towards the development of a climate-resilient Bangladesh are studied. Over the years, a number of different definitions of public policy have been developed. In this research, the definition developed by Jenkins is used. According to Jenkins's (1978) definition, public policy is a collection of interrelated alternatives undertaken by political actors or a group of actors regarding the choice of objectives and methods of accomplishing them in a particular circumstance, choices that should, in principle, ought to be under the authority of those actors. Therefore, the following elements are studied subsequently to identify the existing adaptation policies and strategies for supporting agricultural adaptation in coastal areas.

Primarily, the delineated aims, targets, and objectives of the government are discovered. A scrutiny of several public policy documents, including programs, strategies, and action plans, serves as the basis for these studies. As adaptation in agriculture is relevant to different areas, documents from agriculture, environment, water management, coastal zone development, and market management are analysed. Based on the decisions made at the UNFCCC's 7th session conference of parties (COP7), the major provisions of adaptation programs are formulated. Various elements are carried out from the informal discussion with officials of the Department of Environment and Department of Agriculture, and experts in Bangladesh, on how the government of Bangladesh is preparing to cope with the climate variations. Secondly, after studying the objectives and strategies to reduce the vulnerability of climate extremes taken by the government, the institutional arrangements as well as their instruments for their achievements, are identified and analysed.

Based on the interviews with officials and document review, the public institutions related to coastal agriculture and adaptation actions have been shortlisted. The public institutions for climate change adaptation are considered a system of rules, decision-making procedures, and programs that enhance social practices, determine responsibilities to participants and direct interactions among individuals occupying the relevant roles (IDGEC 1999: 14, cited in Gupta et. al. 2010). Gupta et. al. defined the institutional adaptive capacity as the inherent characteristics of institutions that enable actors (individuals, organisations and networks) to cope with climate change either through planned measures or through allowing and encouraging creative response, which is used in this research (2010, p. 461). Based on this definition, the six dimensions and twenty-three sub-indicators of measuring the adaptive capacity of the public institution are identified and assessed.

Thirdly, the major institutions and the actors involved in the formulation and implementation of public policies in Bangladesh's coastal areas are accredited, along with a description of their key responsibilities and attributes. However, the primary goal of this research is not to analyse public policy in depth; rather, it is to assist institutional obstructions and capacity assessments. The analysis framework, Adaptive Capacity Wheel (ACW) developed by Gupta et. al. (2010), Deeny's indicator-based approach (IBA), and Institutional Analysis and Development (IAD) developed by Ostrome and Crawford (2005) are considered the most accepted approaches to precisely assess the agricultural adaptive capacity of climate change. The actors and institutions are classified in three main categories: field, research and credit organisation.

Research Question 03: Do the institutions have any adaptive measures to increase their capacity for climate change adaptation?

To answer the question, the various projects and actions of each institution regarding adaptation in coastal agriculture are reviewed. First, the plans and policy initiatives about climate resilience developed by the government and international organisations are summarised, and the specific programs and schemes running in the institutions are identified. Then, existing training schemes and workshops for awareness building are reviewed, the technological development and collaboration with other institutions and stakeholders are considered, and finally, whether the institutions have regular monitoring and evaluation procedures or not is acknowledged.

Research Question 4: How far are the institutions capable enough to address these climate change issues?

To answer the question, a list of indicators is identified, and then the indicators of the institutions, including the knowledge and perception of the individuals on climate change, coordination and collaboration with other stakeholders, training and expertise of the officials, plans and priorities for adaptation and resource availability of the institutions are analysed using the UNDP index aggregation method. This approach calculates an index value between 0 and 1, which represents the strength of the indicator from low to high. To make the values of indicators into a similar unit, a normalisation process is used.

Research Question 05: What are the barriers to Climate Change Adaptation (CCA) in coastal districts in Bangladesh?

Based on the indicators-based analysis of the institution's capacity for agricultural adaptation in Bangladesh’s coastal areas, A comprehensive set of barriers and measures to strengthen these institutions' capacity for agricultural adaptation in Bangladesh's coastal regions is proposed. Potential adaptation substances are described through the development of information on global experiences and recommendations from authorities directly involved at the field level.

Research Objectives

The broad objective of the study is to *assess the capacity of public institutions* of Cox's Bazar and Patuakhali districts in Bangladesh.

The specific objectives are

1. To assess the existing institutional framework, including climate change strategies and policies, as well as adaptation plans to support institutional roles and arrangements in adaptation in the agricultural sector in Bangladesh.
2. To review the impacts of climate change on crop production in the coastal areas.
3. To analyse the factors affecting the capacity of public institutions for climate change adaptation.
4. To assess the adaptive capacity of selected institutions by using an index-based capacity assessment approach.
5. To present a comparative picture of the coastal region's public institutions' adaptive capacity to climate change.

The research's ultimate goal is to assess public institutions' capacity for climate change adaptation in the agricultural sector. The aim is to evaluate and understand the ability of the institutions working for sustainable agricultural development to perform effectively to address the impacts of climate change. This involves identifying the existing institutional arrangements, gaps, and opportunities to improve performance.

The first objective is to examine the contextual factors, including policies, strategies, as well as adaptation plans that influence capacity development.

The research under the first objective is carried out in order to reveal the present state of climate change adaptation in Bangladesh. The information collected on the penetration of institutional capacities and the agricultural sector is used as the basis for the analysis. The main characteristics of the agricultural sector of Bangladesh, as well as the existing institutional arrangements for agricultural adaptation in coastal areas, are also studied with the purpose of providing background information and insights on the opportunities for and limitations on wider adaptation initiatives in the country.

In addition, the most contemporary statistical data at the time of inscription on the state of changing climate patterns, its impacts on agricultural production and adaptation enclosures have been gathered. Studies on the major impacts of climate change on crop production and potentials for adaptation in coastal districts are studied in order to explore the opportunities for wider capacity building and to assess what part of the obtainable capacities remains unidentified.

To achieve the first objective, the main policies and regulatory frameworks for enabling climate-resilient, sustainable development are identified and studied. Furthermore, the policy instruments for the subsequent implementation of adaptation policies and the way they function are reviewed. Along with this, the main actors and public institutions are identified, and their capacity and adaptation measures are briefly studied in order to provide a starting point for the research under the third objective.

The second objective is to review the impacts of climate change on crop production in the coastal districts in Bangladesh from an institutional perspective.

The crop production in the coastal districts is highly vulnerable to climate change, and to achieve the second objective, the changes in temperature, rainfall, and shifts in seasonal patterns are studied briefly. The historical and current data on crop loss, climatic variables, crop production, and yield loss have been gathered and analysed. Based on the existing literature, the climate change parameters that affect crop growth, productivity, and quality are identified, as well as the indirect impacts, such as the effect on soil fertility, pest and disease dynamics, and pollinators, are studied systematically following the framework. In addition, based on expert information provided in interviews and face-to-face personal communications with field officers, the impacts of climate change are evaluated.

The third and fourth objectives are to analyse the capacity of institutions and the factors influencing their ability to adapt to climate change.

After identifying the key factors affecting crop production in the coastal region based on a literature review and face-to-face interviews, the capacity of public institutions working for agricultural adaptation in the coastal areas is assessed following the institutional capacity assessment methods (Index-based Capacity Assessment) suggested in the conceptual framework section. At first, the indicators are outlined from several adaptive capacity methods to analyse the indicator-based capacity of the selected institutions through interviews and questionnaire surveys.

The fifth objective is to present a comparative picture of the coastal region's public institutions' adaptive capacity to climate change.

After identifying the institution's adaptive capacity through the index-based capacity approach, a comparative analysis of institutional capacity among the field, research and credit institutions will be presented. The comparison will be described based on the values and respondents' views on the variables described in the conceptual framework section.

Structure of the Thesis

This thesis is divided into three separate groups. In the first group, the introduction, the theoretical background and methodological framework are well-defined. The background information of this study is provided in Chapters 1 through 3, along with a breakdown of the theoretical framework and methods. The first group of this thesis provide the overall introduction and formulates the basic conceptual and methodological frameworks for the research. The second group provides the causes and impacts of climate change and the institutional framework for Climate Change Adaptation in Bangladesh.

The last group presents the findings from the results of the analyses of institutions, relevant literature and interview data; it discusses the results of these analyses following the theoretical frameworks introduced in the earlier parts of the thesis. This part summarises the findings of the research, demonstrating contributions to knowledge about climate change adaptation, and ends with concluding remarks and suggestions for further research.

In connection with the problem of climate change, chapter one starts with an introductory note on the climate change impacts on coastal agriculture in Bangladesh and the role of public institutions in inventing new coping and adaptation strategies. This section provides a preliminary presentation of the background, objectives and research questions of the research, emphasising the climate scenario in the context. Similarly, this chapter rationalises the need for this research by demonstrating the problem of the statements, identifying the gaps in theoretical knowledge, and problems related to the delivery of climate change adaptation, with the intention to provide an understanding of the focused issues that will be addressed in the research.

Chapter two reviews the literature that emphasises how the climate is changing globally and the impacts of that change in Bangladesh. There is also an analysis of the literature that explores institutions' capacity to deal with uncertainties and dynamically changing climates, as well as the gaps that this thesis addresses. Besides, the literature that explores the adaptation potentials and the theoretical frameworks to assess the institutional capacities is also reread. In addition, the empirical studies that scrutinise the factors and barriers that influence adaptation in coastal Bangladesh are also considered consecutively. Additional literature is presented and acknowledged later in the thesis to support the proposed scope for practice and institutional framework improvements.

The framework of the methodology used for this research, as well as the research design, data collection, and data analysis methodology, are discussed in Chapter Three.

It presents the set of methods and approaches regarding institutional capacity assessment and a theoretical background of the whole research. The development of an analytical framework for the research based on several methods and approaches for evaluating adaptive capacity is included in this section. Furthermore, a comprehensive framework for data collection techniques, the process of selecting interviewees and the methods employed in the analysis of the data are discussed in the chapter to answer the research questions and to achieve the research aim.

Chapter Four discusses the causes and impacts of climate change, along with the profile of the two study areas in Bangladesh. By briefly describing how climate change is affecting coastal districts in Bangladesh, Chapter four highlights the key vulnerabilities and potential impacts of climate change on agriculture in the case study area. Besides, the agricultural aspects of the case study area are discussed sequentially.

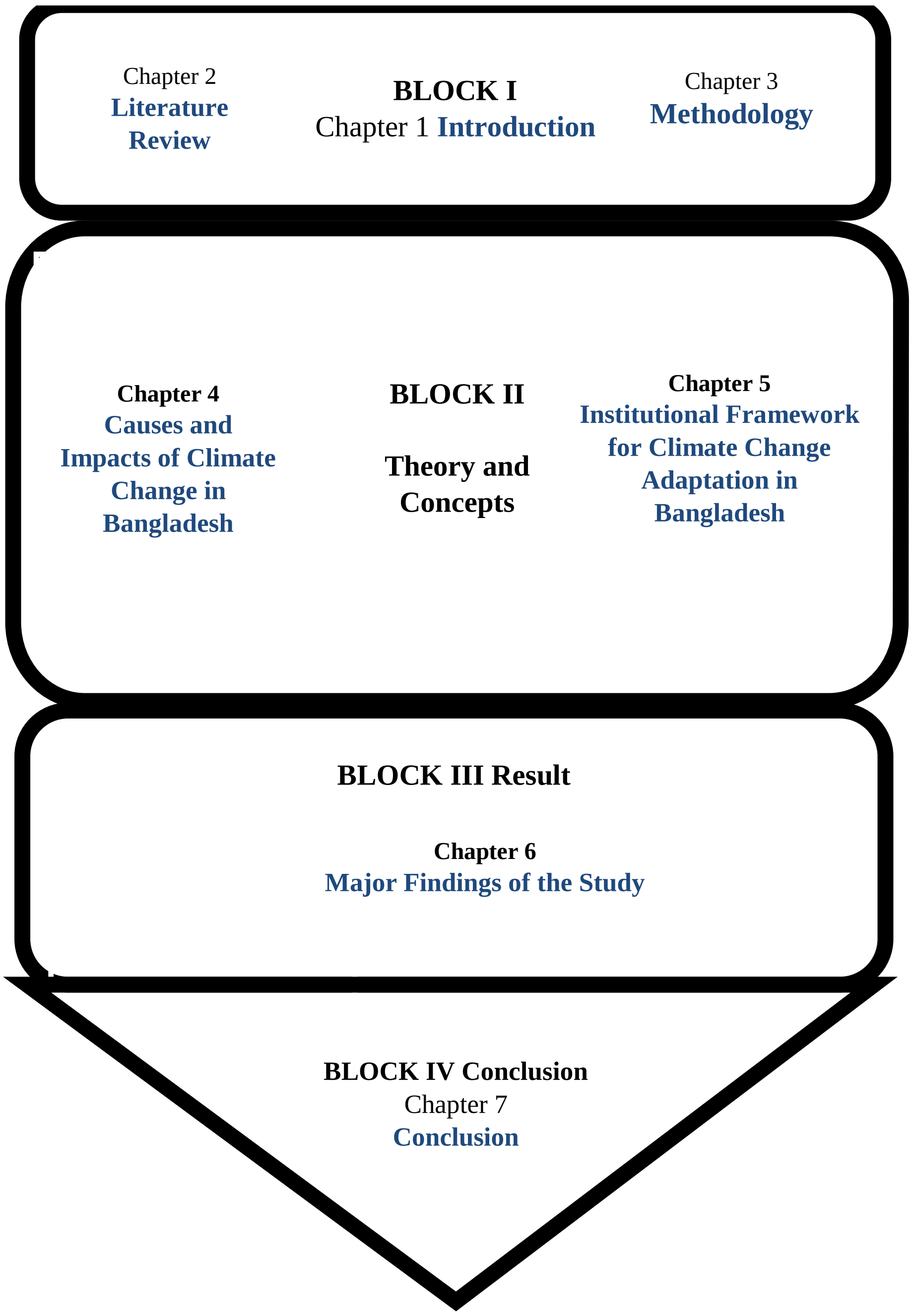
Chapter Five has covered the policies and institutional framework for agricultural adaptation in coastal Bangladesh in depth. This chapter analyses the climate change adaptation policy and agricultural policy from different documents published by public institutions, donor agencies, and the government of Bangladesh. In addition, this chapter identifies the governing instruments currently used for agricultural resilience in coastal Bangladesh for climate change adaptation.

The major findings of the study are discussed and analysed in Chapter Six. The chapter provides the background of those interviewees who responded to the given guidelines. The purpose of this chapter is to discuss the findings of the research and analysis based on the research questions and objectives. Government initiatives undertaken to address the impacts of climate change on agriculture and the institutional capacity index for three different categorised institutions are taken into light in this chapter based on the responses of those who took part in the interviews.

The result analysis is divided into three parts. The chapter begins with the respondents' perceptions of changing patterns of climate change and their opinions on climate-induced production impacts. Initially, the respondents' ratings are employed to evaluate the institutions' ability, and the second subsequent section examines the aspects and justifications provided by the interviewees for what they considered to be an effective adaptation. Finally, the dissatisfaction of the respondents regarding resource availability, collaboration and monitoring systems is discussed. Additionally, the obstacles and difficulties that the institutions encounter are examined.

Chapter seven is the overall conclusion of the research. The research's overall findings are compiled in this chapter and analysed in light of the conceptual framework and research questions. Based on the findings of the research, recommendations will be made for further adaptation measures and initiatives at the national and local levels. Furthermore, the chapter will confirm how the research advances knowledge, and in the conclusion, the research's limitations are addressed.

Figure 1: Structure of the Thesis



Chapter Two

Literature Review and Theoretical Perspectives

“It is the theory that decides what can be observed." – *Albert Einstein.*

Chapter Summary

The purpose of this chapter is to summarise previous studies and literature on climate vulnerabilities, institutional assessment concepts and approaches, policies, and the role of institutions in adaptation, as well as global evidence on adaptation practices and the conceptual and theoretical foundations of the study.

- *Introduction*
- *Review of Literature*
- *Definitions of the Concepts*
- *Linking Theories to Conceptual Framework*
  - *Theories*
  - *Conceptual Framework*
- *Variables*

Introduction

In today's world, the journey of change is persistent. The natural environment and our affiliation with it are subject to change. The sustainability of civilisations that rely upon natural resources for their livelihoods, as well as the management of natural resources, is seriously jeopardised by climate change. So, the sustainability of climate-vulnerable communities largely depends on the capacity to adapt to the climate change we cannot avoid. This chapter aims to define the concepts that are appropriate and best matched to this research. The theoretical context can be defined as the framework that the researcher believes can most effectively explain the usual development of the phenomenon under study (Camp, 2001). It is the researcher's conceptual clarification to define the core concepts underpinning the research. The conceptual framework helps the researcher in identifying and formulating their perspective on the issue (Grant & Osanloo, 2014), which is the most fundamental method by which a researcher can articulate their proposed solutions to the identified problems (Liehr & Smith, 1999; Akintoye, 2015). The well-defined concepts are essential to make it further specific and easy to comprehend the viewpoint of the study phenomenon (Adom, 2018). The first part of this chapter aims to define the major concepts linked with the research problem to enhance methods, increase understanding, and clarify and concentrate on the research problem and concept. The second section consists of a literature review that helps to identify the research objectives, variables, and research gap and provides guidelines for establishing the theoretical foundation for data analysis. And finally, the last section develops the conceptual framework of the study.

Review of Literature

Many authors, planners and scholars conducted and analysed the diverse aspects of climate change, its impacts and related matters in Bangladesh as well as different parts of the world. There is a profusion of literature available associated with the Climate change impacts, adaptation, and the institutional and policy Challenges for effective adaptation and development worldwide, but very few of those shed light on the capacity assessment of public institutions for climate change adaptation in Bangladesh. Climate change is a very contemporary issue at the local, regional, national and international levels, and the hostile effects of climate change, its susceptibility, the adaptation process and the role of public institutions in addressing the challenges vary from country to country and region to region for different geographical situations. The researcher examines the literature and documents pertinent to the study on climate change, including books, published journals and articles, newspapers, and reports from various public and private institutions regarding sector-specific impacts of climate change and adaptation initiatives in the coastal areas of Bangladesh. Furthermore, the literature and different approaches related to institutional adaptive capacity assessment that are widely used in different types of organisations all over the world and cited in different studies were also reviewed. Finally, some keywords were parted, those are related to the study, such as 'Climate Change', 'Impacts of Climate Change', 'Climate Change Adaptation', 'Adaptive Capacity', 'Institutional Capacity Assessment', and 'Coastal Region', to delineate the frontier of the review of the literature.

Climate Change Impacts and Adaptation Challenges

An early writing for this review is 'Climate Change: Causes, Effects and Solutions' by John T. Hardy (2003), which discusses a clear and organised overview of the scientific basis of climate change, its environmental and societal impacts, and the existing policy responses. The text provides an appropriate initial point for exploring the historical context and evolution of climate in recent decades. The book, published in 2003 by Wiley, is divided into three main sections, each of which addresses a crucial facet of climate change, including the global case studies from regions like North America, Europe, Australia and Asia. In the first section, Hardy discusses the fundamentals of greenhouse gas effects and the uncertainties inherent in climate issues, emphasising the significant influences of human activities on the climate system.

In addition, the past climate change and the recent changes in precipitation, temperature, sea level rise, snow and ice attribution and ocean circulation patterns with future uncertainties are discussed. Section two delves into the impacts of climate change on freshwater systems, terrestrial ecosystems, agriculture and marine environments. The section highlights the changes in the life cycle of plants and animals, agricultural losses, and the health of aquatic species due to the shifts in temperature and precipitation. In the third section, the consequences of climate change on humans and societies are discussed. Human settlement, migration, infrastructural vulnerability, and effects on public health are included to discover. Moreover, Hardy discusses the mitigation strategies as well as the intricacies of climate policies and agreements.

'Climate and Sea Level Change: Observations, Predictions and Implications', edited by R. A. Warrick, E. M. Barrow, and T. M. L. Wigley, by Cambridge University Press, is regarded as an additional comprehensive volume that presents the current understanding of sea level rise and climate change as it existed in the early 1994s. The book provides multidisciplinary viewpoints regarding climate challenges and vulnerabilities of climate systems and their impacts. It presents the historical climate data, including trends in temperature increases, changes in precipitation patterns and sea level changes. The text addresses the various dimensions of climate issues, including the greenhouse gas effect and climate change, sea level changes, effects of climate and sea level changes on natural resources for coastal regions. It also discusses the adaptation strategies and the need to integrate the existing knowledge into policy-making processes. The book provides a global overview offering fundamental knowledge on climate change and sea level rise while 'The Greenhouse Effects of Climate Change' (1994), 'Sea Level Changes in Bay of Bengal' (1994), 'The Implications of Climate and Sea Level Change for Bangladesh: A Synthesis' (1994) co-edited by Warrick et al. discuss how the global climate trends are specifically affecting the agriculture, water resources, and health sector in Bangladesh. Assessing the potential impacts of climate change, the editors discussed the possible adaptation measures and policy responses to mitigate the adverse effects of climate change in Bangladesh.

'Storms of My Grandchildren: The Truth about the Coming Climate Catastrophe and Our Last Chance to Save Humanity' is written by one of the world's foremost climate scientists, James Hansen (2009). This book is described as an imperative book that bridges the gap between scientific research and public policy advocacy. A significant portion of the book is about the role of greenhouse gas emissions, particularly carbon dioxide and the release of methane, in driving climate change, resulting in the melting of polar ice caps, which could lead to irreversible climatic consequences. He argues to reduce the carbon dioxide levels to 350 parts per million by reducing the use of fossil fuels, especially coal.

'Experiencing Climate Change in Bangladesh: Vulnerability and Adaptation in Coastal Regions' was written by Ahmed, S. (2019) and published by the Academic Press of Elsevier. In this book, the authors provide both conceptual frameworks and empirical studies that contemplate social, economic and environmental circumstances of climate change and their interdependencies in determining the vulnerabilities and adaptation approaches. The book emphasises the significance of incorporating Indigenous knowledge into adaptation planning by focusing on the perspectives and understanding of the local communities. In the latter part of the book, several adaptation strategies are discussed, and some outlines are recommended for more effective governance.

The book 'Confronting Climate Change in Bangladesh: Policy Strategies for Adaptation and Resilience' by Huq et al. (2019) provides an analytical and empirical view of the country's climate change challenges and the strategies to address them. The book is organised into fourteen chapters, emphasising specific aspects of climate change adaptation in Bangladesh, starting with the introduction of climate challenges, then the country's agricultural adaptation practices, climate-induced losses and damages of freshwater resources, forest resources adaptation, gender inequality, and financial strategies that conclude with a summary of the lessons gained and outlining plans.

Under the guidelines of the IPCC and with support from the U.S. country studies program, Huq et. al. wrote the book named 'Vulnerability and Adaptation to Climate Change for Bangladesh' (1999) by Kluwer Academic Publishers, where a comprehensive assessment of vulnerability to climate change and its potential adaptation strategies is discussed. The book begins with the sector-specific climate scenario of the country. The author assesses the vulnerabilities of forest resources, water resources and crop agriculture to climate change, focusing on inundation, flooding, soil salinity, and erosion. The researcher concludes by proposing different adaptation measures, policy advocacy and community-based approaches for effective resilience.

'Bangladesh I: Climate Change Impacts, Mitigation and Adaptation in Developing Countries', co-authored by Md. Nazrul Islam and André van Amstel, in 2019 and published by Springer, provide insights into the specific challenges of climate change Bangladesh faced in recent decades and present the adaptation and mitigation strategies. The book presents a combination of local knowledge with international research to provide a scientific exploration of the impacts of climate change. The researcher focused on the most vulnerable areas like coastal zones, haor wetlands, Hill tracts and the sectors that are highly affected by climate change, like impacts on agricultural land use, aquaculture-based fish production, environmental migration, and community-based adaptation. The book delivers a wide variety of issues, including sea level rise, salinity, cyclones, river erosion, and socio-economic conditions of the affected people.

Another pioneer volume edited by Shaw et. al. (2013), titled 'Climate Change Adaptation Action in Bangladesh', published by Springer in 2013, is one of the most comprehensive analyses of the impacts of climate change, its potential strategies and action plans to cope with the challenges, climate governance, adaptation practices and socio-economic aspects of the vulnerable group of people. In the first section, a detailed description of climate change impacts in Bangladesh, including sea level rise, increased frequency of natural hazards, urban poverty, and social protection, is encompassed. The second section covers two major national strategies and action plans: i) National Adaptation Program of Action (NAPA) and ii) Bangladesh Climate Change Strategy and Action Plan (BCCSAP). The next section discusses the socio-economic impacts of climate change and coping mechanisms, emphasising gender issues. In the last two sections, agricultural adaptive actions in haor areas, coastal areas, and drought-prone areas, along with climate public expenditure and institutions, are discussed for climate-resilient development.

The book 'Vulnerability and Adaptation to Climate Change in Bangladesh: Process, Assessment and Effects' written by Younus, A. F. (2014) is mostly a well-renowned doctoral thesis accepted by the University of Adelaide, Australia, also selected as one of the very best Ph. D. theses from around the world and recognised as an outstanding work by Springer Theses in 2014. The book provides a review of the flood literature for Bangladesh for three decades, highlighting the history, characteristics, causes and types of floods, assessing vulnerability and adaptation in response to extreme flood events, and conducting a detailed case study to examine the farmers' autonomous adaptation practices.

Bernard et. al. (2022), in the article titled 'Bangladesh's Vulnerability to Cyclonic Coastal Flooding', highlight the extreme climatic events in the low-lying Ganges-Brahmaputra-Meghna delta and review the scientific pieces of literature to define cyclonic flooding in coastal Bangladesh. The study finds coastal flood vulnerability in Bangladesh, merging hazard experience and social understanding using Hydrodynamic Surge Modelling to spatially map flood risk zones and ranks Shariatpur, Chandpur, Barisal and the delta mouth as the highest vulnerable quartile and states that almost 165 million people live in these low coasts exposed to cyclonic storms, tidal surges and inundations. In addition, the paper proposes some interventions needed in the most vulnerable spots, like early warning systems, climate-resilient infrastructure, evacuation planning, etc.

'Bangladesh's Dynamic Coastal Regions and Sea Level Rise' by Hugh Brammer, published in the Climate Risk Management journal of Elsevier in 2014, discusses the physical geography of Bangladesh's coastal area based on ground survey information and the coastline region of Bangladesh is described as the most dynamic and diversified, as opposed to uniform and stagnant. The paper concludes with two significant findings. Firstly, by implementing suitable solutions based on the understanding of the geographical topography of possibly impacted areas, the present estimate of millions of people being displaced might be greatly decreased. Secondly, Bangladesh's rapidly growing population puts pressure on its land and water resources, and the exposure to environmental hazards has more severe effects than the effects of a slowly rising sea level.

The book ‘Effect of High Temperature on Crop Productivity and Metabolism of Macromolecules’ edited by Amitav Bhattacharya (2019) accentuates the effects of elevated temperatures on agricultural crop yields and the metabolic features of macromolecules, such as plant growth hormones, secondary metabolites, carbohydrates, lipids, and proteins. Temperature stress is considered one of the most uncontrollable factors affecting the growth, development and productivity of the plant. The book presents a comprehensive overview of the direct effects of high day or high night temperatures and the effects of high air and high soil temperatures on plants’ growth, days, planting times and reproduction cycles. Heat stress has direct impacts on seed germination, seedling growth, and gametophyte development in different stages of plant growth, for instance, a decrease in pollen viability and pollen tube germination in maize crops, abnormal ovary development in wheat, abortion of tapetal cells that causes delayed flowering, deformity of flower organs and so on. Furthermore, if farmers want to increase agricultural yields and efficiency, this book will instruct students how to make crop varieties more heat-tolerant.

The second chapter of the book ‘Droughts in the Asian Monsoon Region’, edited by Shaw, R. and Nguyen, H. (2011), emphasises the socio-economic impacts of droughts in Bangladesh. The chapter shows that drought is considered the least focused issue in adaptation practices in Bangladesh, though it has a great impact on dry-season crop production. Likewise, Sarker et. al. (2012) examine the impacts of climate variables on rice yields by using the ordinary least squares and median (quantile) regression methods. The study evaluates how various rice types relate to the maximum temperature, rainfall, and lowest temperature and discovers that climate change has a major effect on productivity.

The article ‘Temperature Increase Reduces Global Yields of Major Crops in Four Independent Estimates’ by Zhao et. al. (2017) assesses the effects of increasing temperature on the yields of four major global crops – wheat, rice, maize and soybean by compiling extensive published results from four analytical methods. Findings indicate that worldwide wheat yields will decrease by 6%, rice yields by 3.2%, maize yields by 7.4%, and soybean yields by 3.1% with every degree Celsius rise in global temperatures. Rising temperatures constantly reduce crop yields both in temperate and tropical regions, but tropical regions are observed to be more vulnerable. The study provides strong evidence that continued global warming poses a significant threat to food security and highlights the urgent need for climate adaptation in agriculture.

Role of Institutions in Climate Change Adaptation

Arun Agrawal (2008) provides a conceptual framework and identifies the role and importance of local institutions in adaptation using the AIL (Adaptation, Institutions and Livelihoods Framework) analytical framework in the working paper of the World Bank, ‘The Role of Local Institutions in Adaptation to Climate Change’. The paper emphasises three critical roles of local institutions in influencing climate adaptation, for instance, i) configuring vulnerability and impacts of climate change, ii) referring to individual and collective responses, and iii) distributing external resources to facilitate adaptation.

It thus shows how local rural institutions can serve as anchors and support to strengthen the adaptive capacity and adaptation practices of the rural poor. The author finds that existing national plans to promote adaptation to climate change have been mostly inattentive to the role of local institutions in adaptation. He discusses that local institutions and civil society partnerships are quite close to the private and civil society institutions, and institutional capacity is not effective for the adverse effects of Climate Change. Increasing institutional partnership among local public, private and civil society institutions, enhancing local institutional capacities, understanding the institutional articulations and access patterns before supporting funds, improving institutional coordination, focusing on territorial strategies and adopting integrated climate risk management are the six concluding results of the study that will lead to further issues in facilitating adaptation. 'Climate Policy Processes, Local Institutions, and Adaptation Actions: Mechanisms of Translation and Influence' by Agrawal et. al. published by John Wiley & Sons in 2008 mainly reviews and synthesises four key lessons for future adaptation planning by strengthening local capacity through information, financial, and technical resource transfers, expanding decentralized adaptation planning, establishing channels for decision-makers to share information, and enhancing local decision-makers responsibility.

In 2003, Shardul Agrawala authored numerous reports for the OECD as part of the OECD's 'Development and Climate Change' project, concentrating on the climate change reflection in development planning. The project aimed to assess climate impacts and vulnerabilities in developing countries. The report that integrates the case study for Bangladesh presents the conditions of mainstreaming response to climate change within economic development planning and national policies. The paper reviews the climate trends and scenarios at the country level, assesses economic, environmental and social plans and projects of government and international donors and analyses the climate responses with a particular focus on natural resource management.

According to the study, the low-lying region in the deltaic flood plain of three major rivers is particularly vulnerable to climate-induced disasters. More than thirty to seventy per cent of the country is normally flooded each year. Moreover, sea level rise, higher temperature, enhanced precipitation and reduced dry season precipitation are the major projected climate change impacts specified in the report. The inundation and salinity in the southwestern region of Bangladesh, including the Sundarban forest areas, have already impacted agricultural production, freshwater-loving species such as Sundari, Gewa, Goran and Keora, and almost 425 species of wildlife. Furthermore, the study states that there is an extensive lack of obvious consideration of climate change in many government plans and donor projects in Bangladesh. In addition to these, the paper highlights that the policies and priorities that encourage tourism and the building of tourism infrastructure in vulnerable regions conflict with climate change response and emphasises the importance of the transboundary dimension in climate change adaptation.

The book 'Governance Approaches to Mitigation of and Adaptation to Climate Change in Asia', edited by Huong Ha and T. N. Dhakal (Eds.), and published by Macmillan Publishers Limited in 2013, is considered one of the most valued resources for understanding the institutional dimensions of climate change response in Asia. The book provides an updated and geographically tailored analysis of the ways to explore how Asian countries are developing and implementing governance strategies to address the challenges of climate change mitigation and adaptation. The authors re-discuss the issues and impact of climate change in Asia. They examine the preconditions for good governance regarding climate change, the role of state and non-state actors in climate change governance, and explore different political-legal frameworks. The book emphasises the role of institutions, policies and both top-down (state-driven) and bottom-up (community and NGO-led) cooperation in shaping responses to climate risks. It emphasises both mitigation and adaptation, focuses on developing countries and encompasses a variety of regulating stakeholders, including governments, organisations, civil society, NGOs, and regional entities.

The authors highlight governance as a multi-level and multi-actor process where the interplay between national policy, local implementation, and international cooperation is explained. Furthermore, the importance of transparency, accountability and participation is described. The study identified weak institutional cooperation and capacity gaps as major obstacles and underlined institutional reform, stakeholder engagement, and regional cooperation for effective responses.

‘Climate Change Impact on Livestock: Adaptation and Mitigation’ edited by Sejian et. al. (2015) provides a comprehensive overview of the impacts of climate change on livestock production and its adaptation and mitigation. It addresses the biological effects on animals as well as the management strategies required for adaptation and mitigation. The book describes the consequences of heat stress on reproduction, immunity, and productivity in species-specific animals. It also focuses on the challenges regarding fodder availability, water scarcity and grazing systems. The book largely covers the physiology, nutrition, genetics, environment and policy approaches to climate change challenges of livestock production.

The book ‘Climate Change and Agriculture in India: Impact and Adaptation’, edited by S. S. Mahdi in 2019, contains twenty distinct pieces of research by different authors and explores the impacts of climate change on Indian agriculture, spanning cereals, horticulture, and fisheries. Crop yields, food security, greenhouse gas emissions, and adaptation strategies are all examined concerning climate change. In the first few chapters, the future rainfall and temperature scenario, the effects of El Niño and La Niña on crop production, the evaluation of model accuracy and utility for policy planning, and the application of nanotechnology are discussed. Apart from these, greenhouse gas emissions from selected cropping patterns in Bangladesh, mapping of agricultural dynamics and flood impacts in Bihar using Time series satellite data, agricultural information on risk management and climate scenarios in cold arid regions are emphasised later in the book.

The paper ‘Institutional Adaptive Capacity and Climate Change Response in the Congo Basin Forests of Cameroon’ by Brown et. al. (2010) examines the role of local institutions in the field of community-based natural resource management and climate adaptation in central Africa. The study highlights how the local institutions in Cameroon's Congo Basin forests distinguish and respond to climate change. The analysis is based on group and individual interviews in Cameroon’s humid forest villages, and the result highlights that while decision-makers' awareness of climate change is high, the institutions lack the adaptive capacity, for instance, weak linkages among government institutions, a lack of transparency, and accountability. The author and collaborators suggest that blending the local traditional authorities (like chiefs and clan heads) with democratic elements will make forest management more effective.

The article ‘Managing Climate Change Vulnerabilities: Formal Institutions and Knowledge Use Determinants of Adaptive Capacity at the Local Level in Sweden’ by Glaas et al. (2010) investigates how Swedish municipalities address climate change issues by making vulnerability management a part of their administrative and political agenda in relation to climate change. The paper focuses on the role of formal institutional structures, the use of knowledge and their responsibilities and coordination to resilience. The key findings of the study show that there is limited coordination across the municipal departments, as well as local-level coordination is absent. Furthermore, the lack of institutional memory, infrastructure-focused capacity and shortage of technical resources are considered the major challenges to effective adaptation.

The concluding chapter, ‘Transforming the World’ by Nelson (2009) in the book ‘Adapting to Climate Change: Thresholds, Values and Governance’ edited by Adger et al. and published by Cambridge University Press, emphasises that the adaptation must go beyond reactive measures and become transformative. He demonstrates that there are two types of adaptation: autonomous adaptation, in which people and societies adjust on their own. Another is purposeful adaptation, which is accomplished by prearranged tactics that are directed by policy frameworks. He explained local institutions as a major determinant of the success of the adaptation process.

Institutional Capacity Assessment for Climate Change Adaptation

'The Adaptive Capacity Wheel: A Method to Assess the Inherent Characteristics of Institutions to Enable the Adaptive Capacity of Society' by Gupta et al. (2010) is considered a widely cited article in the field of institutional capacity assessment. The purpose of the study is to develop a comprehensive framework for institutional capacity assessment for climate change adaptation. They develop a worldwide acceptable and conceptual tool to evaluate the institutional capacity for climate change and other long-term challenges. The wheel consists of six dimensions, for instance, variety, learning capacity, room for autonomous change, leadership, fair governance and availability of resources. Each dimension has multiple indicators for detailed institutional assessment. This tool is tested in different institutions and identified as an effective tool to assess, especially the institutional capacity. This study is considered the foundational tool for measuring adaptive capacity and has been adapted and expanded by several researchers. The wheel has a significant impact on the creation of climate governance policies as well as scholarly research.

Grothmann, T. et al (2013) applied the extended Adaptive Capacity Wheel (ACW) to assess the adaptive capacities of the institutions explained in the article 'Assessing Institutional Capacities to Adapt to Climate Change: Integrating Psychological Dimensions in the Adaptive Capacity Wheel' by Gupta et al. (2008). The study shows that institutions cannot adapt successfully unless the individuals within the institutions are prepared to acknowledge and willing to act. The paper aims to incorporate behavioural and psychological aspects into the well-known Adaptive Capacity Wheel (ACW) for assessing institutions' capacity to adapt to climate change. The Adaptive Capacity Wheel (ACW) developed by Gupta et al. includes six dimensions, for instance, variety, learning capacity, leadership, resources and fair governance. Grothmann et al. added perception of risk and self-efficacy, motivation to adapt and responsibility as the psychological dimensions for assessment. Water management, flood/coastal protection, civil protection, and regional planning were the four areas in northwest Germany where the author and collaborators implemented the extended ACW (Hobday et al., 2017). The assessments of adaptation, motivation and belief provided a clear added value in the institutional assessment that significantly advanced the adaptation research.

Haque M. M. et al (2017) argue that it would be beneficial for regions like Bangladesh, which are vulnerable to climate change, to critically examine the knowledge systems that have been mobilised to support adaptation actions, and suggest that ‘knowledge quality assessment’ (KQA) tools can structure this review. They found important differences in approaches to mobilising knowledge, particularly between governmental and non-governmental organisations (NGOs). The study shows that there is an absence of specific guidance on how to use the indicators or assess uncertainty on government policy regarding climate change adaptation. Contrararily, the author argues that the non-governmental organisations can work to identify the indicators and uncertainties through community involvement, with mixed outcomes.

Hossain Z. and Huq N. (2013) emphasise institutional capacity to address the challenges of climate change in the coastal areas. They reviewed the policies, identifying institutional barriers to mainstream climate-smart disaster risk reduction measures in the cities of Bangladesh through an examination of strategies and institutional backdrops and recognised some broad institutional constraints to address climate change risks effectively. Their research indicates that both national and local institutions in Bangladesh are currently facing significant deficits, which limit the capacity of these institutions to mainstream climate-smart risk reduction strategies. Moreover, Kabir, H and Baten, M. A. (2019) focused on the specific sector for climate change adaptation. They find out the adaptation practices to the water sector and their critical analysis through a series of field studies, along with a questionnaire survey and reviewing the secondary literature. In their article, they show that hanging vegetables, cultivating indigenous rice varieties, homestead gardening, detoxifying pond water through traditional techniques, effectively managing direct pond irrigation, and gathering rainwater are the most frequent and effective adaptation strategies in terms of social, economic and environmental aspects.

A comprehensive study on the institutional adaptive capacity in the coastal area was done by Fidelmana P. et al. (2017). They tried to find out the institutional capacity in terms of coastal resource management in the Peam Krasaop Wildlife Sanctuary (Cambodia) and the Tam Giang Lagoon (Vietnam). The study contributes to addressing the knowledge gap regarding the relationship between institutions and the characteristics of adaptive capacity (Fidelman et al., 2017).

McGregor (2015) examines an innovative theoretical framework that integrates institutional and policy network methodologies to analyse multi-level governance. Particularly in the area of land use, the research highlights significant obstacles to inter- and intra-national communication and cooperation between Brazil and Indonesia.

Khanom, T. et al (2019) explore the many ways that strategic forest management contributes to climate change adaptation in Bangladesh by examining contemporary attempts for the preservation of the Sundarbans Reserve Forest, coastal afforestation, and the reforestation of hill tract forests.

Reisinger et al. (2011), in their article published as a chapter of a book named ‘Climate Change Adaptation in developed nations’, discuss the role of local bodies in facilitating adaptation to climate change at the community and regional level from the experiences and lessons from New Zealand. The authors find that raising community awareness, engaging local professionals and experts, adopting sequential approaches and attaining central government support together may contribute to an enabling environment for local government.

Filho (2016), in his book ‘Innovation in Climate Change Adaptation’, presents new tools and methods to facilitate innovation in climate change adaptation. The book proposes innovative ways to address the challenges of climate change, to adapt and to assist the implementation of climate policies for the long term. The authors provide new case studies and data, together with global projects and initiatives, presenting innovative tools, ideas, and methodologies for advancing climate change adaptation.

Zuka, S. (2014) discuss the prospects and challenges of community adaptation to climate change in developing countries through the case study of Malawi. Community adaptation to climate change, according to the study's results, can improve and strengthen local economic systems. The author identifies low institutional capacity, impoverishment in family households, and an absence of a transparent policy framework for community adaptation efforts as obstacles to policy implementation (Zuka, 2014). Similarly, Klein et al. (2011), in their article, emphasise that the Tibetan Plateau, an area experiencing fast climate change, is a prime illustration of how a lack of cooperation may have negative consequences for natural resources and the communities that depend on them.

McLeman et al. (2011), in their article published as a chapter of the AGLO book series, describe various forces that influence the ability of decision-making and institutional structures in Canadian rural and resource-dependent communities to manage, plan for, and respond to future risks and uncertainties resulting from climate change. They conclude that the success of future capacity building and planning will be strongly influenced by such factors as improved coordination across different levels of government, the provision of locally geared information about environmental and climate change, economic diversification and the ability to adjust to and take advantage of rapidly changing demographic patterns in such communities.

Ampairea E. L. et al. (2017) in the paper 'Institutional challenges to climate change adaptation: A case study of Rakai district, Uganda' determine the institutional challenges to adapting to climate change in Uganda by conducting field evaluations and literature studies iteratively across different tiers of government and geographical regions. They discover that policies are primarily developed by central government departments, with little or no input from other groups or local communities. The study also found that there is a lack of communication between the community, the district, and the national levels. The insufficient technical capacity and financial resources, along with political intervention and the lack of effective implementation structures at all levels, hinder climate change adaptation.

Ragasa, C. et al (2013) in their study interviewed 87 practitioners working in government agencies, local organisations, international organisations, and think tanks reporting involvement in climate change adaptation in Bangladesh, Ethiopia, Kenya and Mali. They try to provide some reflections and insights on the level of awareness, practices, organisational and institutional matters being challenged by countries as they adapt to climate change, based on the interviews. The authors find that there is no clear and defined policy and strategy within these organisations outlining their role in and contribution to the national and collective efforts. They show that there are no obvious and assessable targets and monitoring and evaluation (M&E) systems to track progress and outcomes over time. More importantly, they identified two types of capacity gaps that exist there, which are training needs and institutional challenges.

Rahman and Hickey (2019) focus on assessing the response of different institutions to climate change impacts in the northeastern floodplains of Bangladesh. They examine how current legislative barriers can undermine institutional responses to climate change effects, while institutional inflexibility and the exclusivity of bureaucratic entities serve to diminish efficiency, effectiveness, and equity. The study indicates the necessity for public policy to facilitate broader public involvement in the design, execution, and assessment of adaptation programs.

Haque, A. N. et al (2014) worked on low-income households in Khulna City, Bangladesh, to find out the individual, communal and institutional responses to climate-related shocks and stresses to examine the relationship of such responses with extreme poverty.

Rahman, M. M. (2021) evaluated the efficiency of the Ministry of Environment, Forest and Climate Change in accomplishing a sustainable environment in Bangladesh. The author determines that the ministry is unable to create an impartial database for calculating ecological, carbon, and green footprints. Furthermore, the study found that the Bangladesh Forest Research Institute is unable to conduct need-based and globally recognised research operations. Finally, the study promotes institutional and legislative reform to accelerate efforts toward achieving environmental sustainability

Rahman, M. A. (2018) explores the effects of bribery and extortion on livelihoods and adaptive capacity in the face of climate change and claims that corruption expressly reduces the capability to respond to climatic stressors.

Bhuiyan, S. (2015) studies the role that good governance plays in adapting to climate change in Bangladesh. His study strictly exaggerates adaptation preparedness, severely exaggerated due to constant risks for good governance in Bangladesh. The object exposes that the role of good governance plays in adaptation to climate change in Bangladesh is restrained by a lack of public accountability and political stability, ineffective government, poor quality of regulatory instruments, absence of the rule of law and failure to control corruption.

Fatemi, M. N. (2020) examines the integration of climate change issues into national, sectoral, and city development plans with a particular focus on Dhaka, using a framework developed based on the United Nations Development Program's (UNDP) climate change mainstreaming guidelines for national development processes. The author discovers evidence that national and sectoral development plans have gradually included climate change since 2002, and that this integration is persistent. The study mainly focuses on the integration of climate change adaptation in Dhaka city development plans. It reveals that the inclusion of Dhaka city in the sustainable development plan is moderate in terms of institutional structural development, capacity building for climate action, climate risk and opportunity assessment.

Gain, A. K. (2012) examines how developing nations like Bangladesh have been making improvements in vulnerability evaluation methods that pertain to water resources. This research provided a practical assessment of the Lower Brahmaputra River Basin (LBRB). The feasibility assessment outcomes delineate the primary existing obstacles (e.g., lack of institutional coordination) and opportunities (e.g., adaptation) of LBRB.

Islam, M. T. (2017) investigates the value of formal institutions in climate change adaptation for agriculture, from the perspective of farmers and institutional communities of two drought-prone areas in Bangladesh. The study concludes that reliance on technology, neglecting cultural aspects, and the inadequacy of institutional communities that strive to facilitate connections with informal institutional groups are the remaining obstacles to developing adaptive agriculture in Bangladesh.

Huq, S. and Rabbani, G. (2011) discovered the policy and institutional initiatives to adapt to the impacts of climate change in Bangladesh. They suggest balanced climate investment and adaptation measures to decrease the vulnerability of the most exposed groups or populations.

Kabir, M. H. et al (2019) critically analysed the water sector adaptation practices in the southern coastal areas in Bangladesh through a series of field surveys, a questionnaire survey, and a review of secondary literature. The study identifies homestead gardening, purification of pond water through traditional knowledge, rainwater harvesting, and growing local rice varieties as the most common and effective adaptation practices from a social, environmental and economic aspects. But relying too much on donor agencies and non-governmental organisations becomes an emerging challenge for water resource adaptation in future (Mirza, M. 2007). Researchers working on the effects of climate change on water found that South Asia is experiencing more frequent droughts and floods. The research also covers the present state of adaptation and coping mechanisms in South Asian water sectors and states that institutional adaptive governance can reduce vulnerability and strengthen adaptive capacity.

Mondal, M. S. et al (2019) collect data on agricultural adaptation strategies in Bangladesh's coastal zone and provide a synopsis of the findings. The study finds that salinity, lack of capital, poor access to resources, knowledge and information, and a centralised decision-making process appear to be some of the hurdles to implementing the adaptations.

Islam, T. et al (2010) review the proposed and ongoing works and action plans regarding climate change issues in Bangladesh. The review work aims to understand the impacts of climate change, the level of preparedness of the government and nongovernment sectors in areas of disaster risk reduction (DRR) and climate change adaptation (CCA). Rahman, M. S. (2018) analyses the management of projects aiming to adapt to climate change in the period from 2009 to 2015. The study focuses on the overall bureaucratic setup of the adaptation regime, the appointment of directors to the individual programs and what role foreign funding plays in making appointment decisions.

Wang, S. W. et al (2017) attempts to fill the existing gap by assessing the current status and future trends of projects, policies, and other efforts at the regional level in South Asia to highlight the impacts of climate change and implications for agriculture, to assess policies and strategies for adaptation and mitigation, and to identify prevailing gaps and future needs for capacity building, research, and governance. Poor institutional and technical capacities, knowledge gap, lack of adequate research and lack of attention to developing a capable organisational structure are identified as the main constraints towards adaptive agricultural development.

Ayers, J. et al (2014) examine how Bangladesh is incorporating adaptation to climate change into its development efforts. According to the findings, Bangladesh is considered one of the countries that has accomplished significant progress in planning for changes and integration. The study analyses the four-step framework for reviewing progress on mainstreaming in the country. The authors concluded that mainstreaming adaptation in Bangladesh is a more complex process involving multiple phases.

In the article ‘Unlocking ecosystem-based adaptation opportunities in coastal Bangladesh’, Ahammad et al. (2013) discuss the adaptation response of the households from different social classes, the adaptation opportunities and obstacles faced by the households and how these elements interact with growth or hinder adaptive capacities. The researcher used a mixed-method approach to collect the empirical evidence from two coastal districts in Bangladesh. The study concludes that the ability to adapt depends on the family’s wealth. The affluence of the households determines the availability of the resources, which in turn helps them to deal with social and ecological challenges.

Alam, M. S. et al (2017) analyse the insight of local people on waterlogging, its impact on crop production and related adaptation interventions in the Khulna district. The findings revealed that a lack of silt removal or dredging in canals, a lessening of water flow in canals and infringement of canals are the main reasons for waterlogging. Moreover, Ahmad, H. (2019) explores the history, scope, rationale, structure, environmental implications, and future trends of management of coastal areas, as well as the challenges and possibilities associated with coastal development.

A vulnerability study of a rural area in southwest Bangladesh to figure out how environmental change affects development was done by Pouliotte, J. et al (2009). Changes in the environment, politics, and the economy, as well as changes in how resources are utilised (especially shrimp farming), have rendered it difficult for the impoverished to earn a livelihood and made them more vulnerable to future environmental changes, such as climate change.

In the paper ‘Institutional capacity for long-term climate change adaptation: evidence from land use planning in Albay, Philippines’, Cuevas, S. C. (2016)

actually analyses the challenges of mainstreaming climate change adaptation in the province of Albay, Philippines. The researcher identifies the information gap as one of the most critical challenges for adaptation into the local land use plans. In the study, twenty quantitative mainstreaming indicators were developed to evaluate the current status and obstacles of local mainstreaming. Informational, institutional, and resource capacity were the three main categories into which these variables were sorted. The primary obstacles to Climate Change Adaptation (CCA) mainstreaming are the lack of guidance for mainstreaming CCA, redundant policy needs, and inconsistent rules and regulations.

Ishtiaque, A. et al (2021), in the paper ‘Multilevel governance in climate change adaptation in Bangladesh: structure, processes, and power dynamics, provided an overview of the multilevel governance system's structure, procedures, and power dynamics in the coastal regions in Bangladesh. The research identified and analysed the interconnections among the factors influencing adaptive governance using a social network analysis framework. Based on their functions and the way their networks of governance are structured, the research classifies organisations into five distinct kinds. In adaptation governance, it demonstrates the presence of class diversity and influential national organisations. The study shows that it appears that during the phases of planning, implementing, and monitoring, top-down and bottom-up processes collaborate.

The Research Gap

Several pieces of literature confirm that adaptive capacity is a useful concept for assessing the institutions and propose some integrated indicators and approaches to evaluate institutional adaptive capacity (Gupta et al. 2010; Smit and Pilifosova, 2001; Agrawala, 2007; Adger et al. 2007; Willems, 2004). There are large number of research studies have been conducted on climate change vulnerability assessment, risk management, climate change adaptation and impacts of climate change on different sectors in Bangladesh, but very few of them shed light on the indicator-based adaptive capacity assessment of public institutions in the coastal regions to address the climate-induced challenges in different sectors. Significant studies are based on the direct impacts of climate change on agriculture or fisheries, or other sector-wise impacts in the coastal region of Bangladesh, rather than highlighting the capacity of government institutions to address the challenges.

Most of the research focuses on national and regional level community adaptation, with limited insights into local institutions and how their adaptive capacities vary in different situations. A number of policies exist on paper, but there is a gap in understanding how well these policies are implemented and whether institutions have the actual capacity, such as resources, coordination, and skills, to carry them out. Lack of attention in this vital area is a major driving force in conducting the study. Some papers emphasise the vulnerability, causes, impacts and adaptation strategies in the coastal areas of Bangladesh. Hence, there is some literature published about climate governance and the role of different stakeholders, but none has been done to assess the institutional capacity for agricultural adaptation based on the integrated approach of adaptive capacity assessment. Assessing institutional capacity helps to identify the strengths and gaps of the institutions in terms of the institution's skills, resources, knowledge, and coordination mechanisms for successful adaptation. So, it is necessary to assess the strengths, weaknesses, and blockages of the institutions to turn plans into action (Biesbroek et al. 2017).

This study scrutinises the institution's ability to respond towards the impacts of climate change on agricultural production and the capabilities of the institutions to adapt. The findings of the study will help to understand the opportunities and the barriers of coastal agricultural adaptation and enable the institutions to emphasise training, funding, staffing or innovation where it's mostly required.

Bangladesh is considered as the most vulnerable country to climate change and the coastal region in Bangladesh is repeatedly claimed as the most vulnerable region in the world due to its exposure to extreme and frequent climatic events, like sea level rise, increased temperature, reduced dry season precipitation, enhanced monsoon precipitation, salinity intrusion, coastal erosion, and intense cyclones (Islam et al, 2015). Moreover, most of the national and international climate policies, strategies, and adaptation plans prioritise the coastal region because of its vulnerability and importance. The adaptation plans and strategies of the government of Bangladesh also prioritise the coastal region for adaptation due to its significance for biodiversity conservation, critical ecosystem and socio-economic potential. Besides, the dependence of coastal folks on different sectors like agriculture, fisheries, and livestock for their livelihoods makes the coastal area dynamic for adaptive capacity studies. Additionally, in the coastal region, actual impact observation, direct evidence for documentation, and testing adaptive capacity can be more credible than in any other region. So, studying the coastal area will help to better understand the capacity that institutions truly have to address the challenges of climate change in certain conditions. Subsequently, the public institutions under the Ministry of Agriculture in Bangladesh, such as the extension services, research institutions, credit and marketing institutions, are selected for the adaptive capacity assessment because the climate variability has more direct and observable impacts on agriculture, and the agricultural institutions play a central role in adaptation knowledge production and dissemination. Agriculture is considered the primary source of livelihood for almost 60% of the total population and contributes significantly to the national GDP in a developing country like Bangladesh. Also, agriculture is particularly sensitive to climate change perils and vulnerabilities, because agricultural production directly depends on the temperature, rainfall and seasonal cycles. Moreover, the institutional structure in the agricultural sector is wider and largely organised with better extension systems, well-developed research centres, and well-established monitoring systems, facilitating more measurable and assessable in terms of adaptation, adaptive capacity, and governance compared to fisheries and livestock (FAO 2018; IPCC 2014; Gupta et al. 2010; WB 2008; ADB 2009).

Definitions of the Concepts

Climate Change

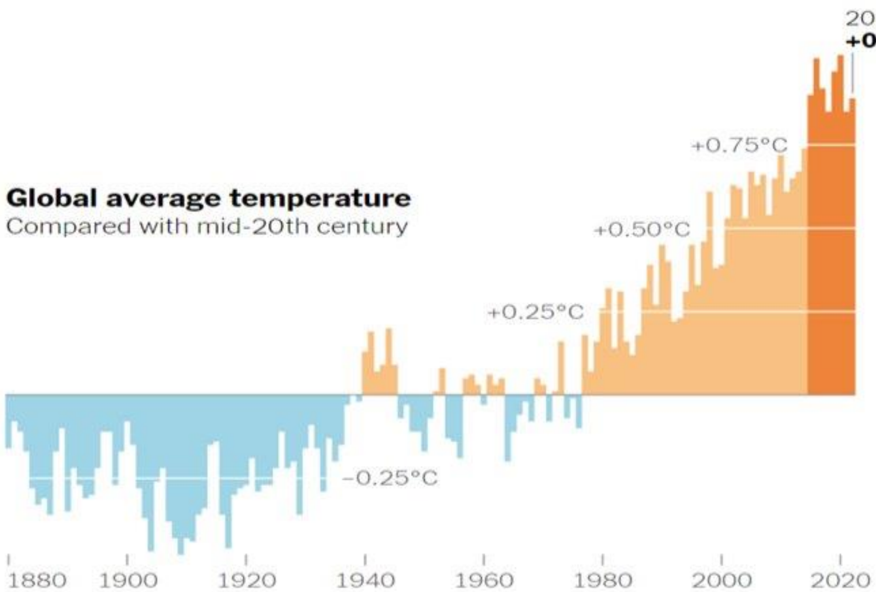
Climate Change can be defined as the long-term change in the average weather patterns which influences the global, national and regional climates. Climate encompasses the general environmental conditions of a region, including temperature, air quality, humidity, precipitation, and wind patterns throughout the year. This is the global phenomenon of changing temperature, precipitation, GHG gases and wind caused by natural and human activities. According to the definition of the National Aeronautics and Space Administration (NASA), the combustion of fossil fuels, which releases gases into the atmosphere that trap heat, is the primary cause of climate change. The trend of rising temperatures, changes in sea levels, melting glaciers, and more intense and frequent weather extremes are examples of global warming (NASA 2023).

The Intergovernmental Panel on Climate Change (IPCC) provides a more detailed definition of climate and climate change. According to IPCC, climate refers to the mean and variability of different types of weather conditions over time (IPCC, 2007) and climate change is defined as '…. a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer' (IPCC, 2014). It describes any gradual shift in the climate, whether brought on by human action or natural variability. Climate is the long-term accumulation of atmospheric elements, such as factors such as exposure to sunlight, humidity, air pressure, precipitation, and temperature (Encyclopedia Britannica, 2025). In contrast to the concept of IPCC, the United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a change in the climate that is directly or indirectly caused by human activity and affects the composition of the global atmosphere. This is in addition to the natural climatic variability that has been documented throughout comparable periods of time.

Climate Change: Global Context

Climate change nowadays represents one of the most pressing global challenges of the 21st century. The excessive burning of fossil fuels, deforestation, and large-scale industrialisation have significantly increased the emission of atmospheric greenhouse gases (GHGs) such as carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4), leading to a temperature rise, causing global warming. As a result, a long-term alteration in global temperature, precipitation patterns, wind patterns and other elements of the earth's climate is shifting and instigating extensive environmental disturbance. With the increase in global temperature, the effects of climate change, such as growing sea levels, melting glaciers, altered weather patterns, protracted droughts, and more frequent and severe extreme weather events, are already apparent.

Figure 2: Global Average Temperature (Source: JPG from NASA Goddard Institute for Space Studies, 2023)



In 2024, the annual mean near-surface temperature was 1.55℃, which is declared as the warmest year in the 175-year observational record, surpassing the record of 2023 (WMO, 2024). In 2023, the temperature of Earth’s surface and Oceans hit an all-time high. The global annual average of carbon dioxide increased by 2.8 ppm in 2024, and the atmospheric carbon dioxide concentration surpassed

430 parts per million (ppm) for the first time in recorded history, which is 155% of the pre-industrial concentration in 1750. In 2014, the concentrations of two additional critical greenhouse gases, nitrous oxide and methane, also reached record highs.

The concentration of methane reached 1900 parts per billion (ppb), 265% of pre-industrial levels and nitrous oxide reached 337 ppb, 125% higher than its pre-industrial level. The warming effect, which causes an increase in surface temperatures worldwide due to the absorption of heat in the atmosphere, becomes exacerbated by these gases. The combined effect of these gases is a fifty per cent rise in radiative forcing compared to 1990. The prediction indicates a 70% probability that global temperatures will rise above 1.5°C between 2025 and 2029.

Table 2: The List of greenhouse gases (From WMO, 2024)

Greenhouse Gases	**Chemical Formula**	**Pre-industrial Concentration**	**Concentration in 2024**
Carbon Dioxide	CO_2	278 ppm	430 ppm
Methane	CH_4	700 ppb	1900 ppb
Nitrous Oxide	N_2O	275 ppb	337 ppb

The latest data and insights indicate that the heat absorbed and stored by the ocean has increased gradually over the past several decades. As the dominant heat reservoir, the ocean heat content reached the highest level in the 65-year observational record in 2024, driven by the high exterior temperatures and widespread maritime heat waves. Absorbing more than 90% of the surplus energy from greenhouse gas emissions, the ocean heat content directly contributes to sea level rise by thermal expansion, exacerbating the intensity and frequency of extreme weather and ocean circulation and stratification. Another most direct and assessable consequence of climate change is the rise of global sea levels, primarily driven by the thermal expansion of salt water and the accumulation of freshwater from melting glaciers and ice sheets. The average global sea level has increased by 20 to 25 centimetres over the last 10 years, which is twice as fast as it was in earlier decades. The sea level is monitored by satellite altimeters, revealing that the pace of the sea level rise has accelerated from 2.1 mm/year in the early 1990s to around 4.7 mm/year as of 2024. Recent data indicate that global sea level rose by 0.59 centimetres in 2024, which is 35% higher than the average annual increase in the previous decade, largely linked to the El Niño-La Niña event. According to the projections, by 2100, the increase may range from 0.3 to more than 1 meter. Furthermore, the acidification of the ocean surface, the lowest sea ice extent, and glacier mass loss are the vibrant indicators of the present global climate warming.

From the historical and future climate perspective, analyses reveal that the trends in global precipitation have increased since the mid-20th century. Simultaneously, extreme precipitation occurrences, such as maximum one-day totals, are getting worse at the same time. Data indicate that these extremes increase by around 7% for each degree Celsius of global warming, and global precipitation upsurges by roughly 1-9% by the end of the 21st century. Since satellite monitoring started in 1979, May 2025 has been identified as the wettest one, and in April 2025, a notable anomaly, such as unusual rainfall in typically dry regions, was detected.

The Intergovernmental Panel on Climate Change (IPCC) reports on climate change provide the most comprehensive and authoritative synthesis regarding current global climate conditions. The first assessment report (AR1) was published in 1990 to establish the scientific basis of climate change. The report highlighted that human activities are responsible for carbon dioxide emissions that increase atmospheric concentrations. The projection indicates that the temperature will increase by 0.3℃ per decade and the sea level will rise by 6 centimetres per decade. The second assessment report (AR2) strengthened the evidence for anthropogenic warming and predicted a 1℃ to 3.5℃ increase in global temperature by 2100, whereas the third assessment report predicted a 1.4℃ to 5.8℃ temperature increase by 2100. Besides, the fourth assessment report of IPCC ‘Climate Change 2007’ comprises the contribution of three working groups highlighting the science of climate change, impacts, adaptation, vulnerability and the mitigation of climate change. The conclusion of the report, supported by the US's National Oceanic and Atmospheric Administration (NOAA), argues that climate change is the result of human activity and the consequences will be devastating if the phenomenon is left unchecked. The report recognised several long-term climatic changes, such as variations in wind patterns, ocean salinity, precipitation levels, arctic temperatures and ice, and extreme weather phenomena including heat waves, droughts, heavy rains, and tropical cyclone severity. The fifth assessment report, released between 2013 and 2014, and the sixth assessment report, released in stages between 2021 and 2023, concluded with high confidence that human influence, particularly the emission of greenhouse gases, is the dominant driver of the observed warming since the mid-20th century. It testified to the global surface temperature escalation of nearly 1.1 degrees Celsius above the pre-industrial levels. Besides, the reports also highlighted significant changes in melting glaciers, shrinking Arctic sea ice, and rising sea levels observed at continental, regional, and ocean-basin scales.

Table 3: Summary of the IPCC Reports (AR1-AR6) on Climate Trends

year	**Warming Evidence**	**Projected Worming**	**Sea level rise**
1990	Probable	.3	6 cm
1995	Apparent	1.0-3.5	15-95 cm
2001	Stronger	1.4-5.8	9-88 cm
2007	Very prospective	1.1-6.4	18-59 cm
2013	Extremely prospective	0.3-4.8	26-98 cm
2021	Unequivocal	1.0-4.4	29-101 cm

Climate Change: Regional Context

Different regions exhibit climate change in different ways because of variations in geography, socioeconomic circumstances, and the ability to adapt. South Asia is not an exception. The IPCC emphasises that nowadays some regions in South Asia with high latitudes and arid zones are undergoing warming above the global average and face intensified monsoonal variability, heatwaves, and sea level rise. Severe drought in Sub-Saharan Africa, rapid ice melting and ecosystem disruption in the Arctic region, sea level rise and coastal erosion in small island developing states, specify the distinctive warming experiences of various geographical areas. The least developed countries all over the world are experiencing greater vulnerability due to their limited resources and institutional capacity. The fourth assessment report of the IPCC shows an increase in annual mean temperature from 0.23℃ to 1℃ in East Asian countries like China, Japan and Korea, whereas 0.6℃ to 1℃ in South Asian countries like Bangladesh, Sri Lanka, Pakistan, India and Nepal (IPCC 2007). Furthermore, the Asia region has experienced a vast variability in precipitation patterns since records. In South Asia, it is reported that Pakistan, northeast of India and a few parts of Sri Lanka face a decrease in rainfall, but in Bangladesh, there is a trend of increase in annual mean rainfall. The coastal belts of these regions are experiencing the rise of sea level due to both the geographic location and the nature of the delta. Satellite altimetry data analysis shows that between 1993 and 2010, sea level rose to 2.8±0.8 mm per year, causing salinity intrusion, flash floods, yield losses and troubles to the ecosystem.

Climate Change Adaptation

Before discussing the concept of climate change adaptation, I would like to focus on the concept of adaptation from a divergent perspective. The term "adaptation" is not new; it has been used to characterise a wide range of biological, psychological, and social phenomena since the nineteenth century. In general, ‘adaptation’ means to adapt to changing conditions. But in climate science, adaptation means the actions that mitigate the problems caused by climate change. Along with mitigation, adaptation is widely recognised as one of the pillars of climate action. Adaptations are influenced by changes in social norms, global governance, information technology, demography, culture, and economics (O'Brien and Leichenko, 2000). Different disciplines have different opinions on adaptation; each perspective emphasises distinct aspects of how communities or systems respond to environmental changes. From an environmentalist's perspective, adaptation is a nature-based solution, such as restoring wetlands and mangroves, conserving forests, promoting organic agriculture, ensuring climate equity and justice, and empowering the community with local adaptive bits of knowledge. Biologists focus on the genetic and physiological modifications and survival of organisms under stresses and changing environmental conditions, but sociologists view adaptation as a social process by which individuals, institutions and communities conduct, norms and structures in response to climate change. Ecologists focus on ecosystem and species-level responses to climate conditions, while Agriculturalists view adaptation as production strategies, crop varieties, farming systems, irrigation practices, and livestock management.

Table 4: Experts' Views of Adaptation from Different Disciplines

Environmentalists	"Adaptation involves proactive efforts to reduce environmental degradation, strengthen ecosystem resilience, and support communities in transitioning toward sustainable practices in the face of climate change" UNEP (2011), IPCC (2014)
Agriculturalist	"Adaptation in agriculture involves modifications in production systems and decision-making processes that enable farmers to maintain and increase productivity despite climate stresses" Smit and Skinner (2002)

Sociologists	"Adaptation is the capacity of societies to adjust to environmental changes through social learning, institutional transformation and cultural resilience" Adger (2003)
Ecologists	"Ecological adaptation is the process through which the ecosystem recognises structurally and functionally to maintain resilience and service provision in changing environmental conditions" Chapin et al. (2010); IPCC (2014)
Biologists	"Adaptation is a genetically determined characteristics that improve the ability of an organism to survive and adapt in a particular environment." Dobzhansky (1973); Futuyma (1998)

Numerous international institutions conceptualised the term adaptation from a climate change perspective, which is acknowledged as an advanced formula in addressing global warming and anthropogenic climate change. IPCC defined adaptation as 'an adjustment process in ecological, social or economic systems in response to actual or expected stimuli and their effects and impacts' (IPCC 2001). UNDP (2005) states adaptation as the process of mitigating the results of climate change and developing, enhancing, and implementing coping strategies. The term "adaptation" describes the actual measures or adjustment process adopted to reduce vulnerability to climate change or to benefit from its consequences (Nelson et. al., 2007; Adger et al., 2005; Burton et al., 2009; Smit & Wandel, 2006; Fussel, 2007; UNFCCC, 2012). Based on the above discussion, it can be said that-

- Adaptation refers to the adjustment in human or natural systems to address the actual or expected climate change impacts.
- Climate change impacts refer to the effects of climate change on agriculture, biodiversity, health and the economy.

- Adaptation aims to reduce the losses and damages related to climate change
- It helps to reduce the vulnerability of people, especially the vulnerable community, highly exposed to climate-related hazards like floods, droughts, and heatwaves
- Through adaptation measures like better infrastructure and disaster preparedness, losses can be minimised.
- Adaptation ensures climate-resilient agriculture to support long-term productivity, aligning with sustainable goals like poverty reduction and food security.
- It reduces damages and maximises the advantages of beneficial opportunities.

There are many classifications of adaptation options based on timing, intent, purpose, means of implementation and on the institutional shape they adopt (Smit et al., 1999). Adaptation to climate change can be categorised into different types. Based on the definition given by IPCC, adaptation can be classified into the following categories: Proactive-Reactive Adaptation, Autonomous-Planned Adaptation. Proactive adaptation, also called anticipatory adaptation, takes place before the impacts of climate change are experienced, whereas reactive adaptation occurs after the impacts of climate change have been observed. Contrararily, the adjustment made by individuals and communities without the help of institutions or regulations is known as autonomous adaptation, while adaptation based on planned actions by governments or institutions is categorised as planned adaptation. Furthermore, Sectoral adaptation is the term used to describe actions taken to mitigate the effects of certain sectors, such as agriculture, water, and the health sector.

Table 5: Types of Adaptation

Types of Adaptation			Reference
Based on Timing	**Anticipatory or Proactive Adaptation**	Takes place before the impacts	IPCC AR5 Group II (2014)
	Reactive Adaptation	Takes place after the incidents	
Based on Intent	**Autonomous Adaptation**	Involves changes that the system will undergo t response regardless of policies, plans or actions.	
	Planned Adaptation	Purposeful policy actions and strategies based on the awareness that conditions have changed	
Based on the Approach	**Structural or technological Adaptation**	Use of physical or technological infrastructure to reduce vulnerability	Smit & Wandel (2006)
	Ecosystem-based Adaptation	Use of the ecosystem or natural biodiversity for adaptation measures	
	Behavioral Adaptation	Changes in behaviour or practices by individuals or communities	Smit & Pilifosova (2001)

	Institutional or Policy Adaptation	Changes in policy, governance or regulations to adopt	Adger et al. (2005)
Based on the Sector	**Agricultural Adaptation**	Crop varieties, alteration in harvesting dates	
	Water Resource Adaptation	Rainwater harvesting for improved irrigation,	
	Urban Adaptation	Green infrastructure	
	Health Sector Adaptation	Heatwave early warnings, disease surveillance	Convention on Biological Diversity (2009)

Adaptation can also be short-term or long-term, confined or widespread, sector-specific, public or private. To best define adaptation, this paper focused on the intent of planned institutional adaptation and adaptive capacity for agricultural adaptation in coastal Bangladesh.

Institutional Capacity Assessment

The main objective of the study is to assess the institutional adaptive capacity. The explanation of key terms 'institution,' 'adaptive capacity,' and 'Adaptive capacity of institutions' is essential to describe institutional capacity assessment.

Institution

Institution refers to the occasion where the systematic rule, law, or custom begins or is introduced to serve and support the people with a need to fulfil the purpose of the state or society. In the report of IDGEC (1999), an institution is defined as the combination of decision-making procedures and programs to intensify the social practices, to allocate the participants' roles, and to guide connections among the stakeholders. Some researchers differentiated institutions from organisations in terms of values and norms (Young 2020, IDGEC 1999). Public institutions refer to the governmental agencies at all levels. Strong institutional arrangements are important for successful adaptation actions at all levels and in all dimensions. The institutions include local, regional, and national levels, as well as nongovernmental organisations and non-profit organisations, which are also a part of public institutions. In the study, the institutions that are working at the national, district, and Upazila levels on sector-specific climate resilience work to address the challenges are considered as public institutions. The institutions are categorised into three different types: implementing departments, Research institutes and credit and marketing institutions.

Adaptive Capacity

The term 'Adaptive Capacity' is dynamic and context-specific. It is difficult to give a simple definition of adaptive capacity. It refers to the ability or potential of some systems to adjust to changes. There are many different definitions of adaptive capacity. The definition by the IPCC is considered the most influential definition of adaptive capacity. IPCC (2007) defines adaptive capacity as 'the ability of systems to adjust to climate change, to mitigate potential damages, to take advantage of opportunities or to respond to consequences. Adger et al. (2004) define adaptive capacity as 'a system's ability or capacity to change its attributes or behaviour to cope better with existing crises. Adaptive capacity is known as the potential or ability to modify structures or functions to achieve desired environments (Smit & Wandel 2006; Smit & Pilifosova 2001; Klein et al. 2011; Adger et al. 2005; Preston & Stafford 2009).

The resilience framework mainly focuses on the system's capacity to respond to disturbances as well as the capability to mobilise the resources to make adaptation actions (Carpenter et al. 2005; Gallopin 2006; Nelson et al. 2009). Vulnerability-grounded valuation to adaptive capacity concentrates on the interdependence of exposure and sensitivity of vulnerability to shape the adaptive capacity at the local or community scale. Adaptive capacity requires vulnerability assessment to identify the determinants of climatic influences (Adger et al. 2005; Preston & Stafford 2009). Moreover, the community-based approaches to adaptive capacity focus on the ability of management and community to learn, experiment and act collectively to foster the solutions in complex social and ecological circumstances (Armitage, 2008).

Table 6: Adaptive Capacity Approaches

Adaptive Capacity		
Resilience Framework	**Vulnerability Assessment**	**Community based Approach**
1.Ability to respond 2.Resources Availability 3.Ability to mobilize the resources 4.Ability to revitalise and renew itself to face the change	1.Ability to reduce vulnerability 2.Ability to manage the factors driving exposour and/or sensitivity	1. Learning to live with uncertainities 2.Ability to experiment and innovate 3.Ability of the community to act collectively

So, it can be said that adaptive capacity is the set of features that allows a given system to identify, perceive and evaluate changes, modify itself for long-term proactive adaptation, develop adaptation tools and methods to cope with current or future hazards. Adaptive capacity varies from country to country, from community to community, and from institution to institution, over time and in different situations (Adger et al. 2005).

Adaptive Capacity of Institutions

The term adaptation differs from the term adaptive capacity. Gupta et al. (2010) describe the difference between adaptation and adaptive capacity for institutions clearly and explain the meaning of adaptive capacity when it's functional at institutions. They define adaptive capacity as the inherent characteristics of institutions, like formal and informal institutions, rules, norms, and values that help actors, for instance, society, individuals, and organisations, to deal with climate change and help to modify the institutions to address the change.

Assessment of Adaptive Capacity

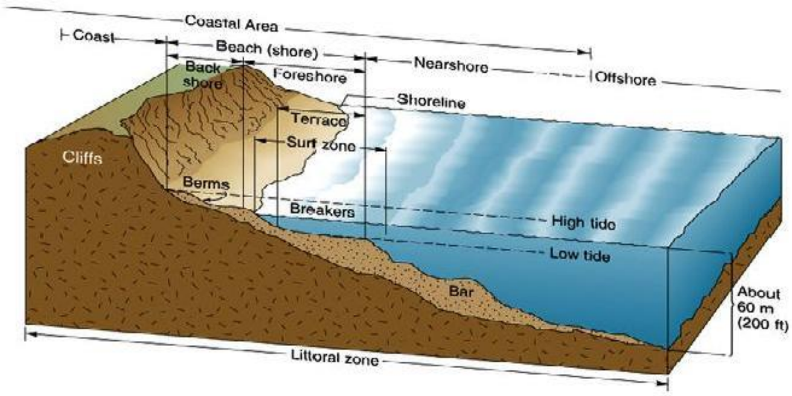
From the different perspective of adaptive capacity, it is found that the assessment of adaptive capacity in climate change studies is primarily consequent from climate impacts and vulnerability assessment. At first, the impact assessment of climate change was only concealed by the changes in temperature and precipitation. Later, Vulnerability assessments encompass non-climatic elements such as environmental, social, economic, demographic, technical, and political aspects, as well as possible adaptation strategies. In the advanced part of the climate change vulnerability assessment, adaptive capacities of social and natural systems are evidently included. From the 1st assessment report to the 4th assessment report by IPCC, the economic indicators of adaptive capacity have visibly changed, including the availability of economic resources, technology, information, institutional capacity, social capacity, like perceptions, values, social capital, and equity, to adapt to the risks related to climate change. Economic, social and institutional factors get equal consideration for reducing vulnerabilities. Though many studies demonstrate the significance of social factors like institutions, perceptions, and social capital for successful adaptation (IPCC 2007; Adger et al. 2005; Smit & Pilifosova 2001; Jones & Boyd 2011), very few of them focus on evaluating institutions' adaptive capacity and on developing advancements in systematic methodology (Grothmann et al., 2011).

However, it is very difficult to develop a single methodology to assess the adaptive capacity due to the complexity and diversity of situations. The adaptations needed by various sectors, actors, geographical regions, and decision-making levels differ, as do the adaptive capacities of the different social systems. Several studies measure adaptive capacity through the framework that focuses on social, economic, informational, technological and institutional determinants (Smit & Pilifosova, 2001) known as the Indicator-based quantifiable approach. Eight determinants of adaptive capacity, including technology, resources and infrastructure, are suggested by Yohe et. al. (2002). Some studies involve qualitative approaches to assessment. IPCC develops a vulnerability framework to assess the adaptive capacity, whereas a governance-oriented framework with six dimensions and 22 criteria was developed by Gupta et al. to assess the institutional adaptive capacity, which is known as the Adaptive Capacity Wheel (ACW). However, to assess the adaptive capacity of social systems, particularly of institutions, numerous studies incorporate a large number of indicators from many models or methodologies, which are known as index-based approaches.

Coastal Zone

The coastal zone is known as the dynamic interface between the land and water bodies. According to the explanation of the IPCC, the coastal zone is the place where land and water interface with each other because of the complex interactions of terrestrial, atmospheric, and marine processes. Cowell et al. (2003) state the coast as a dynamic system that adjusts its form and processes at different time and space scales. The area encompasses high and low tide lines, beaches, estuaries, mangroves, cliffs, deltas, coral reefs, shorelines, nearshore and offshore.

Figure 3: Diagram of zones of the shoreline. U.S. Navy. 2006. Public domain.



The zone is featured by distinctive natural, ecological and economic features. Repetitive erosion, sedimentation, and sea level changes constantly transform the coastal areas. The ecological productivity is very high in the coastal zone due to the mixing of nutrients from land and sea. These features make it one of the most favourable habitats for rich biodiversity, like fisheries, aquatic birds, and mammals. The coastal zone covers 20% of the Earth's land surface, and up to 40% of the world population lives on the coast (UNEP, 2011). In Bangladesh, the length of the coastline is approximately 710 square kilometres, and the size is 47,201 km², geomorphologically and hydrologically ruled by the Ganges-Brahmaputra-Meghna (GBM) river system and mostly running along the Bay of Bengal from Teknaf to the Sundarbans in Khulna.

Table 7: List of Coastal Regions in Bangladesh

Coast Type	Regions
Deltaic Coast	Noakhali
Estuarian Coast	Feni
Marine Coast	Cox's Bazar, Teknaf
Mangrove Coast	Khulna, Satkhira, Bagerhat
Coral Reef Coast	St. Martin's Island
Accreting Coast	Sandwip
Eroding Coast	Kutubdia

The large coastal zone is highly exposed to erosion, coastal flooding and submergence due to sea level rise. In the coastal system, Sea level rise, ocean temperature and ocean acidity are the three key drivers allied with climate change. These factors originate from physical or chemical effects like salinity intrusions, wetland losses, storm surges, rising water table, overtopping, etc. (IPCC, 2007). So, it can be said that

- Coastal Zone has a dynamic interface, diverse landforms, and rich biodiversity.
- It has high ecological productivity
- It is highly exposed to natural hazards
- Coastal areas host a high population density
- It is an economically important zone for ports, shipping, trade, aquaculture and tourism.

Theoretical Framework

The conceptual framework is based on numerous concepts and approaches that are frequently used to evaluate the adaptive capacity of institutions. The methodologies encompass institutional theory methods, capacity development theories, adaptive capacity evaluation frameworks, and governance theories. The effectiveness and capacity of the public institutions are the combination of human resources, organisational structures, financial capabilities and technical assets (Grindle, 1997). The capacities described by the IPCC (2007) and Smit and Wandel (2006) assist institutions in the development, implementation, and monitoring of adaptation strategies. At first, numerous pieces of literature were reviewed regarding institutional capacity assessment. We know that it is important to establish the criteria for assessing the institutional capacity for climate change adaptation. Several guidelines are available from research on this topic conducted earlier. Among them, the widely used approaches to assess the institutional capacity for adaptation are considered to be gathered and discussed below.

Institutional Analysis and Development (IAD)

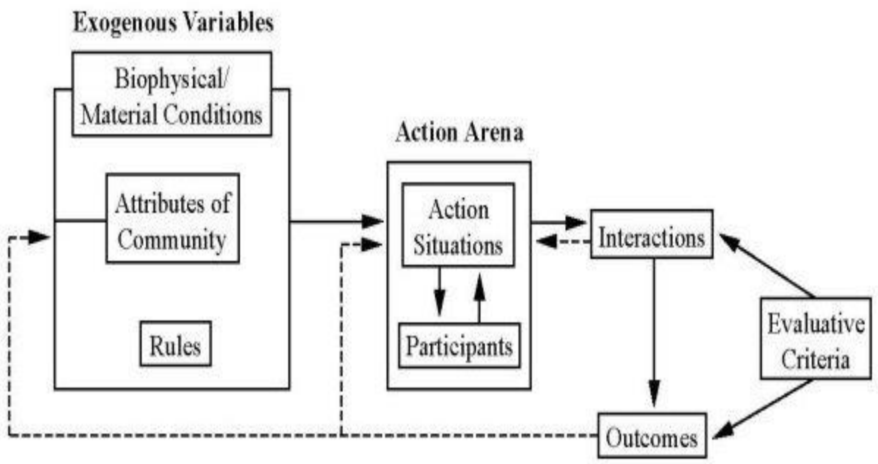
One of the approaches is Institutional Analysis and Development (IAD), developed by Ostrom& Crawford. The IAD Framework that had been framed over several years by Dr Ostrom and her colleagues at Indiana University's Workshop in Political Theory and Policy Analysis (Blomquist & de Leon, 2011). The IAD framework is one of the main approaches to institutional analysis. As with any framework, IAD's primary value lies in providing a means of organising inquiry into a subject and a set of variables to examine or a set of questions to ask. It does not tell us what will happen, and it does not tell us whether what occurred was necessarily good or bad. Primarily, the IAD framework assists us in enlightening what to think about when we are observing a phenomenon (Blomquist and Deleon, 2011). They propose seven types of institutional rules that are position, boundary, choice, aggregation, information, payoff, and scope rules that directly affect the action situation (Ostrom, 2005). The action situation refers to the social space where actors interact, make decisions and realise outcomes from their interactions (Ostrom, 2011).

The IAD framework is a multi-tier theoretical map. One component of the approach involves identifying an action context, analysing the corresponding action designs and final results, and then assessing these outcomes. The initial step is to identify the conceptual unit or an action area to evaluate a problem, which can be used to explain, analyse, anticipate and illustrate behaviour within institutional frameworks (Ostrom, 2011). Action arenas include an action situation and the actors in that situation. An action situation can be considered through seven clusters of variables. They are-

1. Participants,
2. Positions,
3. Outcomes,

4. Action-outcome linkages,
5. The control that participants exercise,
6. Information, and
7. The costs and benefits assigned to outcomes.

Figure 4: A Framework for Institutional Analysis (IAD) Source: Adapted from E. Ostrom, Gardner and Walker (2011, 37).



The word "action arena" refers to a social setting where people engage in a wide variety of activities, including exchanging products and services, solving issues, dominating one another, and fighting (among the numerous activities that players engage in in action arenas). There are many complications regarding the framework developed by Ostrom. The first one is the multiple definitions of institutions, which may generate misperception, to progress much in the study of institutions. Secondly, the indiscernible nature of institutions sometimes hinders the real outcomes. Furthermore, a structure of rules at a different level is often used to make choices about rules at a lower level. Therefore, institutional instruction requires numerous stages of analysis.

Social Network Analysis (SNA)

Another frequently used method for assessing institutions' capacities is Social Network Analysis (SNA), which is mainly concerned with the aspects of hierarchy level cooperation and collaboration. Social Network Analysis (SNA) can be used as an empirical form of an assessment framework for measuring institutional relationships in terms of climate change. It is a collection of methods and tools that could be used to study relationships, interactions, and communications.

The study of social networks is a new but quickly widening multidisciplinary area involving social, mathematical, statistical, and computer sciences. It has its parameters and methodological tools. A social network can be defined as the relationships among a person, family, household, village, community, region or other groups. In addition to being social actors, each of them can function as a social network component. It is actually a set of techniques and methodologies for studying communication, relationships and interactions. It can be concluded that it is necessary to examine several features of the distribution pattern of interpersonal relationships (Sonawane et al., 2022).

Institutional Response Capacity Framework (IRCF)

The Institutional Response Capacity Framework (IRCF) was developed by Lankao et al., who used four indicators (Information and knowledge, Legal framework, Network, and Participation) to evaluate the response capacity of urban institutions in Mexico City and Santiago. The first element of their framework is the issue of concern (climate change), upon which policy responses are undertaken, which is the policy domain in which the city is or could be acting. Inside the realm of the issue of concern, different urban actors come together with varied and sometimes conflicting interests and visions of the city. These institutional features or components of institutional response capacity are the level of cooperation and coordination between actors (networks), the effectiveness of the legal framework, the availability and use of information, and the mechanisms by which actors contribute to decision-making.

Table 8: The Institutional Response Capacity Framework (IRCF) developed by Lankao et al. 2013

Indicator	**Indicator description**	**Codes used in data analysis**
Information and knowledge	means (meetings, Internet, and media) used by authorities to collect, exchange, and disseminate information with other governments, stakeholders, and the public	information, transmission of information, information needs, information block, learning, flexibility
Participation	mechanisms by which authorities engage stakeholders, and incorporate stakeholders' input into organisational decisions and strategies	participation, participation needs, conflict
Network	high levels of coordination and cooperation among relevant groups and stakeholders—that is, low levels of fragmentation	vertical network, horizontal network
Legal framework	The legal framework for climate and disaster management is complete, unambiguous, and is reviewed and changed periodically	legal, accountability, role, planning, perception of government

Adaptive Capacity Wheel (ACW)

The most quoted method in the literature is regarded as ACW (Adaptive Capacity Wheel), developed by Joyeeta Gupta et al., that assesses institutional adaptive capacities dealing with environmental challenges. Academics and social actors can use this wheel to determine if and how institutions should be modified in order to enhance society's adaptive ability in response to climate change (Gupta et. al., 2010). They developed the method to assess the adaptive capacity provided by a society’s system of institutions. Institutions that maximise adaptive capacity are perceived as those that facilitate the integration of diverse perspectives, stakeholders, and solutions, empower social actors to engage in continuous learning and institutional enhancement, encourage self-regulation among social actors, maximise leadership potential, mobilise resources for the successful implementation of adaptation strategies, and promote equitable principles of governance. The six components comprise twenty-two criteria for assessment. The researcher will try to assess the capacity of institutions in light of these six dimensions and their 22 criteria from the Adaptive Capacity Wheel.

The following table shows the adaptive capacity dimensions, criteria, and definition of these criteria.

Table 9: Adaptive Capacity Wheel (ACW) developed by Joyeeta Gupta et al. (2010)

Dimension	Criteria	Definition
Variety	Variety of problem frames	• Room for multiple frames of reference, opinions and problem definitions.
	Multi-actor, multi-level, multi-sector	• Involvement of different actors, levels and sectors in the governance process
	Diversity of solutions	• Availability of a wide range of different policy options to tackle a problem
	Redundancy	• Presence of overlapping measures and back-up systems, not cost-effective

Learning Capacity	**Trust**	• **Presence of institutional patterns that promote mutual respect and trust**
	Single Loop Learning	• The ability of institutional patterns to learn from past experiences and improve their routine
	Double Loop Learning	• Evidence of changes in assumptions underlying institutional patterns
	Discuss doubts	• Institutional openness towards uncertainties
	Institutional memory	• Institutional provision of monitoring and evaluation processes of policy experiences

Room for Autonomous Change	**Continuous access to information**	• **Accessibility of data within institutional memory and early warning systems to individuals**
	Act according to plan	• Increasing the ability of individuals to act by providing plans and scripts for action, especially in the case of disasters
	Capacity to improvise	• Increasing the capacity of individuals to self-organise and innovate – a fosterer of social capital

Leadership	**Visionary**	• **Room for long-term visions and reformist leaders**
	Entrepreneurial	• Room for leaders who stimulate actions and undertakings; leadership by example
	Collaborative	• Room for leaders who encourage collaboration between different actors – adaptive co-management
Resources	**Authority**	• **Provision of accepted or legitimate forms of power; Whether or not institutional rules are embedded in constitutional laws**
	Human Resources	• Availability of expertise, knowledge and human labour
	Financial Resources	• Availability of financial resources to support policy measures and financial incentives
Fair Governance	**Legitimacy**	• **Whether there is public support for a specific institution**
	Equity	• Whether or not institutional rules are fair
	Responsiveness	• Whether or not institutional patterns show a response to society
	Accountability	• Whether or not institutional patterns provide accountability procedures

Indicator-Based Approach

The researcher employs several indicator-based approaches to assess the capacity of the different institutions. Among them, Danny's Indicator-Based Approach is well-suited for experiential studies. A four-indicator-based approach (collaboration, financial, technology, and information) was developed by Danny. The capacity of the health and water sector regarding climate change in Cambodia was assessed by him. Meanwhile, the capacities of the Australian water governance were evaluated by evaluating the stakeholders' capacity to learn, to make decisions, and to take actions.

Analytical Framework

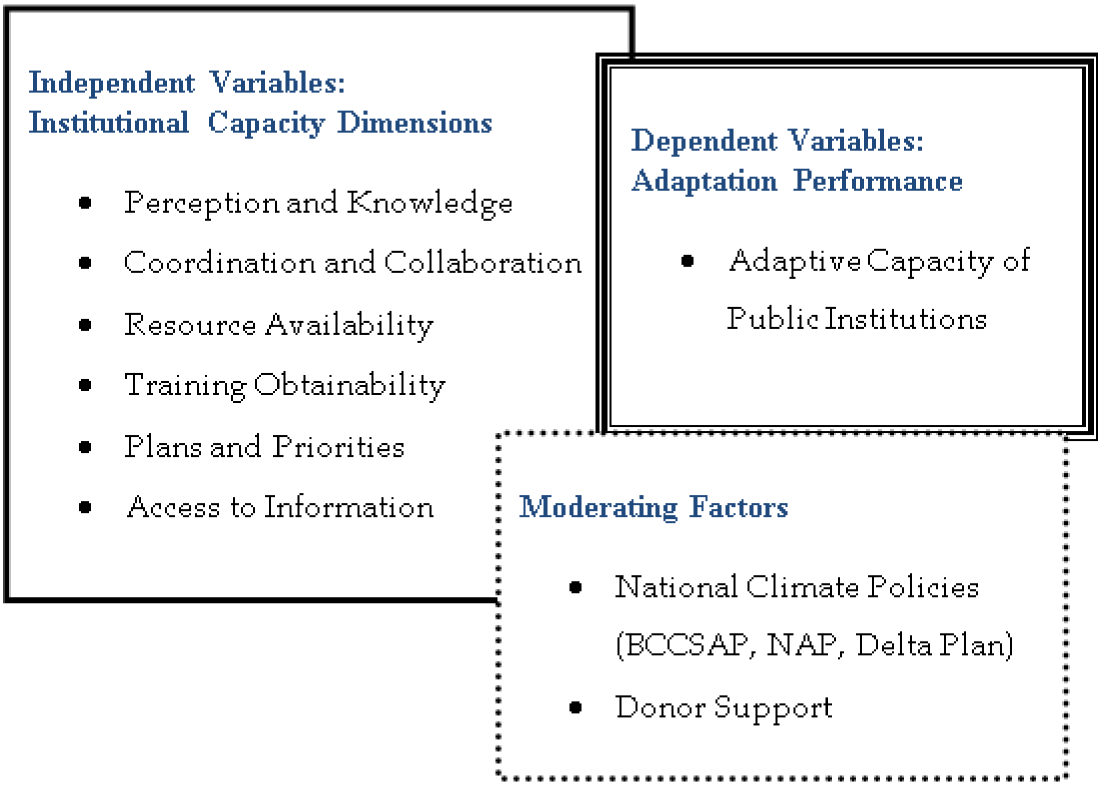
The following are the predominant institutional capacity assessment methods acknowledged in the academic literature. In light of the literature voids and contemporary empirical studies, six independent variables have been selected for assessing institutional capacities for climate change adaptation in the agricultural sector. Then, a total of twenty-nine sub-indicators were chosen and assessed. The six indicators included officials' perception and knowledge, coordination and collaboration, resource availability, training and expertise obtainability, plans and priorities, and room for autonomous changes of the institutions dealing with climate change adaptation. A comprehensive enlightenment of the indicators and sub-indicators is given in the following table.

Table 10: Adaptive Capacity Indicators and Sub-indicators

Indicators		**Sub Indicators**
Climate Perception and Knowledge (PKI)		Climate Change Perception
		Perceived Impacts of Climate Change
		Knowledge of CCA Practices
		Acknowledgement of CCA Practices
Coordination and Collaboration (CCI)		Intra-Institutional Coordination
		Community Coordination
		Inter-Institutional Collaboration (Public)
		Inter-Institutional Collaboration (Private)
Resource Availability (RAI)	Physical Resources	Machine/Equipment Availability
		Machine/Equipment Requirement
		Machine/Equipment Availability for CCA
	Financial Resources	Funds Availability
		Funds Sufficiency
		Funds Requirement
	Human Resources	Staff Availability
		Training Needs
		Staff for CCA
Training Obtainability (TEI)		Expertise in Climate Change Adaptation
		Working Experience
		Professional Training
		Trained Staff
Plans and Priorities (PPI)		Institutional Priorities
		Past Programs
		Present Programs
		Future Programs
		Emergency Planning
Room for Autonomous Changes (ACI)		Access to Information
		Act according to plan
		Capability to Improvise

The independent variables and sub-indicators have been determined from the Adaptive Capacity Wheel (ACW), indicator-based approach and Institutional Response Capacity Framework (IRCF) theories mentioned earlier that explain how institutions develop and implement capacity for climate change adaptation. Those theories highlight the perception and knowledge, resources, training, structures, information, and coordination as the core components of capacity that form the independent variables in the framework. Moreover, the theories explain that enhanced institutional capacity contributes to improved climate adaptation outcomes. Thus, the multiple theories were integrated to justify the selection of variables in the conceptual framework.

Figure 5: Analytical Framework (Prepared based on Adaptive Capacity Assessment Theories and approaches)



Conclusion

This chapter reviews the literature on vulnerability, institutional and policy documents related to climate change adaptation, adaptive capacity assessment theories and identifies the variables to develop a conceptual framework. The study found that there is a bounty of literature accessible related to the role of institutions in addressing the impacts of climate change adaptation worldwide, but very few of those focus on the climate resilience role of Bangladesh's government institutions. Moreover, though the country is the most vulnerable all over the world in terms of climate change, most of the literature found that the public institutions are not fully prepared for effective adaptation and mitigation processes. It shows that institutional constraints hinder the adaptation progress in most of the developing countries. So, addressing the policy gap on climate resilience and strengthening the financing and capability of institutions has emerged as a significant field of research at the end of the twentieth century onwards.

In addition, the empirical studies on institutional adaptive capacity assessment show that the structural and human resources, coordination among institutions, knowledge on climate impacts and fair governance are the prerequisites for an effective adaptation process. Based on the literature, it can be concluded that the academic work on the assessment of institutional capacity to address climate change impacts in different countries of the world can contribute to developing some insight for any research on the assessment of government institutions' climate change adaptation capacities at the multi-governance level in Bangladesh.

Chapter Three

Research Methodology

"Research methodology simply refers to how a researcher systematically designs a study to ensure valid and reliable results that address the research aims and objectives."

Jansen and Warren, 2020

Chapter Summary

The purpose of this chapter is to discuss the research design, data collection, and data analysis methodology. This chapter comprises the development of an analytical framework for the research and a comprehensive framework for data collection techniques.

- *Introduction*
- *Research Design*
- *Description of Study Area*
- *Description of the Institutions*
- *Sampling Methods*
- *Data Collection Methods*
- *Data Analysis Methods*
- *Research Ethics*
- *Methodological Limitation*

Introduction

In the previous chapter, the conceptual framework for the research on institutions' capacity for climate change adaptation was discovered. Based on the particular conceptual frameworks, the study area and the list of institutions were shortlisted. The purpose of this chapter is to discuss and justify the systematic framework of the research encompassing the research philosophy, research design, research approach, study area and institutions, data collection methods and data analysis methods to answer research questions, along with research aims and objectives.

In Chapter One, the main objective of the research is to assess the capacity of public institutions (Field, Research, and Credit organizations under MoA) for climate change adaptation in the agricultural sector of the coastal districts in Bangladesh and the separate specific objectives are *firstly*, to observe the adaptation measures taken by the institutions for agricultural development, *secondly*, to determine whether the institutions have the capacity for agricultural adaptation throughout the institutional arrangements, and *thirdly*, to identify the barriers of CCA of coastal districts in Bangladesh. The research aims to identify how public institutions are responding to address the impacts of climate change in the coastal areas in Bangladesh and to explore the challenges and barriers of the institutions observed in the process of agricultural adaptation by interviewing officials from different hierarchical administrative units.

This chapter provides information regarding the methodologies used in answering the research questions and achieving the goal of the research. In order to identify the impacts of climate change on agriculture and adaptation measures undertaken by public institutions, a literature review and document analysis techniques are conducted. To assess the capacity of institutions in terms of knowledge and perception, coordination and collaboration, resources availability and training obtainability, plan priorities and information access, semi-structured, open and closed-ended interview questions were prepared for face-to-face interviews.

To identify the challenges and limitations of adaptation practices, the interviewees' opinions and experiences are investigated using half-standardised interviews as a multiple-embedded case study of coastal districts in Bangladesh.

The reason semi-structured interviews were chosen is that the techniques provide the opportunity to ask subsequent inquiries, promote contemplation and uncover more detailed information; they are comparable and credible and are flexible enough to allow interviewees to bring up issues that are not specified in the guidelines. The case study area is selected on the basis of the following criteria, such as severity and quantity of climate-induced vulnerability, its significant contribution to national agricultural production and subsequent impacts of climate change, its potentialities for the energy and tourism industry, shrimp and crab culture and dry fish industry and necessities for better capacity development in terms of adaptation and risk management process.

Table 11: Research Aim, Objectives and Questions

Research Aim

To assess the capacity of public Institutions for climate change adaptation

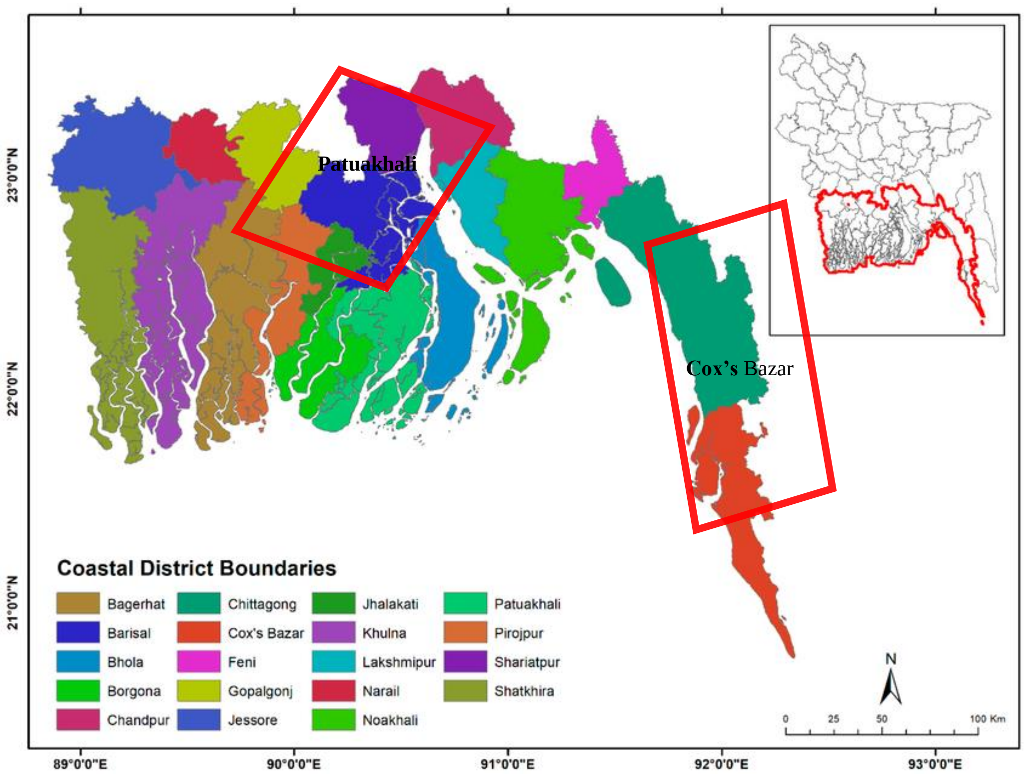
Research Objectives	Research Questions
To assess the existing institutional framework, including climate change strategies and policies, as well as adaptation plans to support institutional roles and arrangements in adaptation in the agricultural sector in Bangladesh.	What are the major impacts of climate change on the coastal agricultural sector in Bangladesh?
To review the impacts of climate change on crop production in the coastal areas.	What is the existing policy framework for supporting agricultural adaptation in coastal areas?

To analyse the factors affecting the capacity of public institutions for climate change adaptation.	What are the adaptive measures taken by the relevant public institutions for climate change adaptation?
To assess the adaptive capacity of selected institutions by using an index-based capacity assessment approach.	How far are the institutions capable enough to address these climate change issues?
To present a comparative picture of the coastal region's public institutions' adaptive capacity to climate change.	What could be the means to increase the capacity of public institutions in Bangladesh for climate change adaptation in future?

Overview of the Case Study Area

Bangladesh's coastline area is classified into the eastern, central, and western zones. Numerous canals and waterways cross the semi-active delta in the west of the region known as the Ganges tidal plain. The most vigorous and perpetual processes of erosion and sedimentation are found in the central area. The estuary of the Meghna River is located here. The eastern region is surrounded by hilly areas that are more stable. Approximately 711 km of coastline encompasses Bangladesh's coastal zone with a significant range of landscape diversity inhabited by human settlements, forests, plentiful tidal wetlands and rivers, natural dams, estuaries, mangrove forests, and sandy beaches. The entire coastal region of Bangladesh, an area of 4,625,334 hectares, is comprised of nineteen districts (Bagerhat, Barisal, Borguna, Patuakhali, Bhola, Chittagong, Cox's Bazar, Jessore, Jhalakati, Lakshmipur, Narail, Noakhali, Pirojpur, Satkhira, and Shariatpur comprising one hundred and forty-seven Upazilas), among which a total of 48 Upazilas and 12 districts are defined as the exposed coast facing the estuary. As an empirical study regarding the institutional capacity for climate change adaptation in the coastal area, Patuakhali and Cox's Bazar districts are selected as the study areas.

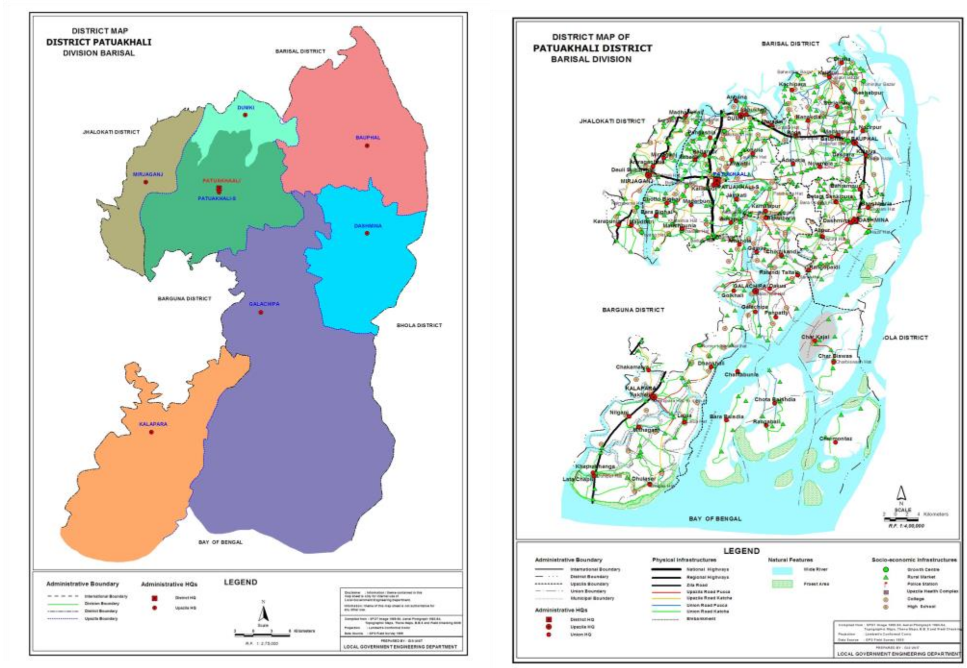
Figure 6: Coastal district boundaries in Bangladesh showing the location of the study area (Abdullah et al. 2019)



Description of the Study Area

Patuakhali District: Patuakhali, the second largest district of Barisal Division and fifteenth among the 64 districts of Bangladesh, is situated between latitudes 21°48' and 22°36' north and longitudes 90°08' and 90°41' east. It covers 3221.31 square kilometres, including a riverine area in which 165.67 sq. km. is river area and 607.03 sq. km. is under forest area (BBS, 2019). The boundaries of this district are the Bay of Bengal to the south, the Barisal District to the north, the Bhola District to the east, and the Barguna District to the west, and the total population is 1535834 (Banglapedia, 2023). The district comprises eight Upazilas, namely Bauphal, Dashmina, Dumki, Galachipa, Rangabali, Kalapara, Mirzaganj, and Patuakhali Sadar, among which Kolapara, Rangabali, and Golachipa are highly exposed to the coast. The administrative unit comprises five municipalities, eight Upazilas, and seventy-six unions (BBS, 2019). The area consists of numerous tidal rivers named the Laukathi, the Lohalia, the Payra, the Bura Gowrango, the Andharmanik, the Tetulia, the Karkhana, and the Agunmukha etc., among which the majority of rivers are distributary tributaries that flow into the Bay of Bengal from the Ganges (Hossain et. al. 2017).

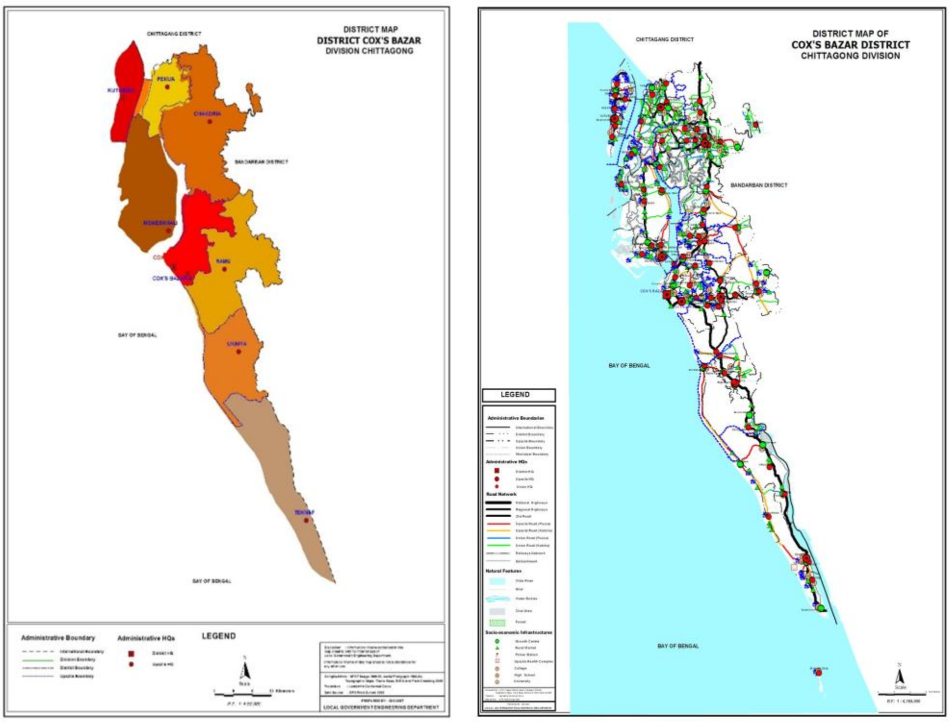
Figure 7: Patuakhali District Map (Source: LGED, Bangladesh)



The northern part of the districts comprises sedimentary non-saline clay soil, whereas the central and southern parts consist of saline-prone muddy soil from the lower Meghna tidal floodplain. The primary economic activities are based mainly on agriculture. The crops, including local HYV and hybrid paddy, oilseeds, vegetables, spices, wheat, pulses, and maize, are mainly produced in this area.

Cox's Bazar District: Cox's Bazar, with one of the longest sea beaches in the world, is situated between 20°43' and 21°56' north latitudes and 91°50' and 92°23' East longitudes. It is a district of the Chittagong division in Bangladesh. The district is encircled by Chittagong on the north, on the East by Bandarban and Myanmar, by the Bay of Bengal on the West and on the South. The expanse of the district is 2,491.85 sq. km., which covers around 1.69% of the entire part of country. The district consists of eight Upazila named Coxsbazar Sadar, Pekua, Chakoria, Moheshkhali, Ramu, Kutubdia, Teknaf, Ukhiya and Eidgaon, among which Cox's Bazar Sadar, Ramu, Ukhiya, Moheshkhali and Teknaf are declared as Ecologically Critical Area (ECA) by the government of Bangladesh. The district has three islands named Kutubdia, Maheshkhali, and St. Martin, which are located in the Bay of Bengal. The administrative units encompassed 4 Municipalities, 4 Upazilas, 71 Unions, and 180 Mauzas (Agricultural Census, BBS, 2019).

Figure 8: Cox's Bazar District Map (Source: LGED, Bangladesh)



The district is comprised of active mangrove tidal floodplains with grey muddy sand on its western side, unconsolidated silty loam sediment in the eastern belt, and grey clay soil in the northwestern central belt, which is mostly flooded by saline water. The Matamuhuri, the Bagkhali, the Naaf and the Reju are the prime rivers that flow through the districts. The total length of the waterbodies is approximately 22.3 km, with an area of around 188 sq. km (73 sq. miles), covering nearly 7.55% of the district's total area.

Climatic Aspects of the Study Area

This section briefly discusses the current climate of the coastal areas in Bangladesh. It reviews the projections of temperature, precipitation changes, sea level rise, changes in intensity and frequency of natural calamities, as well as the significance of climate change impacts on agriculture in the coastal areas. Coastal Bangladesh has a complex climate, characterised by monsoon seasons from June to October, warm temperatures from March to May, a dry season from November to February, and high vulnerability to pre-monsoon and post-monsoon cyclones and storm surges. Additionally, it faces growing challenges from salinity intrusion and sea level rise.

The most dominant feature of climate patterns in coastal Bangladesh is the southwest monsoon, which is responsible for heavy rainfall in the months of June to October. Although projecting rainfall is more challenging, climate models largely indicate that regional monsoon precipitation is expected to increase under a warmer climate. The most accurate projection indicates a 10 to 15% enhancement in average monsoon precipitation by 2030, however, with considerable uncertainties (Warrick et. al., 1994). It is predicted that the precipitation percentage of Bangladesh will increase from 7% to 13% from the year 2040 to 2050 (Hossain 2009). Over the 50 years of 1971-2020, the Chittagong division experienced the largest decrease in precipitation per decade (- 47.74 mm), whereas Barisal observed a significantly drier pre-monsoon season but a slight increase during fall months (+24.09 mm).

Figure 9: Average Temperature and Average Rainfall in Bangladesh (Source: BARC)

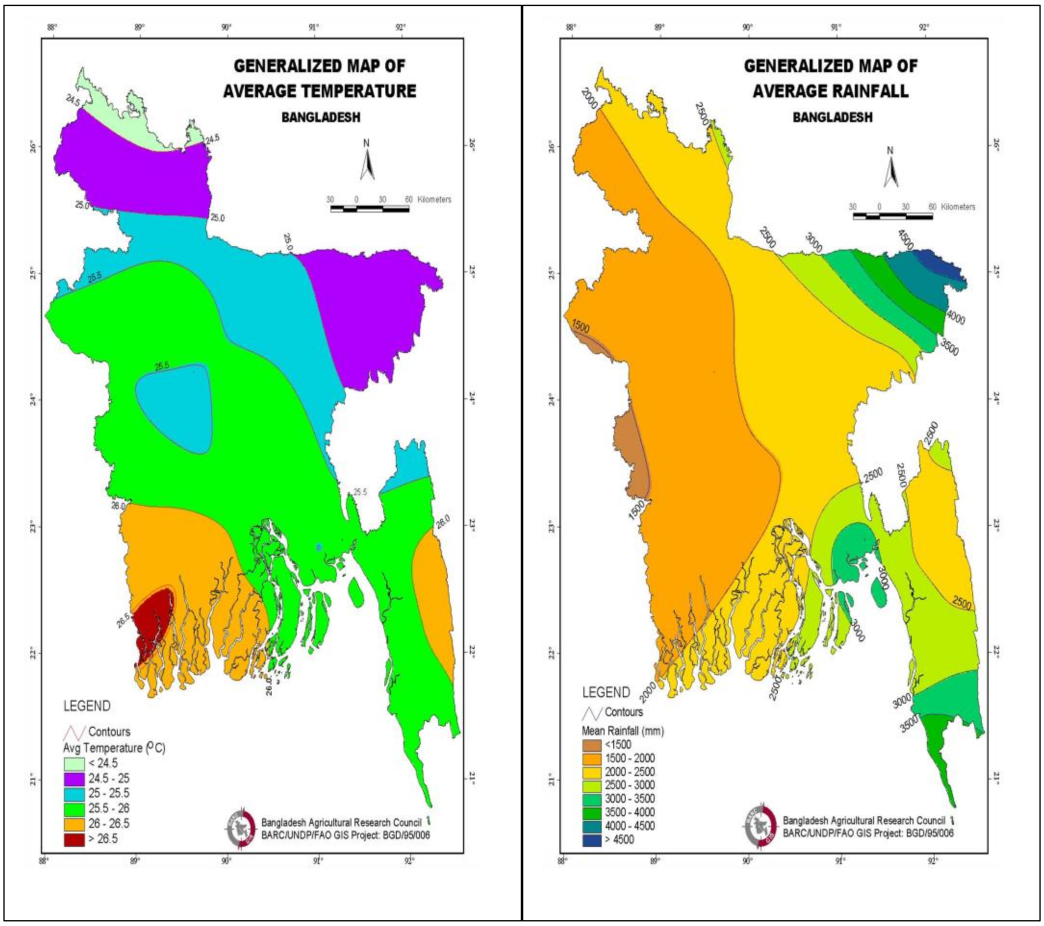


Figure 10: Climatology of Chittagong and Barisal Division (World Bank Group, 2024)

For the IPCC (1990) emissions scenario based on a range of GCMs, Bangladesh is projected to be 0.5°C to 2.0°C warmer than today by the year 2030. The coastal areas uphold comparatively warm temperatures year-round, averaging between 25°C and 30°C, which can increase to over 35°C during the pre-monsoon period from March to May. Bangladesh's average mean temperature was amplified by 0.16℃ per decade, where the Chittagong division recorded the highest increase in temperature (0.28℃), and the Barisal Division observed a 0.11℃ minimum increase per decade. Besides, during the winter months, from November to February, the dry season occurs when the temperatures of the coast are relatively cooler, the humidity level drops, and the rainfall is minimal.

The average annual rainfall varies from 2100 to 5100 mm all over the country. In 2020, the maximum rainfall was recorded in the coastal areas in the Chittagong division. For the years 2019 and 2020, the annual average rainfall was observed at 1869.79 mm and 2293.13 mm, respectively, and the rainfall volume was 4659.51 m^3 and 5714. 49 m^3in Cox's Bazar. In addition, the annual average rainfall was observed at 2594.90 mm and 3399.53 mm, respectively, and the rainfall volume was 8316.64 m^3 and 10895.48 m^3in Patuakhali district in the years 2019 and 2020. Furthermore, for the years 2017 and 2018, the annual average rainfall was observedt 6378 mm and 5143 mm, respectively, in Cox's Bazar, which was the highest yearly rainfall.

Table 12: Rainfall Pattern of Study Area (Sources: BWDB, 2023)

Study Area	**Annual Average Rainfall 2017**	**Annual Average Rainfall 2018**	**Annual Average Rainfall 2019**	**Annual Average Rainfall 2020**
	Rainfall Volume 2017	**Rainfall Volume 2018**	**Rainfall Volume 2019**	**Rainfall Volume 2020**
Patuakhali	2541	2025	2594.90	3399.53

	8144.39	6488.76	8316.64	10895.48
Cox's Bazar	6378	5143	1869.79	2293.13
	15893.37	12815.98	4659.51	5714.49

Furthermore, the exposed coast areas are highly vulnerable to cyclones and storm surges during the period of April-May and October-November. Study shows that more than 88 devastating cyclones hit the coastal area of Bangladesh in the last 200 years, and almost 10,00,000 people died from catastrophic cyclones during the last 40 years (Islam and Ahmed 2004). Most of the cyclones were in Cox's Bazar, Patuakhali, Chattogram, Noakhali, Sonadia coast, Teknaf, and Kutubdia Island, followed by the Sunderban. Moreover, Coastal regions are experiencing greater saline intrusion as a result of increasing sea levels and decreasing freshwater flows from upland rivers. The sea level is rising by about 5 to 7 mm per year on the western coast, 9 to 10 mm per year on the central coast and 14 to 23 mm per year on the eastern coast (Brammer, 2014).

Key vulnerabilities of the Coast

People living in low-lying coastal flood plains are highly vulnerable to the risks of coastal floods, cyclones, storm surges, Sea level rise (SLR), salinity, shoreline erosion, and accretion. Bangladesh is not an exception, and the coastal community exceedingly depends on agricultural production from crops, fish and livestock for livelihood. Due to the increase in climatic hazards and extreme events on the coast, the production in coastal areas is decreasing (IPCC 2014, Barbier 2015, Rashid and Paul 2013).

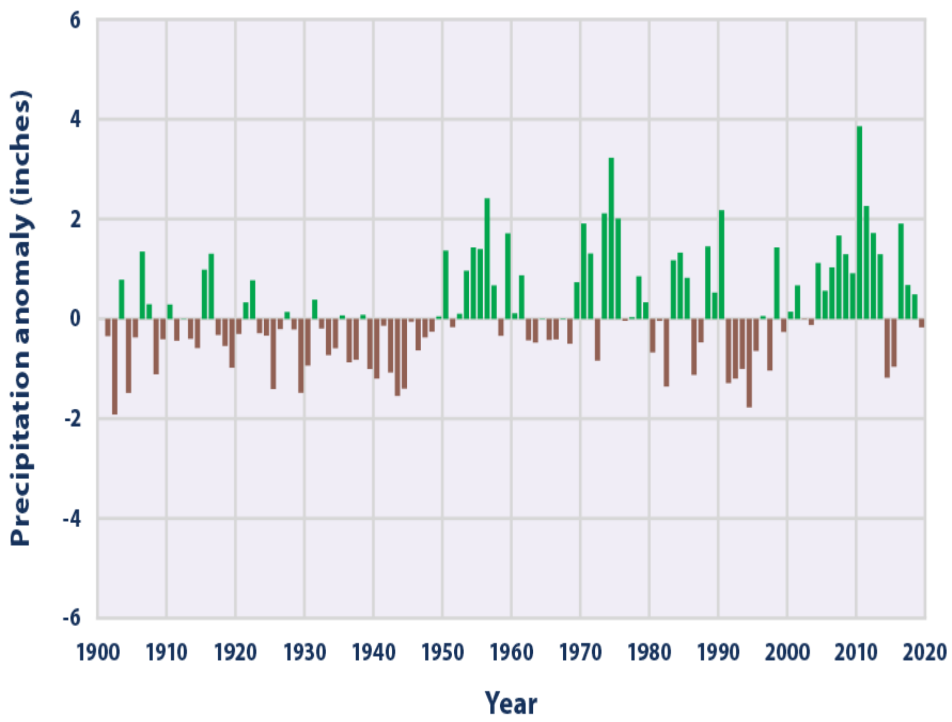
Table 13: Key Vulnerabilities and potential impacts of Climate Change in the Coastal Regions (Source: NAP, 2022)

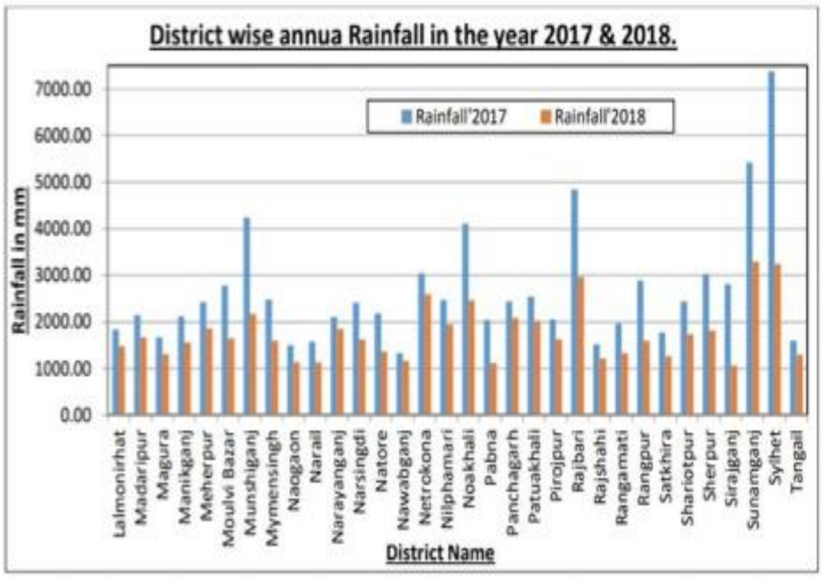
Climatic Trends	Vulnerabilities	Impacts
Rise in Temperature **Rainfall Variability** **Sea Level Rise**	Salinity Intrusion Water Scarcity Frequent Floods Excessive Rainfall Extreme Heat waves Extreme Cold Cyclones, tornadoes and Storm Surges	Crop Damage Loss of Cultivable Land Pest infestation and disease outbreaks Harvesting and storage problem Cropping pattern change Less suitable irrigation water Low crop yields

Numerous studies show that almost 70% of people's agricultural livelihoods in the Patuakhali district are affected by climate change in many ways. Due to rising sea levels, 0.2 million metric tons of rice will be lost to saline intrusion alone (WB, 2000). In recent studies, the Meghna estuarine is found to be very high to moderate vulnerable to salinity, high rate of sea level change, very high accretion due to huge sediment loads, highly vulnerable to coastal flooding and storm surge height (Mahmood et. al. 2020, USAID 2016).

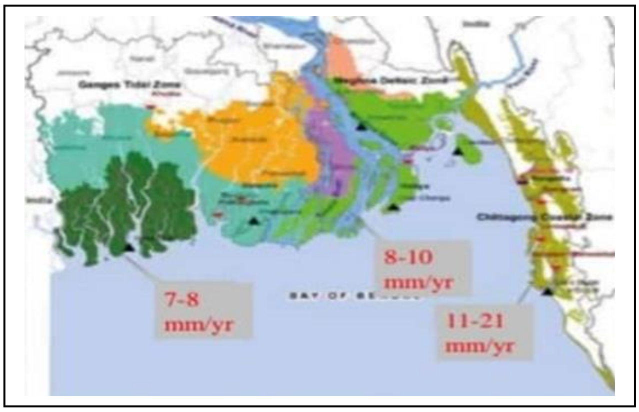
According to IPCC AR6 (2021), the annual global temperature is projected to increase by 1.6 °C, 2.4 °C, and 4.4 °C by the years 2030s, 2050s and the end of the century, respectively. The annual temperature of Bangladesh is expected to increase by 1.0 °C, 1.4 °C, and 2.4 °C for the years 2030, 2050 and 2100, respectively, as described by Agrawala et al. (2003), whereas the yearly rainfall is expected to increase by 3.8, 5.6, and 9.7 per cent (NAP, 2022). IPCC (2007) predicted that the annual rainfall will increase by 11-15% over South Asia. Since 1901, global precipitation has increased at an average rate of 0.10 inches per decade (IPCC 2007). It is predicted that monsoon rainfall may increase (Warrick et al. 1996) by and10-15% by the year 2030 and 15-20% by the year 2050, 11% to 28% by the year 2075 all over Bangladesh (Alam et al. 1999).

Figure 11: District-wise Annual Rainfall in the Years 2017 & 2018





In addition to that, according to the IPCC 5th assessment report, the global sea level rise is projected to be between 0.11-0.12 m in the near term, 0.23-0.27 m in the mid-term and 0.54-0.86 m in the long term. It is projected that over 15.5 cm sea level rise may cause permanent inundation of 115 hectares of land by 2050 (IPCC 2001). Furthermore, according to Ahmed et al. (2018), the water and agricultural areas decreased by-3.27% and -2.19%, respectively, as a result of rising sea level and salinity. In contrast, the plain area increased from 135 hectares to 17,312 hectares.



Earlier studies (based on tidal data) show that the global sea-level rise varies from 1.1-1.8 mm per year, whereas (based on satellite altimeter data) shows that the rate varies from 2.8 mm per year to 3.4 mm per year, which is 80% faster in recent years, and ocean thermal expansion contributed 50% of the rate. IPCC shows a global rise of 110 cm (1990), 94 cm (1995), 88cm (2001), 59 cm (2007) and 98 cm (2014) by 2100. It is projected that by 2100, sea level will rise at least 2m (Pethick 2012) to the highest of 4.5m (Milliman et al, 1989) along the Bangladesh coast. Wahid et al (2007) estimated a rate of 25 mm per year at Mongla and Nalianala (Sundarban area) over 30 years. Pethick and Orford (2013) have shown a rise of which is 10.7 mm per year at Hiron Point (mouth of the estuary), 14.5 mm per year at Mongla and 17.2 mm per year at Khulna. Rogers et al (2013) have estimated a rise of 5.0 mm per year at Hiron Point, 15.0 mm per year at Khepupara and 5.0 mm per year at Hatia. Becker et al (2020) have shown a rise of 2.1-2.7mm per year in the SW (Sundarbans); 3.2-3.6 mm per year at SC, 3.0-3.4mm per year at Meghna Estuary and 1.3-3.4 mm per year at SE. This recent research shows a lower rate of rise than previously estimated.

Figure 12: Salinity information of Cox's Bazar and Patuakhali District (Source: BWDB, 2023)

Relevant Public Institutions

The MoEF is mainly responsible for the policy formulation on climate change and its adaptation. It is responsible for discussions, planning, policymaking, and program development related to climate change. It also moves the problem forward on an international level by functioning as the operational administrative centre for the UNFCCC and the Global Environment Facility (Huq & Rabbani, 2011). In 2010, the Ministry of Environment and Forests (MOEF) established the Climate Change Unit (CCU), responsible for integrating the diverse climate change cells within each ministry to facilitate the integration of climate change across sectors and enhance governmental capacity for climate change research, including forecasting and adaptation (Ayers et al., 2014). The CCU has now been replaced by the BCCT, which helps to manage the BBCCRF and the BCCTF.

Table 14: List of Public Institutions in Study Areas (MoA, 2025)

Patuakhali	**Cox's Bazar**
1. Department of Agricultural Extension, Patuakhali	1. Department of Agricultural Extension
2. Bangladesh Agricultural Development Corporation (BADC)	2. Bangladesh Agricultural Development Corporation (BADC)
3. Bangladesh Agricultural Research Institute (BARI)	3. District Agricultural Marketing Office
4. District Seed Certification Agency office	4. District Seed Certification Agency office
5. District Soil Resource Development Institute	5. Jhilongjha Seed Production Farm, BADC
6. District Cotton Development Board Office	6. Salt Industry Development Office
7. District Livestock Office	7. District Agriculture Information Service office

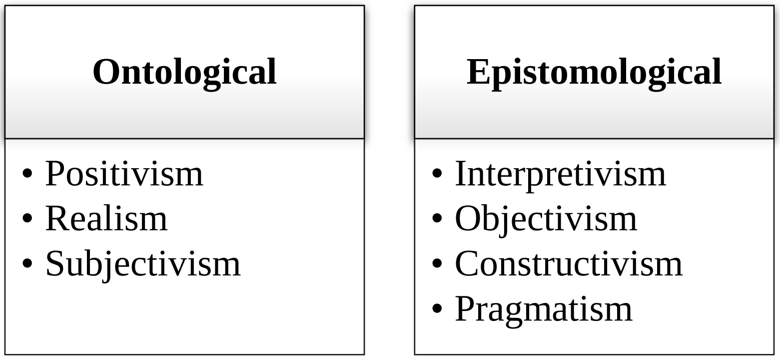
8. District Artificial Reproductive Centre	8. Water Development Board
9. District Fisheries Office, Patuakhali	9. Bangladesh Fisheries Research Institute
10. Office of the Executive Engineer, Bangladesh Water Development Board	10. Fisheries Officer's Office
11. Department of Environment, Patuakhali	11. District Livestock Department
12. District Relief and Rehabilitation Office	12. Coastal Forest Department
13. BIWTA, Patuakhali River port	13. Department of Environment
14. Payra Port Authority	14. Northern Forest Department
15. Department of Coastal Forest, Patuakhali	15. Southern Forest Department

Research Design

Research Philosophy

Research philosophy comprehends ontological, epistemological and theoretical deliberations that outline the research process (Muhaise et al. 2020). It encompasses the principles and assumptions about the nature of reality, the nature of knowledge and its sources that strongly influence the interpretation of data and the methods used to gain the knowledge. The study aimed to explore the major vulnerabilities of climate change in the coastal area of Bangladesh, its impact on agricultural production, and thus to assess the capacity of public institutions in terms of addressing those impacts of climate change on agriculture. Thus, the two central philosophical stances, ontological and epistemological, developed by Sounders et al. (2009) are critically discussed. Initially, the study extensively depends on the **subjectivist research philosophy**, from an ontological perspective, distinguishing the major climate change and its impact on agriculture, beginning with the perceptions and significant actions of the officials from different public institutions associated with agricultural adaptation in coastal districts. Additionally, the epistemology position of the study is based on **interpretivism,** which demonstrates the willingness to use impartial methods for gathering, interpreting and presenting qualitative data based on respondents' perspective and their understandings.

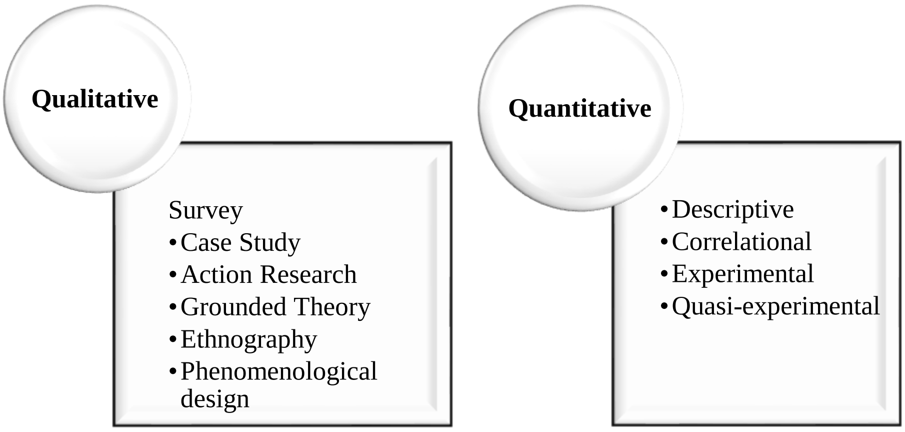
Figure 13: Research Philosophy (Saunders et. al., 2007)



Research Approach

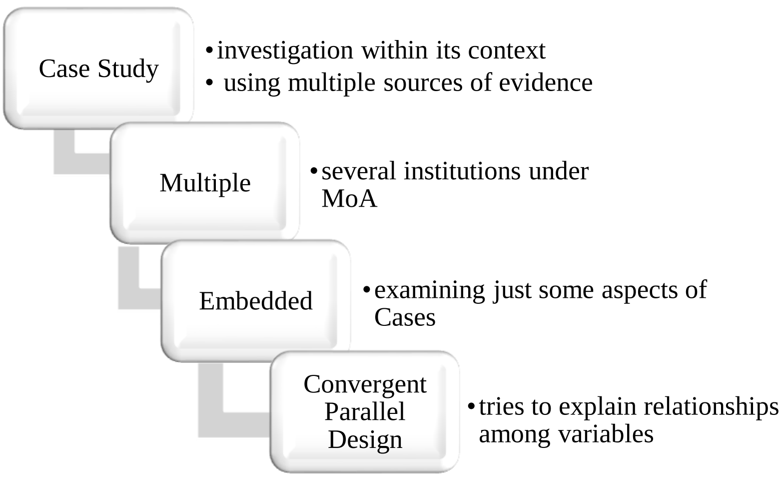
The research will be conducted by a ***mixed methods approach*** that combines both qualitative and quantitative approaches to integrate various data types to acquire a more thorough picture of a research subject and to expand both the breadth and depth of understanding of the problem (Johnson et al., 2007). The research strategy applied in this research is ***multiple embedded case studies,*** which will assist in an in-depth understanding of the research problem and thus answer the research aims and objectives proposed in this study. The research strategy can be classified into the following.

Figure 14: Types of Research Strategy (Creswell, J. W. 2014)



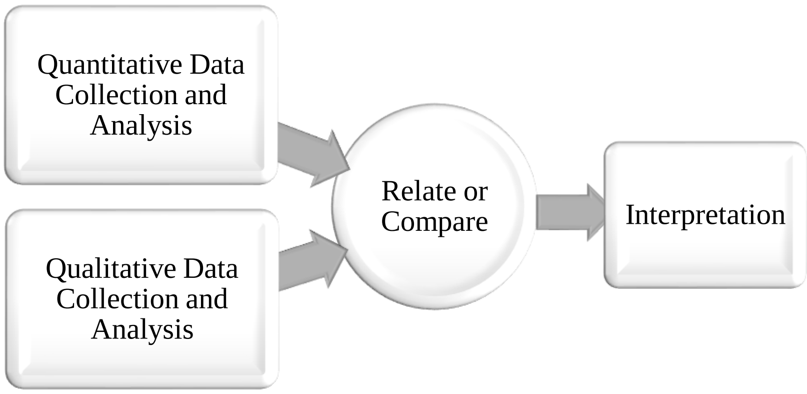
A ***case study*** aims to combine the quantitative and qualitative data to expand a deep understanding of procedures and outcomes in real-life contexts and contains the incorporation of multiple data collection methods like surveys, interviews, document reviews, and observations. Heale and Twycross (2017) suggested that a multiple case study permits a more inclusive exploration of research questions and affords more consistent evidence compared to single case studies. Furthermore, the ***embedded study*** is selected to explore some specific aspects of thirteen different institutions under the Ministry of Agriculture.

Figure 15: Research Strategy (Prepared by the author)



Additionally, the nature of the research applied in the study is ***a convergent parallel design***, which is a mixed-method approach whereby both quantitative and qualitative data are collected and analysed simultaneously and independently. The findings are then integrated to produce a comprehensive interpretation (Creswell et al. 2011). Adhikari et. al. (2024) state that the convergent parallel approach usually collects data in parallel, analyses it separately and integrates it in the interpretation phase.

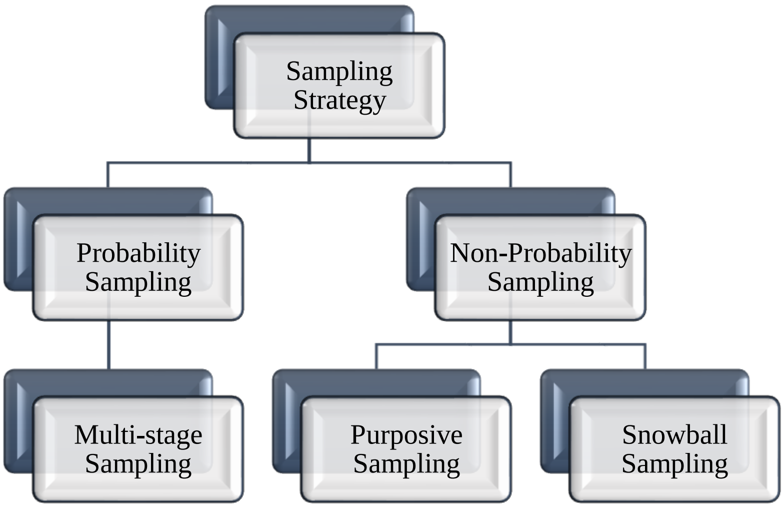
Figure 16: Types of MMR Design, Convergent Parallel Design (Creswell et. al. 2011)



Sampling Strategy

This research applied multistage sampling (MSS) for quantitative data collection, whereas criterion sampling, homogenous purposive sampling and snowball sampling techniques were applied for in-depth interviews. Saunders et al. (2009) suggested these techniques are most suitable for the mixed methods convergent parallel design as they allow for the collection of higher quality data. Patton (1990) specified that criteria sampling is highly effective in quality assurance, as the data gathered will come from credible sources, whereas homogeneous purposive sampling reduces variance, simplifies analysis, and makes group interviews easier. Furthermore, according to Patton (1990), snowball sampling helps the researcher to find several different sources with an extensive amount of information from one participant, and the chain continues.

Figure 17: Research Sampling



Respondents were recruited through a four-stage process to quantitatively investigate the aim and objectives of the respondents. Initially, two coastal districts -Cox's Bazar and Patuakhali districts were selected as the primary study area because of their considerable agricultural significance and the vulnerability of climate change on agriculture. In the second stage, thirteen (13) relevant agricultural institutions under the Ministry of Agriculture (MoA) and the Ministry of Water Resources (MoWR) were selected based on the duties and responsibilities related to agricultural adaptation. Thirdly, each selected institution was contacted for the allocation and availability of pertinent key informants designated by the Director General or the Chairman of the respective institutions. Finally, the fifty-five (55) officials were interviewed through face-to-face sessions and group discussions. Respondents were selected based on the study objectives, assessing the institutional capacity using the most appropriate sampling, e.g. purposive sampling and multistage sampling, to ensure reliable and valid data. The sample size was determined considering the research scope, time and resource constraints. A primary semi-structured questionnaire survey was employed to gather official responses regarding the previously identified indicators of institutional capacity.

Table 15: List of the Respondents

SL	Institutions	Number of Respondents
1.	DAE	15
2.	BADC	05
3.	SCA	03
4.	AIS	05
5.	BARC	02
6.	BARI	04
7.	BRRI	04
8.	BINA	03
9.	NATA	02
10.	BWDB	03
11.	DAM	04
12.	BKB	05

Furthermore, fifteen (15) participants were chosen for in-person in-depth interviews using the non-probability selection approach, which includes homogeneous criteria and snowball sampling. Respondents' professional experience and knowledge in coastal agricultural adaptation and technology were highly valued in order to gain a different viewpoint on the phenomenon, which included project planning and implementation, information and technology development for adaptation, policy execution, decision-makers, and technical experts.

Data Collection Methods

To get an understanding of the institutional capabilities in agricultural adaptation, two types of data collection methods have been applied in this research: primary and secondary data collection. The study is conducted with a literature review, document analysis as a secondary mode of data collection and in-depth interviews (expert judgment), semi-structured questionnaire-based interviews, focus group discussion and direct observation technique as a primary mode of data collection.

The literature review includes a systematic study that assesses vulnerabilities to climate change and its impacts on agriculture in the coastal districts of Bangladesh. Furthermore, several scientific peer-reviewed articles and reports without peer review were acknowledged and thoroughly studied. However, numerous studies have attributed potential climate change impacts on agriculture in the coastal districts in Bangladesh, but no precise study evaluates the institutional capacities by means of an indicators-based assessment to adapt to these impacts in these two districts.

Table 16: Data Collection Methods

Primary Data Collection Methods	**Secondary Data Collection Methods**
• Semi-structured Interview (SSI) • Focus Group Discussion (FGDs) • Direct Observation	• Literature Review • Documents Analysis • Policy Papers

The document analysis mainly reviewed governmental documents, annual reports, project manuals and policy papers because very few documents from NGOs and newspapers denote climate change adaptation and institutional adaptive capacities. The analysis included formal and informal documents relevant to the study area, about the impacts of climate change on agriculture in coastal regions, documenting the vulnerabilities, documents regarding adaptation measures undertaken by the government, similar contexts in other countries and cities around the world, national policy papers, laws, regulations and press releases. These documents were reviewed to understand relevant theories and pieces of information regarding adaptation measures and institutional capacities. The most significant information for assessing the criteria for institutional capacity assessment was derived from semi-structured interviews with officials and stakeholders who possess knowledge about agricultural adaptation and the impacts of climate change on agriculture in the coastal districts in Bangladesh. The respondents were identified based on different hierarchical levels of relevant institutions, from Upazila to the district administration. The identified organisations were requested to select individuals who are well-informed about potential climate change impacts and possible adaptation measures for the agricultural sector in selected areas. Depending upon the willingness of the contacted person, we conducted three to five interviews per institution. Most of the respondents were mainly from extension officers, project directors, scientific officers, administrative officers and employees in relevant institutions.

The interviews lasted one to two to three hours and were conducted based on methodologies, problem-centred and expert opinions. These methods encourage reflection and exploration of more in-depth information, are comparable and reliable in nature, have the flexibility to ask follow-up questions, and are sufficiently open to allow respondents to mention aspects that are not addressed in the interview guidelines. The majority of the interviews were held in the office of the respondents formally. All interviews were audio recorded on an audio recorder with respondents' preliminary written or verbal consent and partly transcribed.

The questionnaire is divided into seven sections, and each section contains ten to twelve open, semi-open and closed-ended questions to reveal the aim and objectives of the study. The interview started with contextual questions like age, position, educational specialisation, and position of the respondents held in the institutions. In the second section, the interviews started with a question regarding the activity of the institution the interviewee is working for, including the work region and the activity of the respondents themselves, to measure the relevance of adaptation in the institutions. Then, they were asked to describe the recent climate issues they perceive for their respective sectors (agricultural production, water management, coastal protection, regional planning, etc.) and their induced impacts at the farm level in two coastal districts in Bangladesh. To measure the knowledge and beliefs of officials from different institutions, the officials were asked to answer how their organisation has action plans to lessen the effects of climate change at the farm level and the effectiveness with which the sector is putting these plans into practice. After that, they were asked to rate the realizability of their practices and behaviour to cope with the effects of climate change and to describe the major indicators of climate change in their region. Here, they were requested to score how the previous five years had affected productivity in their area due to climate change on the following scale: Very low, low, average, high, and very high, considering other challenges of the institutions. In the last part of this section, they were queried to identify the barriers and potential synergies concerning these adaptation measures.

In the third section, the respondents were then questioned whether their institution is currently coordinating and or collaborating in another way with other institutions concerning climate change adaptation in coastal districts. To evaluate the coordination and collaboration among the stakeholders, the respondents were asked to answer whether their institutions have the mandates for institutional collaboration and coordination for adaptation planning and implementation. After the interviewees had answered the mandates for institutional cooperation, they were asked to mark the level of coordination between different levels and sectors of government institutions, private organisations, non-government organisations, and the community. They were asked to rate the level of coordination on the following scale: No coordination, Poor level of Coordination, Average level of Coordination, High level of Coordination, Very High level of Coordination.

The queries in the fourth section addressed resource availability. To evaluate the resource availability, the respondents were questioned about the current state of resources in order to assess the availability and adequacy of financial resources, human resources and physical resources for general operations and emergency actions to address the impacts of climate change. They were asked to score the requirements and availability of the resources using a scale from 1 to 5, where 1 is the lowest and 5 is the highest score.

The fifth section of the questionnaire evaluates the training obtainability of the employees regarding climate change adaptation. To evaluate the professional training and expertise of the officials, the respondents were asked to answer questions about their educational background and experience compared to climate science, environmental policy, sustainable agriculture, and other related subjects from national and international institutions. Then, the interviewee was questioned to answer whether they have participated in any formal training programs, workshops, or seminars conducted by national and international institutions focusing on agricultural adaptation. As a sub-indicator of the training and expertise index, we then asked whether they have practical experience with agricultural practices and climate adaptation strategies in Bangladesh, and/or have practical experience in managing agricultural projects focused on climate adaptation. Finally, they were asked to provide information on any previous climate change adaptation activities they accomplished at the farm level.

To evaluate the plans and priorities index of capacity, the interviewees were asked to answer whether or not their institutions considered climate change in the coastal area to be a significant concern in the sixth section of the questionnaire. To evaluate the capability in terms of institutional plans and priorities, the respondents were asked to score institutional priorities, past programs, present Programs, future programs, and emergency planning of the relevant institutions. In the last section, the following questions were asked of the respondents to gauge the institutional capacity for data management and information congregating: Do the institutions commit to managing and disseminating information on climate vulnerability, hazards, and impacts to support agricultural decisions regarding adaptation, as well as the victims' ability to act proactively and improvise? In addition, the respondents were asked to indicate whether or not the information was sufficient and whether or not the organisation's goals and objectives aligned with the efforts being made to give priority to data. The respondents were also asked if the employees were capable of analysing and providing data to support decision-making and to enhance farmers' ability to adapt.

Focus Group Discussion (FGDs)

Focus group discussions with the field officials in two districts have worked as a very useful method for collecting data to validate the secondary data. Two focus group discussions were arranged at the district office, where all the Upazila officials and training experts participated to discuss the major impacts and the factors affecting the adaptation process.

Direct observation

Moreover, direct observation of the institutions in the study area is very helpful in identifying the actual status of the institutions regarding their operational resources.

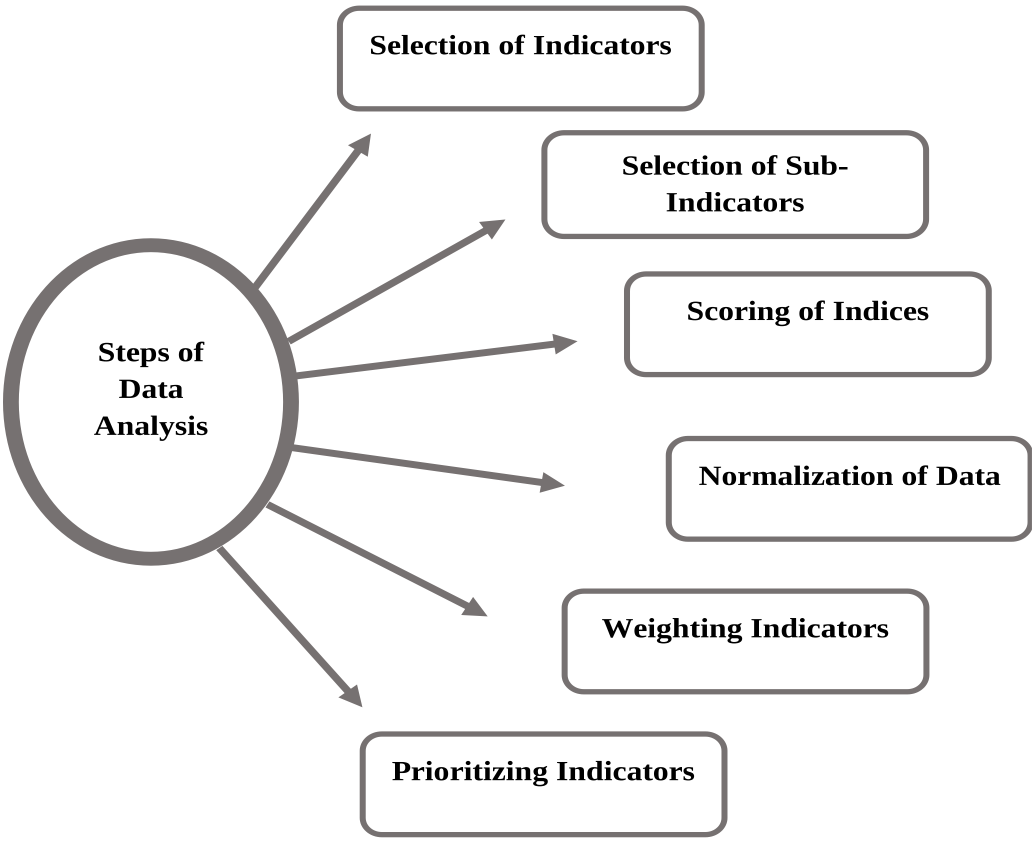
Data Analysis Methods

Following the intensive literature review, the collected documents and partly transcribed interviews were analysed based on the method of qualitative content analysis and the index values were calculated using the UNDP index aggregation method to summarise the institutions' capacities into six selected indicators. Excel and IBM SPSS were used for data analysis, and numerous descriptive and inferential statistics-calculating tools are pre-installed in this program. All the questions were standardised and written in Excel and SPSS, from which the results were obtained by importing the data sections.

Steps for Analysing the Data

The first step is to prepare an exposure index for climate change impacts on agriculture in the study area. Exposure of the study area to climate change is analysed by assessing a range of environmental and climatic factors, including changes in temperature and precipitation patterns, sea level rise, extreme weather events, water availability and variation in cropping calendars. Desk research has gathered secondary data in order to carry out these tasks. Then, the impacts of these phenomena on crop production in the study area were identified by secondary data collection as well as by questionnaire survey and face-to-face interviews with field-level officers of the relevant institutions. After that, based on available secondary data and the primary data collected by focused group discussion and face-to-face interviews with the officials working at the field level who have prime experience regarding the factors that affect the adaptive capacity of the institutions. In this study, the Data analysis steps encompass the selection of indicators, the selection of sub-indicators, the scoring of indices, normalisation of values, weighting the indicators, and prioritising the indicators. In light of the literature voids and contemporary empirical studies, six variables have been selected for assessing institutional capacities for climate change adaptation in the agricultural sector. Then, a total of twenty-nine sub-indicators were chosen and assessed.

Figure 18: Steps of Data Analysis



The six indicators included officials' perception and knowledge, coordination and collaboration, resource availability, training and expertise obtainability, plans and priorities, and room for autonomous changes of the institutions dealing with climate change adaptation. A comprehensive explanation of the indicators and sub-indicators is given in the following table.

Table 17: Comprehensive Explanation of the indicators and sub-indicators of the study

Indicators	**Sub Indicators**	**Description**	**Literature Sources**
Climate Perception and Knowledge (PKI)	Climate Change Perception	Changes in local climate patterns	Brown et. al., 2010 Gupta et. al., 2010 Dany et. al., 2015 Kuhlicke et. al., 2011 Grothmann et. al., 2013 Fidelman et. al., 2017
	Perceived Impacts of Climate Change	Impacts of Climate Change	
	Knowledge of CCA Practices	Knowledge regarding climate change adaptation	
	Acknowledgement of CCA Practices	Acknowledging CCA practices	
Coordination and Collaboration (CCI)	Intra-Institutional Coordination	Coordination within the institutions under the MoA	
	Community Coordination	Coordination with farming communities	

				Huq, N., 2016 Bettini et. al., 2015 Nelson et al. 2010 Mendelsohn & Nordhaus 1999; Yohe et al. 1996; Smit et al. 2000 Yohe & Tol 2002 Brown et. al., 2013 Pielke et. al., 1998 Folke et al. 2005; Milman & Short 2008; Polsky et al. 2007
		Inter-Institutional Collaboration (Public)	Collaboration with other public institutions	
		Inter-Institutional Collaboration (Private)	Coordination with the private sector's institutions and NGOs	
Resource Availability (RAI)	**Physical Resources**	Machine/Equipment Availability	Availability of machines/equipment for general operations	
		Machine/Equipment Requirement	Availability of machines/equipment for general operations to actual requirements	

		Machine/Equipment Availability for CCA	Availability of machines/equipment for CCA and emergencies	Armitage 2005; Folke et al. 2003 & 2005; Pelling & High 2005; Weick & Sutcliffe 2001; Orlikowski 1996
	Financial Resources	Funds Availability	Fund Availability for CCA Operations	
		Funds Sufficiency	Sufficiency of available funds to meet challenges	
		Funds Requirement	Current fund availability with respect to the actual requirement	
	Human Resources	Staff Availability	Staff available for general operations	
		Training Needs	Training needs regarding CCA	
		Staff for CCA	Staff availability regarding CCA	

Training Obtainability (TEI)	Expertise in Climate Change Adaptation	Practical skills regarding CCA	
	Working Experience	Previous working experience with CCA	
	Professional Training	Formal training course attended regarding CCA/CRM	
	Trained Staff	Percentage of trained staff in institution	
Plans and Priorities (PPI)	Institutional Priorities	CC is an important concern for the institutions	
	Past Programs	Institutions carried out programs regarding CCA	
	Present Programs	Ongoing CCA Programs	
	Future Programs	Project in pipeline	

	Emergency Planning	Emergency response planning for extreme events	
Room for Autonomous Changes (ACI)	Access to Information	Accessibility of information regarding climate change impacts and early warning	
	Act according to plan	the ability of individuals to act by providing plans	
	Capability to Improvise	Capability to adjust, modify or innovate	

Index Calculation

The UNDP index aggregation method was used to calculate the index value for each indicator. In order to transform the variable value into a comparable unit, a normalising procedure is typically required. In the study, a procedure of rescaling the data from the original was accomplished to facilitate interpretation and make it easy to interpret and compare. At first, the scores rated by the respondents were taken in percentages, then the maximum and minimum values were measured, and the indicators' indices were calculated using the following method.

$$Index_{sd} = \frac{Sd - Smin}{Smax - Smin}$$

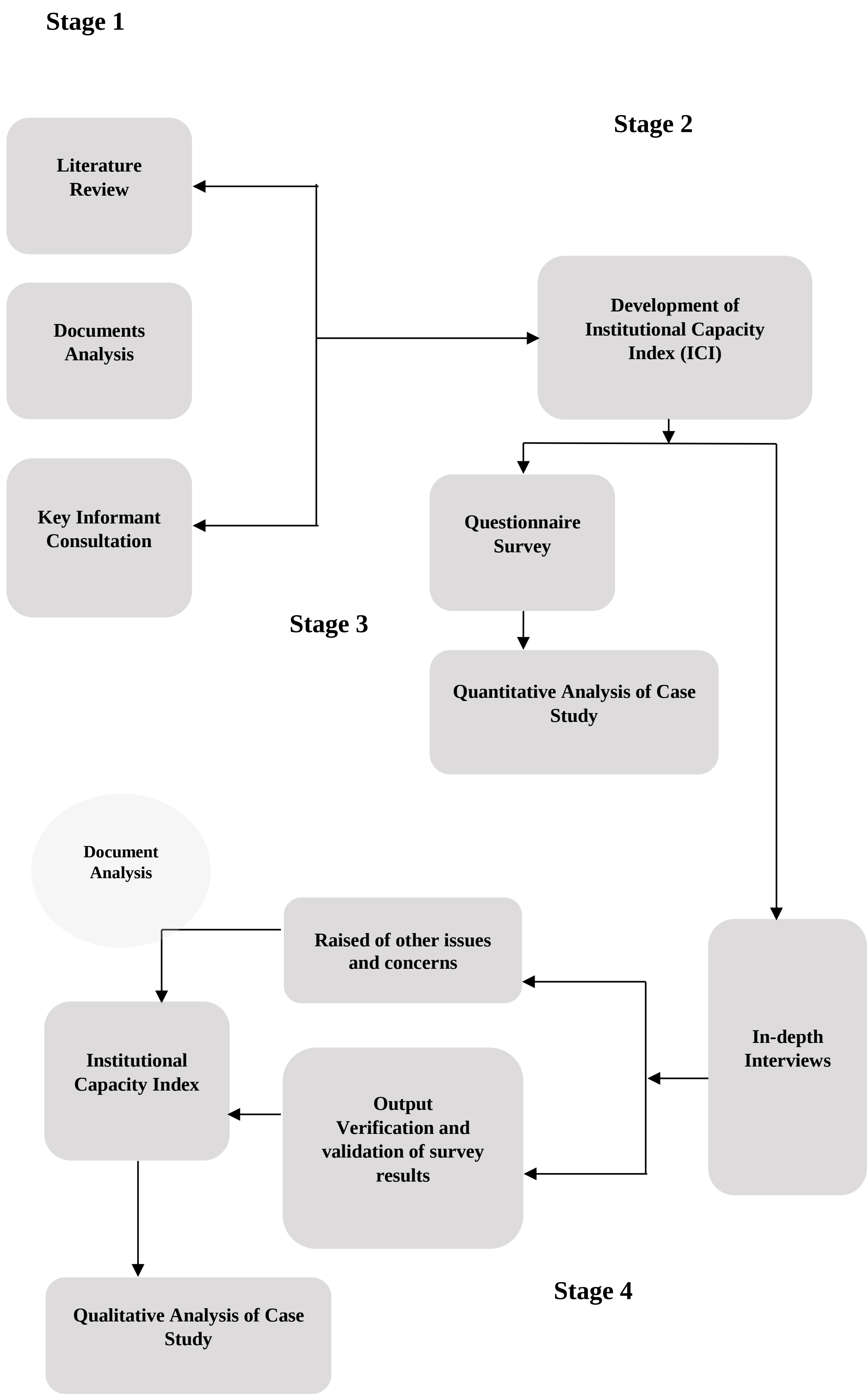
Here, *sd* stands for the average value of the mean ICI indicator, *Smin* is for the lowest value of the sub-indicators of the ICI indicator, and *Smax* is for the maximum value of the ICI sub-indicators. Then, the total of six indices, that is Perception and knowledge index (PKI), Coordination and Collaboration index (CCI), Resource Availability Index (RAI), Training and Expertise Index (TEI), Plans and Priorities Index (PPI), and Access to Information index (AII), were calculated. A cumulative institutional capacity index (ICI) was calculated after estimating the index for each indicator. The process was as follows:

$$\text{ICI} = \frac{(PKI)+(CCI)+(RAI)+(TEI)+(PPI)+(AII)}{2}$$

Table 18: Summary of Research Methods and Approaches

Research Philosophy	Subjectivism (Oncological) Interpretivism (Epistemological)
Research Type	Mixed Method Explanatory Research
Research Strategy	Multiple Embedded Case Study
Sampling Strategy	Multistage Sampling (Criterion Sampling, Homogeneous purposive and Snowball)
Data Collection Methods	Secondary Primary
Data Analysis Methods	Indicators-based Approach
Index Calculation	UNDP Index Aggregation Method

Figure 19: Stages of the Research Methodology



Limitations of the Study

The subsequent challenges throughout the execution of the study are-

- There are a lot of variables to consider in assessing institutional adaptive capacity. Although it was difficult, a single study could not have adequately examined all the variables (resources, training availability, knowledge and perceptions, coordination, plans, and information), and some dynamics might not have been thoroughly investigated.
- Some of the institutions maintain limited access to the internal institutional process, which limits the ability to cross-verify the organisational practices.
- Most of the data was based on interviews and questionnaires. Response bias may occur if respondents provide responses that are socially desirable.
- The study encompassed a certain number of institutions and places, including two coastal districts and thirteen institutions. Consequently, the results may not entirely represent national disparities in institutional capability or challenges.
- Due to the limited research time, only the most important variables and indicators were considered. For more in-depth cross-institutional comparison or periodic analysis, a longer study time is needed.

Ethical Issues of the Study

I am firmly stating that all the ethical issues to ensure responsible research conduct were maintained. Firstly, all the respondents were informed about the purpose of the research, the expected use of information and their right to withdraw at any time without any consequences. Also, their prior permission was taken before data collection. In addition, each interview and questionnaire survey began with obtaining informed consent in written form. Secondly, the study ensured that all participants remained anonymous and that their confidentiality was maintained by not including any personally identifiable information in the transcripts, analyses, or reports. Thirdly, the security of the data was ensured strictly and used exclusively for scholarly purposes. Furthermore, important institutional information was handled with utmost care to prevent any misunderstanding or misconduct. Participants were guaranteed that their comments would have no impact on their professional or personal standing with the organisation.

Finally, I therefore declare that the data were analysed and interpreted using appropriate tools and methodologies, and that I conducted the writing. No ideas were presented for consideration that could potentially harm any community. Notes were taken by suitable methods (summary, paraphrasing, quotations, etc.), and references were cited properly.

Chapter Four

Causes and Impacts of Climate Change in Bangladesh

'Pollution and climate change by excessive burning of fossil fuels are real threats, not the people who warn that we must take these threats seriously.'

David Suzuki,
Canadian Academic & Environmental Broadcaster

Chapter Summary

The purpose of this chapter is to describe the primary causes of climate change and its adverse impacts on agriculture, fisheries, livestock, water resources and health in coastal regions of Bangladesh and worldwide.

- *Introduction*
- *Causes of Climate Change*
- *Global Impacts of Climate Change*
- *Major Impacts of Climate Change in Bangladesh*
- *Sectoral Impacts of Climate Change in Bangladesh*

Introduction

The Earth's climate has incessantly changed with significant changes in global temperature. Scientific research shows that global warming is the result of human activities rather than natural processes (Oreskes, 2004). The greenhouse gases such as methane, carbon dioxide, and CFCs are necessary for maintaining the temperature in Earth's surface troposphere. Excessive burning of fossil fuels, industrialisation, deforestation, disproportionate land use to meet the growing demands of an increased population, the use of fertilisers and the methane produced by cattle are increasing the concentrations of greenhouse gases, influencing the climate and the Earth's atmosphere (IPCC 2021; UNEP 2022). The warming trend has increased recently, and the years 2015–2024 were declared the warmest on record. In 2024, the average global temperature rose 1.55 degrees Celsius over pre-industrial levels. Energy and transportation-related combustion of fossil fuels, such as coal, oil, and natural gas, is the primary cause of carbon dioxide (CO2) emissions worldwide (IPCC, 2021). Livestock and agricultural output both contribute to the creation of methane, while fertilisers use releases nitrous oxides, which raise the atmospheric concentration of greenhouse gases. Furthermore, modern civilisation, like rapid urbanisation, industrial processes, increased consumption, and undue deforestation, is all contributing to the greenhouse gas effect (UNEP, 2022).

The consequences of changing the greenhouse with natural atmospheric gases are difficult to predict. The effects of extreme weather, increasing sea levels, changing wildlife populations and habitats, and a host of other repercussions are all part of the consequences of climate change (Lockwood, 2020). There is a vibrant affiliation between rising temperatures and the frequency and severity of natural catastrophes. The increasing natural hazards like cyclonic storms, heat waves, droughts, rising sea levels, melting glaciers, extreme precipitation, and floods directly distress the habitat and livelihoods of communities and living beings, especially in the coastal areas.

Bangladesh is an exceptionally vulnerable country to climate change, and so far, it is one of the countries that contributes the least to greenhouse emissions. Due to the low-lying geographical location, high levels of poverty, reliance on climate-sensitive productions, mostly on agriculture, fisheries and livestock, and inefficient institutional capacities are making the country increasingly vulnerable to climate change. Furthermore, the country consists of nineteen coastal districts, which account for 32% of the total land area and almost 40 million people are highly exposed to the adverse effects of climate change. The frequent natural calamities like strong cyclones and storm surges, intense monsoon rain, heatwaves, and flash floods are the major factors impeding the agricultural production, freshwater availability and destruction of vital infrastructure in the coastal areas in Bangladesh, which have substantial impacts on the country's economy, environment, and sustainable development (Huq et al., 2008). The main purpose of this chapter is to explain the primary causes of climate change and its detrimental effects on agriculture, fisheries, livestock and health in coastal areas in Bangladesh and throughout the world.

Causes of Climate Change

Natural Causes

The phrase "climate change" describes long-term changes in weather and temperature. The causes of climate change must be identified before comprehending its consequences on the environment and humanity. Climate change is a natural phenomenon that is caused by several natural factors, like volcanic eruptions, ocean currents, changes in the Earth's orbit, and solar fluctuations. The emission of carbon dioxide, sulphur dioxide, ash particles, and aerosols from volcanic eruptions has an impact on the global climate. The circulation of oceanic currents plays a crucial role in distributing heat energy, cycling nutrients and gases and ultimately causing climate change. Climate changes appear to be largely the result of orbital forcing changes on the 10,000 to 100,000-year timescales. According to the Milankovitch Theory, long-term climatic shifts like ice ages and interglacial periods are brought on by variations in Earth's orbit. It explains that small but significant fluctuations in the seasons' intensity over tens of thousands of years are caused by variations in the Earth's orbit. The Sun is the primary energy source for Earth's climate system. From a daily viewpoint, the Sun's energy production appears to be constant, but at times of high solar energy activity, it may induce warming. From a daily viewpoint, the Sun's energy production appears to be constant, but at times of high solar energy activity, it may induce warming. From a daily viewpoint, the Sun's energy production appears to be constant, but at times of high solar energy activity, it may induce warming. From a daily viewpoint, the Sun's energy production appears to be constant, but at times of high solar energy activity, it may induce warming. From a daily viewpoint, the Sun's energy production appears to be constant, but at times of high solar energy activity, it may induce warming. These are the most common natural factors played a central role in shaping Earth's climate system.

Human Causes

Even if natural processes are still occurring, human activity that intensifies the greenhouse effect is the primary factor driving the current rapid rate of climate change, which cannot be explained solely by natural factors. Burning fossil fuels, deforestation, and livestock farming are some of the ways humans are affecting the climate and temperature of the planet. Extreme volumes of greenhouse gases are being released into our atmosphere as a result of such activities. The key greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs), have unquestionably been present in the atmosphere in higher amounts. It is also evident that human actions are responsible (IPCC Report, 1990).

According to a new Turtle Island Restoration Network analysis, the top four warmest years on record have occurred in the last four years, and the 20 warmest years on record have occurred in the last 22 years. The Earth's average temperature has increased by 1.8°F during the last century. According to scientists, the temperature is expected to rise by an additional 0.5 to 8.6°F during the next century. Due to human activity, massive amounts of carbon dioxide and other greenhouse gases have been emitted into the atmosphere, which is considered the key cause of this temperature change. Most greenhouse gases are produced when fossil fuels are burned to generate electricity. ***Fossil fuel***, any of a class of hydrocarbon-containing materials of biological origin occurring within Earth's shell that can be used as a source of energy. Fossil fuels include tar sands, bitumen, oil shales, coal, petroleum, natural gas, and heavy oils. All contain carbon and were formed as a result of geologic processes acting on the remains of organic matter produced by photosynthesis, a process that began in the Archean Aeon. Carbon dioxide is being released into the atmosphere by the combustion of fossil fuels. ***Deforestation*** is another human cause of temperature escalation. Trees absorb carbon dioxide during photosynthesis. There will be higher amounts of carbon dioxide in the atmosphere if they are cut down. ***Dumping waste*** in landfills is another reason for increasing methane. When the waste decomposes, it produces methane. ***Agricultural practices*** lead to the release of nitrogen oxides into the atmosphere. ***Ammonia*** is another nitrogen chemical that is released into the atmosphere, mostly from food production but also from burning fossil fuels. The combustion of fossil fuels used in industry and transportation accounts for the majority of nitrogen oxides emitted. Vehicles, big industrial activities, coal-fired power stations, ships, and aeroplanes are the main producers of nitrogen oxide ejections. Too much nitrogen in the atmosphere is deposited back to the land as ammonia, which pollutes surrounding water bodies. These are a few examples of human activities that raise atmospheric concentrations of greenhouse gases. These human-induced changes have led to rising temperatures, melting glaciers, increased frequency of extreme weather events, and rising sea levels.

Global Impacts of Climate Change

Climate change is likely to have a significant impact at global, regional, and local levels. The terrible effects of major natural disasters are being felt by people all over the world. For example, tropical storms are sweeping throughout Southeast Asia, the Caribbean, and the Pacific, while sub-Saharan Africa is enduring a lengthy drought. The frequency and severity of extreme weather events, such as floods, droughts, and cyclones, have increased, upsetting human populations, agriculture, and water supplies. It is obvious that every aspect of human life on a global scale is already being impacted by climate change, and in the upcoming years, this effect will only get stronger (Onwuka & Onwuka, 2021).

Climate change can lead to the emergence of new patterns of pests and diseases, affecting plants, animals, and humans, and posing new risks to food security, food safety, and human health. It is regarded as one of the biggest threats to the environment worldwide, with its possible detrimental impacts on food security, agriculture, human health, biodiversity, water supplies, economic activity, and other natural resources. These changes are worsening the economic, social and demographic challenges globally. The frequency and duration of heat waves are increasing to a large extent due to the rise in temperature over a long period. Meanwhile, with the rise of sea level due to the melting of glaciers in Arctic and Antarctic areas, low-lying areas will be submerged, and coastal flooding will occur more often. Another factor affecting climate change is the shifting of seasons, which will increase due to shifts in monsoon patterns and arrive earlier than usual. The change leads towards a decrease in plants and animals, with the deterioration of important ecosystems drastically. At the same time, the increase in intensity and frequency of natural calamities, including flash floods, droughts, and heavy rainfall, exacerbates desertification in many regions of the country. Furthermore, the changes in climate patterns also have significant health threats.

The shifting of weather patterns and temperatures will accelerate the spread of infectious diseases globally (Islam, 2012).

Table 19: Causes and Impacts of Climate Change

<table>
<tr><th colspan="2">Causes of Climate Change</th><th>Climate Change Variables</th><th>Affected Sectors</th></tr>
<tr><td>Natural Causes</td><td>Volcanic Eruption
Ocean currents,
Earth’s orbital changes,
Solar variations</td><td rowspan="2">Sea level rise
Changes in Precipitation Patterns
Increased Temperature
Increased frequency of cyclonic storms
Salinity Intrusion
Increased flooding
Drought
Acidification
Light Intensity</td><td rowspan="2">Agriculture
Fisheries
Livestock
Water and Hydrology
Forestry
Biodiversity
Human Health
Infrastructure
Coastal Area
Food Security</td></tr>
<tr><td>Man-Made Causes</td><td>Burning of fossil fuels
Deforestation
Dumping waste
Agricultural Particles
Ammonia</td></tr>
</table>

Climate change poses a fundamental threat to the places, species and people’s livelihoods. The most common effect of climate change is Earth will become warmer. While warmer temperatures can be tolerated in some locations, they pose challenges for living things in the majority of them. Higher temperatures cause more evaporation, and precipitation causes areas to become progressively wetter and drier. Sea levels are rising as a direct result of warming ocean water caused by an increase in greenhouse gases. Furthermore, crop yields are impacted by increased carbon dioxide (CO_2) gas combustion. Several studies show that high carbon dioxide levels may stimulate plant growth and have nutritional consequences. In addition, changing temperatures, water and nutrient constraints affect the potential increase in yields. For some crops, exceeding the temperature can result in decreased or even reversed yield increase potential. The extreme climatic hazards lead towards crop losses, food security and threaten the livelihoods of the communities living in vulnerable areas. Outbreaks of diseases, pets and insects due to wetter and warmer temperatures and increased greenhouse gases.

Major Impacts of Climate Change in Bangladesh

Over the past 100 years, the board region encircling Bangladesh has warmed by about 0.5 °C. In future, Bangladesh may get warmer and wetter. For the IPCC (1990) emissions scenario based on a range of GCMs, Bangladesh is anticipated to see a temperature increase of 0.5 °C to 2.0 °C compared to current levels by the year 2030. Despite the complexities of rainfall predictions, climate models largely agree that regional monsoon precipitation is expected to increase under a warmer climate. The most accurate prediction is that normal monsoon rainfall will rise by 10 to 15% by 2030 (Warrick et. al., 1994).

Increased intensity of cyclone winds and precipitation

Tropical Cyclones accompanied by storm surges are one of the major disasters in Bangladesh, and the Bay of Bengal is a favourable breeding ground for these disasters. The cyclones have been categorised into 3 forms -depressions (wind speed less than 17 m s–1), tropical storms or cyclonic storms (CS, with wind speed between 17 and 24 m s–1), and severe cyclonic storms (SCS, with wind speed greater than 24 m s–1). According to the UNDP, Bangladesh is one of the most vulnerable countries to tropical cyclones, with an average of four cyclones occurring there annually. Tropical cyclones in Bangladesh are predicted to increase in frequency and intensity due to climate change, driven by their strong connection to sea surface temperature, sea level rise, higher mean temperatures, increased glacier melt, and stronger monsoon precipitation (UNDP, 2012). Study shows that more than 88 devastating cyclones hit the coastal area of Bangladesh in the last 200 years, and almost 10,00,000 people died from catastrophic cyclones during the last 40 years (Islam and

Ahmed 2004). Most of the cyclones were in Cox’s Bazar, Patuakhali, Chattogram, Noakhali, Sonadia coast, Teknaf, and Kutubdia Island, followed by the Sunderban. The Great Backerganj Cyclone of 1876, Barishal Cyclone 1965, Bhola Cyclone 1970, Urir Char Cyclone 1985, Cyclone Sidr 2007, Cyclone Nargis 2008, Cyclone Fani 2019, Super Cyclone Amphan 2020 are the most devastating tropical cyclones that hit Bangladesh from 1965 to 2021 (Hossain & Mullick, 2020).

It is reported that Bangladesh is the worst victim of all cyclonic casualties in the world, with a death toll of about 53% of the global total when the least death tolls over 5000 are measured (Ali, 1999). The high number of casualties in Bangladesh is because cyclones are always associated with storm surges, which are amplified on the Bangladesh coast and are facilitated by a number of factors, including the shallow water in the north bay, the northward converging nature of the Bay, and high astronomical tides. Any rise in Sea Surface Temperature (SST) due to climate change is likely to be accompanied by an increase in cyclone frequency and cyclone intensity that will cause an increase in storm surge heights and the horizontal extent of flooding. The number of cyclones and their severity show that what used to be a one in 5 years cyclone in the past is now likely to become a one or two in each year event in future. For instance, Amphan became a super cyclone because the higher sea surface temperature made landfall on the coast of Bangladesh and India (Huq, 2020). It is important to point out that human-persuaded climate change does not cause these events, as they are still logically happening events, but they boost their severity or intensity (which is what makes them more destructive) due to the preeminent temperature of the atmosphere (The Daily Star, June 2020). It is also noted that climate change will be allied with greater precipitation extremes, which includes more concentrated monsoonal rainfall (Haque and Ayers 2008). It is predicted that the precipitation percentage of Bangladesh will increase from 7% to 13% from the year from 2040 to 2050 (Hasan, 2009).

Increased moisture stress during dry periods

One of the most devastating natural hazards is drought, which can be defined as a result of prolonged summer season and lack of precipitation over a long period of time, resulting in water deficiency. The drought in Bangladesh is gradually worsening due to high temperatures, higher evaporation, warmer winters, and less precipitation. Drought is a common hazard for rainfed cultivation in Bangladesh. Bangladesh's annual precipitation depends on monsoon rains that produce 80% of it, and when this is reduced, drought becomes a significant problem; between 1949 and 1991, a total of 24 droughts happened in Bangladesh (WARPO, 2005). Droughts are slower to occur and considerably more persistent than floods and cyclones. Bangladesh has a long history of dry weather. Approximately 53% of the population and 47% of the country have been affected by droughts in previous decades. A region of 5.46 million hectares, comprising the districts of Rajshahi, Natore, Chapai Nawabganj, Rangpur, Dinajpur, Bogra, Kushtia, Jessore, and Dhaka, has been hit by severe droughts (Hasan, 2009). The Southwest and Northwest regions are mainly vulnerable to drought. Larger precipitation excesses related to climate change also mean less rainfall in the dry season, which will upsurge water stress on those areas that previously experienced water scarcities, mostly in the winter seasons. As glaciers regress with increasing temperatures, the situation will be worse for the areas that depend on glacier meltwater for their dry-season water supply (Haque and Ayers, 2008).

Increased flooding

Flood in Bangladesh is an annual phenomenon. Regular floods are seen as beneficial to Bangladesh since they deposit floodplain sediment, which gives the soil essential moisture and fertility; however, moderate to extreme floods are of great concern as they inundate large areas and cause widespread damage to crops and properties (Hasan, 2009). Bangladesh is one of the most vulnerable countries to floods in South Asia, as well as to the costs of climate change that exacerbate floods in terms of intensity and severity, connected with increased monsoon precipitation, higher transboundary water flows, and rising sea levels. Bangladesh experiences five primary kinds of natural floods: floods caused by rivers, floods caused by rainfall, flash floods, tidal floods, and storm surge floods. Over a span of 17 years, from 1987 to 2004, four major floods occurred in Bangladesh. According to the satellite images by the Institute of Water and Flood Management of BUET, around 37% of the country's total area was flooded in the year 2019 (The Daily Star, July 2020). The Brahmaputra, Ganges, and Meghna are the three main river systems that cause floods. Sea level rise and high-intensity and long-duration rainfalls are also associated with increased riverine floods. Due to local rainfalls, the water cannot be drained because of high outflow water levels and higher riverbed levels. Because of geological shifts, sea level rise in Bangladesh is faster than the average rate of sea level rise around the world over the past 100 years (Haque and Ayers, 2008).

Increased salinity

Soil salinity and scarcity of fresh water are very common problems in many parts of the coastal area. The contrary effects of saltwater intrusion are substantial in Bangladesh, as it is a country with a significantly long coastline. Salinity mainly affects land and water in coastal areas. The effects of climate change cause it to continually expand towards inland soil and water. The surface water systems experience saltwater intrusion due to the decreased river flows during the winter season, which is making the resource unusable for agriculture, domestic, and industrial purposes. The accessibility of freshwater will be undermined by enhanced saline intrusion into freshwater sources under low-flow conditions. In coastal areas, this phenomenon is caused by rising sea levels, leading to saline water intrusion in estuaries and groundwater.

According to the report of the Soil Resources Development Institute (SRDI), Bangladesh had 83.3 million hectares of land impacted by salinity in 1973. In the years 2000 and 2009, the salinity intrusion increased to 102 million hectares, 105.6 million hectares, and is continually growing. Agricultural activities suffer greatly. Rahman and Ahsan (2001) estimated that in the Khulna and Barisal divisions, 70% of the 2.34 million land are negatively affected by different levels of soil salinity. Khulna and Patuakhali districts have the highest soil salinity, whereas Khulna, Bagerhat, and Satkhira districts have the most surface water salinity, with nearly 49% of their land area being severely saline (Hasan, 2009). High soil salinity disturbs the cultivation of *Aus* (summer rice), *Boro* (dry season rice) and dry season *Rabi* crops. The reports of the World Bank's Institute of Water Modelling and World Fish acknowledged the consequences of increasing salinity in river water between 2012 and 2016 throughout the coast, including the Sundarbans, the largest mangrove in the world. Bangladesh between 2012 and 2016 have quantified the effects of increasing salinity in river waters in coastal Bangladesh, including the areas in and around the Sundarbans - the world's largest mangrove forest. They state that '…*The southwest coastal area will experience big changes in river salinity during the dry season (October to May) by 2050. This is likely to cause problems with drinking and irrigation water as well as changes in aquatic ecosystems* (World Bank, 2022).

Light Intensity

With the increase in temperature, the ocean would evaporate additional moisture. Consequently, the frequency of days with thunderstorms might increase accordingly. Clouds obstruct the reception of solar energy, potentially diminishing plant development and yields.

Sea Level Rising

The increasing level of greenhouse gas concentrations in the atmosphere due to global warming may result in rising sea levels. The scientific community throughout the world has agreed on the consensus that rising atmospheric concentrations of greenhouse gases will lead to a warming planet in the coming decades. Global warming may accelerate the rate of global sea level rise by expanding ocean volumes and enhancing the melting rates of ice sheets and glaciers. Thus, the frequency and intensity of cyclones, storm surges, and coastal flooding will increase in the oceans and seas (Warrick et al, 1994).

Sectoral Impacts of Climate Change in Bangladesh

Climate change carries a serious threat to civilisation in developed and developing countries and is already affecting South Asia. Bangladesh is considered the most exposed country to the impacts of global warming and climate change because of its geographical location, physiographic features and low capacity to adapt to the change. Socio economic resources and different sectors like water resources, agriculture, food security, human health, infrastructure, coastal zone, fishery, biodiversity, ecosystem will be noticeably affected because climate change is causing changes in rainfall patterns, increased frequency and intensity of floods, droughts, storms, heat waves, change in growing seasons and regions, changes in water quality and quantity, sea level rises, glacial melt etc. (Islam, 2012). The most affected sectors that are struggling to cope with current climate conditions are water, agriculture, fisheries, livestock, forests, ecosystem and infrastructure in coastal areas of Bangladesh.

Impacts of Climate Change on Agriculture

Agriculture is considered one of the main pillars of an agrarian country like Bangladesh. The economy of the country largely depends on agriculture, and almost two-thirds of the total population directly or indirectly relies on agricultural activities, though the country is moving towards industrialisation. The agricultural sector alone contributes 19.29% of its GDP and 47.5% of the total workforce in Bangladesh (MoA, 2014). In order to eradicate rural poverty and ensure food security, the sector provides for a significant portion of rural communities' livelihoods. However, the agricultural sector becomes more vulnerable to climate change because of the significant effects that variations in temperature, precipitation, light intensity, and solar radiation have on agricultural production. IPCC (2014) states that the changes in climate change have significant impacts on every aspect of agriculture, including production, distribution, marketing, access to food and food prices.

Most of the land area in Bangladesh is occupied by agriculture, forests and habitat. Approximately 59.8% of total land (14.3 million hectares) is suitable for cultivation (WB Data, 2018). Depending on the depth of the floods, the area is classified as highland (20%), medium highland (39%), medium lowland (15%), lowland (8%), and extremely lowland (2%). Among them, one-third of the cultivable lands are in coastal and offshore areas, which are extremely susceptible to climate change effects. Not all land areas are suitable for all types of crops. Seasonally flooded land is suitable for rice cultivation, whereas deep flooding for long periods limits land use to a single low-yielding, deep-water rice crop. Hence, agricultural land use in coastal areas is limited to wet season cropping because of the high dry season, soil salinity, and lack of suitable quality irrigation water (UNEP 2011). Study shows that almost 37% of the cultivable seaside land is already degraded by changing degrees of soil salinity. Additional effects of climate change, including temperature extremes and drought, are contributing to diminishing crop yields in Bangladesh (Mondal et. al., 2014).

Impacts of Temperature on Agriculture

The primary factor influencing a crop's adaptability and yield potential for a particular region is the climate. More than half of the crop variety is determined by the climate. Each crop has a range of temperatures in which it can germinate and breed. Several studies indicate that the increased level of carbon dioxide

(CO_2) influences plant growth and yield positively (Jablonski, 2002; Ainsworth, 2005). But increased temperature may reduce CO_2 effects indirectly on the species, photosynthetic pathway, growth stage, and water management practices. About 40% of the greenhouse gas emissions have remained in the atmosphere (880 ± 35 GtCO2); the remainder was detached from the atmosphere and deposited on land (in plants and soils) and in the ocean (IPCC 2014). There are restrictions on the production of crops when the temperature drops below the range or rises above the maximum level. The increase in temperature has negative impacts on rice and wheat yields in different parts of the country (Hossain et al., 2015). Studies confirm that wheat yields are projected to fall by 6-9% in sub-humid, semiarid and arid zones with a 1-degree Celsius upsurge in temperature (Ali et. al. 2017). Crops like wheat, cotton, mango, and sugarcane would be more sensitive to an increase in temperature compared to rice (Sivakumar, 2011). Global warming is projected to have a significant impact on conditions affecting agriculture, and the most climatic factors that influence growth, development and yield of crops are temperature, solar radiation, carbon dioxide, glacial runoff, precipitation, and the interaction of these elements. Climate change is related to warmer summers and cooler winters. From 1985 to 1998, the temperature in Bangladesh rose by 1°C in May and 0.5 °C in November. Winter temperatures lower than 5°C have been recorded in January 2007, which is estimated to be the lowest in 38 years (Haque and Ayers, 2008). Plants can grow only within a certain range of temperature. There are not only optimal temperature limits, but also various growth phases and functions that require an ideal temperature and which species might survive in any particular area depends on the temperature (Ahmed, 2020). High-temperature stress is one of the least well understood of all the abiotic adversities that affect crops (Paulsen, 1994) and is one of the major uncontrollable factors affecting plant growth, development, and productivity (Marshall, 1996). Research indicates that excessive heat damages the exposed portion of the plant, causes dehydration and damaged leaves, and interferes with respiration and photosynthesis, whereas the low temperature affects several aspects of crop growth like survival, cell division, photosynthesis, water transport, growth and finally yield. Research shows that an increase of 2 degrees Celsius in temperature could decrease the rice yield by about 0.75 t/ha in high-yield areas, while a 0.5-degree Celsius increase in winter temperature would reduce wheat yield by 0.45 t/ha.

Impacts of Rainfall on Agriculture

Rainfall is one of the most important parameters of climate. Although rain is considered beneficial to crops and harvests, but most crops have an optimal amount of rainfall during any given growing season. Significant increase or decrease in rainfall can lead towards decreased of yields or flooded crops. Rainfall is the major factor in the growth and production of food crops, both at the germination and fruit development stages. It is obvious that the rain-fed agriculture system is susceptible to climate change impacts. Climate change disturbs rainfall through rainfall unpredictability, which is habituated by the hydrological cycle, and visible rainfall patterns. The high variability of rainfall in the minor season correlated with a reduction in crop production output (Mensah et al. 2019). But temperatures will rise, and rainfall will increase in some places with a change in the world's climate, and in other places, rainfall will decline. Other than the effect of high and low rainfall on cropping patterns, it is projected that phenomena such as coastal flooding will decrease the amount of land accessible for agriculture. Farmers previously viewed it as problematic to survive with these ecological changes, as almost all yields are season-dependent and rainfall-dependent. Temperature and rainfall changes prompted by climate change are likely to further respond with other limits of plant growth like atmospheric gases, fertilisers, insects, plant pathogens, weeds, and the soil's organic matter. Study shows that a 1 mm increase in rainfall at the germination, reproduction and maturation stages decreased Aman rice yield by 0.036, 0.230 and 0.292 tons, respectively. According to the Bangladesh Agriculture Development Corporation (BADC), a shortage of water limits crop productivity, and just 56% of crops are irrigated. In the recent climatic period of 1981-2014, the main factor influencing agricultural crop output in Bangladesh is a gradual decrease in rainfall across various regions, particularly during the Rabi season. The rainfall pattern in the southwestern part of Bangladesh has been decreasing in recent periods of time. The unusual pattern of the rainfall in particular areas poses a great threat to crop production. In 2015, excessive rainfall triggered severe floods and crop damage. In Bangladesh's coastal areas, irregular rainfall patterns combined with issues including drainage congestion, inundation, waterlogging, and salinity intensification are impacting the production of crops (H & J, 2017; Kabir, 2019). It is predicted that the summer rainfall will increase by 5 to 10 per cent by 2030, and by the year 2050, seasonal rainfall will be increasing by around 15 to 20%, causing greater challenges for farmers. (Warrick, 1994).

Impacts of Sea Level Rise on Agriculture

Climate change is likely to accelerate the rise in sea level through the warming of oceans and the melting of ice. Cyclones, storm surges, and coastal floods in the Bay of Bengal could be impacted by global climate change, both in terms of frequency and intensity (Warrick et al, 1994). Bangladesh has a 710 km long coastline. The coastal areas are already struggling with various natural and man-made stresses, including sea level rise, erosion, storms, landslides, wetland loss, salinity of aquifers and agricultural soils, loss of habitat for fish, birds, plants and environmental deterioration (Nunez, 2019). The IPCC-AR4 study has referred to various researchers who have reported that in the coastal area of Asia, the current rate of sea level rise is marginally greater than the global average. It is predicted that the potential sea level rise in Bangladesh is 30 -50 cm by 2050 (DoE, 2023). The SAARC Meteorological Research Centre (SMRC) projected that the sea level rise is 18 cm, 30 cm and 60 cm for the years 2030, 2050 and 2100, respectively.

Sea level rise may affect agriculture in three ways: by salinity intrusion, by flooding and by increasing cyclone frequency and its depth of damage. Collective effects of these three factors decline agricultural production in the coastal zone (Rashid et al, 2004). Salinity intrusion due to sea level rise will reduce agricultural production due to the unavailability of fresh water and soil degradation. Salinity affects the reproduction and incubation rate of the plants (Ashraf et al, 2002). A study showed that rice production in a village of Satkhira district decreased by 1,151 metric tons in 2003 compared to 1985, representing a 69% reduction, with 77% due to the conversion of rice fields into shrimp ponds due to saline intrusion and 23% resulting from yield loss (Ali, 2015).

The Bay of Bengal are encroaching on extensive flat agricultural lands in the southern districts of Khulna, Satkhira, Bagerhat, Jessore, and Magura due to the sea level rise. Such an increase in sea level rise is likely to lead to soil salinity and several environmental challenges in southern Bangladesh. The result has been devastating. The once fertile land of this whole southwestern region has now turned into a huge saline swamp where no vegetation grows. Rising sea levels will result in increased inundation of land and worse crop losses in the future. It is revealed that almost one-third of the coastal land is highly exposed to the tides of the Bay of Bengal, resulting in inundation of cultivable land, which has adverse effects on agricultural activities.

Study revealed that a meter increase in sea level could result in an increase of flood waves from 7.4 meters to 9.1 meters. As a result, about 15-17 million people will be displaced from the land inundation by sea level rise, which will cost 12-16% of the total land area. Thirty-seven million people in different coastal districts are highly vulnerable and directly affected by the sea level rise. In 1973, 1.5 million hectares of agricultural land had moderate salinity, which increased to 2.5 million hectares by 1997. Salinity in the rivers of southern Patuakhali, Pirojpur, Borguna, Satkhira, Bagerhat and Khulna districts has increased by 45 per cent since 1948.

Table 20: Climate change Scenarios for Bangladesh

Year	Temperature Change Mean		Precipitation Change Mean		Sea Level Rise (CM)		
	Monson Season	Dry Season	Monson Season	Dry Season	SMRC	NAPA Scenario	3rd IPCC
2030	.8	1.1	+6.0	-2.0	18	14	14
2050	1.1	1.6	+8.0	-5.0	30	32	32
2100	1.9	2.7	+12.0	-10.0	60	88	88

Impacts of Flood on Agriculture

Flooding is the most persistent natural disaster in Bangladesh. The country’s geographical and geological features are mainly regarded as the primary causes of this flood hazard and vulnerability. Major floods in Bangladesh are triggered by a complex combination of factors, including large river flows from upstream catchments, extreme rainfall across the country, and several other aspects (Yang et. al., 2015). Bangladesh is the highest precipitation zone because of its location near the Himalayan Mountain range. The country is situated in the delta of the three largest rivers in the world—the Brahmaputra, the Ganges, and the Meghna (MoEF). The country's geography is predominantly low-lying and flat. Two-thirds of the land is less than five meters above sea level and is vulnerable to river and rainfall flooding. As a result, nearly a quarter of the country is flooded in an average year.

Flood is the most common water-related natural hazard in a deltaic floodplain like Bangladesh is flooding. The most common types of flood are rainfall floods, flash floods in the eastern hill basin, major river floods, and floods caused by tidal storm surges during cyclones. Among these, riverine floods impose the most significant threat to the population (Ahmed, 2004). Though inundation offers advantages to production, as flooding brings silt and nutrients that enhance soil fertility, prolonged floods have had a detrimental impact on crop yields. In the floods of 1974 and 1987, 0.8 metric tons and 1.0 metric tons of rice were lost, respectively. From 1962 to 1988, nearly 30 per cent of the annual food grain imports of the country decreased (Huq and Ayers, 2008). The 1988 flood resulted in a 45% decrease in agricultural productivity (Karim, 1996). Prolonged floods, higher discharge and low drainage capacity enhance the effects on production and significant loss of potential. Loss of Boro rice production from flash floods in haor areas, delays in Aman production have become a regular phenomenon in Bangladesh. The adverse effects of climate change on agriculture worsen the vulnerability of crop farming in Bangladesh in a warming climate (World Bank 2000).

Impacts of Cyclone on Agriculture

Bangladesh is at high risk of cyclone hazards. In Bangladesh, extreme cyclone events are today happening more recurrently today. Tropical cyclones might turn out to be further persistent with more strength under current climate change circumstances. Nowadays, the major issue is whether global warming will increase the frequency and intensity of several tropical cyclones and their associated storm surges in the Bay of Bengal in the near future. Large changes in sea level occur from storm surges. Storm surges have devastating consequences for Bangladesh. Such surges result from fluctuations in air pressure and wind stress associated with severe tropical cyclones (Warrick, 1994). The sea level rise on various time scales is a major problem challenging Bangladesh. It is predicted that cyclone winds are likely to rise in concentration for the reason of the optimistic connection with sea surface temperature. And this will lead to an everlasting inundation of the coastal zone and an expansion in storm surge events. Though Bangladesh experiences severe 52 cyclones from 1960 to 2010, and the estimated percentage of storm surge effect is 40%, which is the largest in the world, but very little is initiated in the literature on upcoming conceivable changes in cyclone concentration sideways the coastal zone in Bangladesh.

Cyclones usually form from a deep depression, which is a consequence of high amount of temperatures in the coastal region, which is quite common in Bangladesh. The cyclones are developed when Sea Surface Temperatures persist above 26 degrees Celsius over an ocean depth of 60 m for a period (Gray 1977). They generally occur in the early summer of the month from April-May or the late rainy season from November-December (Chowdhury, 2010; Paul, 2019). Cyclones cause enormous impairment to crop production. The study reported that almost 70% of the annual production of the main rice "Aman" in the most affected area was nearing harvest at the time of the passage of cyclone SIDR in 2007 (FAO/GIEWS Global Watch (2007)16). The Department of Agricultural Extension of Bangladesh estimated the loss in rice at about 1.23 million tons. Among these, 535,707 tons were in the four severely affected districts, 555,997 tons in the nine badly affected districts and 203,600 tons in the 17 moderately affected districts in Bangladesh.

Impacts of Drought on Agriculture

Drought is a common hazard in rainfed agricultural countries like Bangladesh. It is a deliberate inception of natural calamities that has been taking place more frequently in Bangladesh in the past few decades. It seems to be a slinking event in this country. Every year, Bangladesh is confronted with a dry period for seven months, especially from November to May, when rainfall is normally low. IPCC (2007) reported that Bangladesh may experience a 5% to 6% increase in rainfall by 2030 due to glacier melting and more intense monsoons, and extreme modification in rainfall patterns in the warmer climate, which will generate recurrent large and lengthy floods as well as an upsurge in droughts outside the monsoon season. Karim et. al. (2019) indicated that climate change effects cause moisture stress and lead to droughts. Most of the droughts primarily occur in the pre-monsoon (March-May) and post-monsoon (October–November) period in Bangladesh, when soil moisture content is insufficient for optimal agricultural growth during the typical crop growing season. Study shows that past droughts have typically disturbed about 47% area of the country and 53% of the total population (WARPO, 2005). Karim et. al. (1999) emphasised that severe drought caused an enormous loss of agricultural production and resulted in the loss of around 2,000 people and 50,000 people in 1978–1979 and 1989, respectively.

Geographical dispersion of drought-prone ranges under climate change circumstances displays that the Southwest and Northwest districts are predominantly vulnerable to drought. Greater rainfall extremes related to climate change mean less precipitation in the dry season, which will increase water strain on the zones that previously experienced water scarcities, mostly in the wintertime months. Study shows that both the south-western and the north-western parts of the country will be at higher risk of droughts during both Kharif (June- October) and pre-Kharif (January-May) seasons. The rice production in north-western Bangladesh decreased to 3.5 million tons in the 1990s due to the drought situation. (BCCSAP, 2009).

Drought habitually distresses Bangladesh in the pre-monsoon and post-monsoon periods. During the last 50 years, droughts have befallen Bangladesh 24 times. Droughts not only affected the production of the monsoon crops but also affected the perennial agricultural resources and other crops like Sugarcane, Tobacco, Wheat, bamboo, betel nut, fruits like Litchi, Mango, Jackfruit, Banana, etc. It is found that under a severe climate scenario, Aus production would decline by 27% while wheat production would be reduced to 61%. With 60% moisture stress, the yield of Boro might be reduced by 55-62% (Karim et al. 1999).

Impacts of Climate Change on Fisheries and Livestock

Fisheries and livestock are considered the second most important economic pillar of Bangladesh. Bangladesh is the third among the top inland fish-producing nations and also the third in inland aquaculture production (BBS, 2005). The country is significantly dependent on these resources for the sake of its rapidly expanding economy and to guarantee food security. Roughly 1.2 million people find direct employment in the fishing sector, and another 0.9 million depend on subsistence fishing as an informal means of livelihood. It is estimated that the fisheries sector contributes about 6% of the GDP of Bangladesh, 80 % of the total animal protein consumed in the country, and about 12 % of foreign exchange earnings mainly from shrimp. The diverse aquatic ecosystem of Bangladesh can be divided into three categories: freshwater, estuarine and marine. They are encompassed by rivers, floodplains, *Beel*, *Haor*, *Baor*, ponds and marine production areas. Floodplain fisheries mostly overlay with agricultural land, *Baor* and pond fisheries, most shrimp farms and some *Beel* and haor fisheries from a separate land use covering an estimated 444,000 ha (Ahmed 1999).

Global warming might distress some of the world’s most prolific fisheries. Indirect effects of climate change on fisheries may be greater than direct effects. The process of the fish production system could be affected by temperature. Because of increased temperature levels and carbon dioxide, there could also be a considerable indirect impact on fisheries. Due to the increasing salinity intrusion into freshwater sources during the low flow conditions, the obtainability of freshwater will be reduced in the coastal region. There are 260 species of fish, all of which are delicate to precise salt and freshwater situations (NAPA, 2005). Furthermore, if agricultural land and settlements can be better protected against rising flooding by the implementation of flood control and drainage systems, the benefit of fish habitats and production in the coastal areas will also be affected (Warrick, 1994).

Impacts of Temperature Rise on Reproduction and Growth of Fish

The amount of fish spawning, the accessibility of food for young fish larvae, the physical transport of larvae in the water, and predation on larvae and juveniles are the four primary factors that control fish populations. All these processes are affected by temperature. A small reduction in plankton production, in response to climate change, could lead to a great decrease in fish production.

Instabilities in ocean temperature are likely to lead to changes in fish populations. Erratic and unpredictable precipitation, along with temperature variations, will disrupt the preparedness, growth, and reproductive development of fish throughout the breeding period. Higher water temperature may influence fish physiology, timing of laying, migrations, and/or highest abundance, productivity across marine and freshwater systems, aggressive species, illnesses, and algal blooms. These will drive modifications in timing and levels of production across marine and freshwater systems and condensed productivity of target species in marine and freshwater systems. Alteration of water temperature may change gender ratios; alter the time of spawning; alter the time of migrations; alter the time of peak abundance, which will disturb the water diversity.

Impacts of Sea Level Rise and Salinity

All coastal ecologies are exposed to global warming, sea-level rise, salinity ingression, ocean acidification and cyclones. The Sundarbans, a habitat for several fisheries, will be entirely devastated with a 1-meter rise in sea level (World Bank, 2000). Due to sea-level rise and increased salinity intrusion, valuable buffer mangrove forests of the Sundarbans are disappearing. Reduction in freshwater supply, excessive siltation, and acidification will harshly change the country's ecology and thus fisheries production can be affected as changes in species diversity, composition, distribution and evolution, as well as modification of fish breeding and nursery grounds. In addition, low-salinity-tolerant fish species may be threatened by the reduced influx of freshwater and increased salinity in the ecosystem, which is creating a home for euryhaline fish species. Quite a lot of fish will be abolished from different areas as they cannot adapt to the altering salinity levels (Gopal, 2009). Increased salinity and change in water quality instigate the species composition and distribution and seasonal abundance of individual fish, particularly in coastal areas. This would, in turn, lead to a change in fish culture practices in the affected areas

Impacts of Rainfall on Fisheries

The precipitation pattern in Bangladesh is predicted to decline during the dry season and rise throughout the wet season (World Fish Centre, 2007). The changes in rainfall patterns will alter the distribution pattern of hilsa fish, sea bass, prawn, and mud crab fisheries. Furthermore, Havenhand et al. (2008) reported that acidification in the water would affect the spawning success of the fisheries species through instigating compact sperm motility and reproduction rate, as in the sea and cause problems in shell calcification of crustaceans, molluscs and other species of water resources.

Impacts on Aquaculture

Climate change has significant impacts on aquaculture production in coastal areas. The temperature rise is influencing both freshwater and marine ecosystems. Rising temperatures may cause fish metabolism, growth and reproduction across several species, leading to increased stress and disease outbreaks, which may cause decreased production efficiency and economic losses. Salinity intrusion and changes in precipitation patterns are affecting species that are sensitive to saline levels. In addition, extreme weather events such as cyclones, floods, and heatwaves destroy the aquaculture infrastructure, disrupt the production and supply, which leads to economic losses. Adaptive management and technological innovation are needed to address the direct and indirect impacts of climate change on aquaculture.

Impacts on Habitat Quality and Migration Routes

A significant consequence of climate change is the loss of habitats and the modification of migration paths. Due to temperature rise, ocean warming, changes in precipitation patterns, and the increasing frequency of extreme weather events, the availability of habitats for thousands of species has been reduced (IPCC, 2022). The Arctic ice is melting to a large extent, that reduced the breeding and feeding grounds for polar bears, seals, and other species. The temperature and daylight control the migration timing for different birds. Shifting in daylight timing affects the migration of such species. Many birds arrived earlier or later than usual and faced an inadequate food supply. Fish migration patterns also changed due to the rise of ocean temperature, affecting ocean and marine ecosystems and fisheries (Both et al., 2006; Perry et al., 2005). Biodiversity is affected by climate change because of the destruction of habitats and changes in migration patterns, which result in population reductions, genetic isolation, and disruption of environmental equilibrium.

Impacts of Climate Change on Livestock

Bangladesh's livestock plays a significant role in national and farming economics. They contribute about 2.8 per cent of GDP and nearly 10 per cent of foreign exchange earnings through exports of leather, leather goods, hides and skins. Moreover, it is assessed that it employs 20 per cent of the rural population directly and indirectly (Warrick, 1994). There is a lack of economic research addressing the climatic impacts on the livestock sector globally. Livestock in developed nations appears to be less vulnerable to climate change due to its occupancy in confined surroundings (sheds, barns, etc.) and has supplementary feed (e.g., hay and corn). In Bangladesh, by contrast, the bulk of livestock lack protective shelters and food.

Grassland changes

Due to climate change, dry weather and salinity have increased in the coastal areas, which decreases the grazing areas for livestock. Scarcity of food and freshwater reduces the milk production and weight of the animals.

Temperature and growth

The temperature increases are projected to occur by 2030, from 0.5 degrees Celsius to 1.7 degrees Celsius, and seem unlikely to have serious direct effects on livestock health or production. Higher temperatures could increase heat stress in farm animals, but higher winter temperatures could reduce cold stress. Temperature increases will enhance metabolic rates, resulting in diminished growth in livestock.

Rainfall and Humidity

Projected increases in rainfall and subsequent flooding could lead to a rise in humidity-related diseases. In low-lying regions, increased flooding causes significant threats to animal mortality. This impacts poultry productivity.

Extreme Hot Weather

Creates stress in livestock and poultry. This leads to less meat, milk and egg production.

Impacts on Water Resources and Hydrology

Bangladesh experiences different types of natural disasters almost every year because of global warming as well as climate change impacts, including flash floods, salinity intrusion, cyclones and storm surges, extreme temperature and drought. Bangladesh is a highly densely populated country, and the effects of climate change on surface and groundwater resources are severe here. The coastal community is highly dependent on surface water for irrigation. Changes in water resources and hydrology hamper the proper irrigation system, especially during the dry season (Islam & Karim, 2019).

Sea level rise and climate change have the most significant impact on Bangladesh's water system. Coastal and riverine flooding has become increasingly critical in both coastal and inland areas in recent years, and droughts during the winter season have risen in certain regions. Moreover, changes in river flows and sediment deposits affect the riverbed. These changes in the riverbed and water system will consequently induce further changes in river level and increase the effects of rising sea level upstream.

Forecasts show that the bed levels of the Jamuna river, with its distributaries the Dhaleshwari river and the old Bhramaputra river, will rise approximately 0.05 to 0.41m for the years of 2015, 2025 and 2095, respectively, which will increase the discharges in distributaries and a small decrease in the discharge of the Jamuna and Padma rivers (Alam, 2004). Furthermore, the discharges at the Gorai and Arial Khan rivers, the tributaries of the Ganges and Padma rivers, are also expected to increase as a result of sediment deposition. The changes in the riverbed and sediment deposition substantially affect the main river channels in Bangladesh. The climate change country study assessed the vulnerability of water resources in flood conditions and sedimentation during the monsoon rain for the two projection years 2030 and 2075. The result shows that the susceptibility of water resources is very high and identifies that the embankments can play an important role in the north-central region of the country (Rahman et al., 2008).

Impacts on Forestry and Biodiversity

Bangladesh has a wide diversity of Ecosystems, including Mangrove forests in the extreme south of the country. The “Sundarbans”, a World Heritage, is the largest Mangrove Forest in the world. It is the largest single tract of mangrove ecosystem in the world. It is located in the southeast corner of Bangladesh, within the Khulna administrative division and extends over parts of Khulna, Satkhira and Bagerhat districts, comprising 10,000 square kilometres of land area along the Bay of Bengal. This area is home to a total of 453 faunal species that were officially listed. Other sources report over 120 species of fish, 290 species of birds, 42 species of mammals, 35 reptiles and 8 amphibian species representing almost 35-36% of birds, mammals, reptiles of the country. The Sundarban is the most significant habitat for the famous Royal Bengal Tiger. Moreover, the Sundarbans provide livelihood and employment to woodcutters, fishermen, honey and wax collectors, shell collectors, timber traders, fish drying industry workers, golpata collectors, and shrimp collectors, representing from 5% to 27% dependent households of Khulna districts.

The detrimental effect of climate change on biodiversity and forestry is substantial. The IPCC report shows that almost one-third of the forests of the country are adversely affected because of changing temperatures, precipitation patterns, and increasing frequency of extreme climatic events (Quayyum, 2021).

The report shows that the sea level at Sundarban may rise by over 15.5cm by 2050, which may cause permanent inundation of land areas. Such losses will lead to altering the habitats of many species. The composition of aquatic fauna, terrestrial fauna will likely be changed. Sea level rise will surely increase the level of inundation, which will certainly change the species composition. Moreover, the substantial flow of tidal currents during inundation may adversely impact the ecology of the Sundarbans. The water turbidity may increase, which will affect the composition of the aquatic population. Though salinity is critically important for mangrove ecosystems, the excessive rise in salinity will result in the complete elimination of the freshwater zone.

Furthermore, the rapid loss of forests is not only contributing to the build-up of atmospheric carbon dioxide (CO2) but is also directly undermining the world's biological resources, ultimately precipitating species extinctions and biodiversity loss. The inability of many species to cope and adapt to change; Major loss of biodiversity through changes in the community; Migration and extinction of certain species are the most common effects of climate change on biodiversity. Therefore, it requires special attention for protection against the effects of climate change, which could potentially destroy the delicate ecosystem of the forest resources in Bangladesh.

Impacts on Human Health

The impacts of climate change on human health are less compared to other areas. More flooding and more storms will put people at greater risk for health problems. High temperatures and increases in precipitation may spread many infectious diseases, like water-borne diseases and vector-borne diseases. Heat waves, combined with heat and humidity, increase risks of heat stroke, various respiratory problems and cardiovascular stress. In addition, climate shocks like floods, drought, and salinity intrusion undermine food production and nutritional status, leading to malnutrition and other associated health issues. Contaminated water due to floods, erratic rainfall, flooding, and salinity intrusion raises health risks like diarrhoea, cholera and other water-borne diseases. Meanwhile, the psychological distress due to repeated disasters, migration, and livelihood losses increases stress and mental health issues. In Bangladesh, climate change is likely to make health problems more severe, especially since the country's public health system is in poor condition. Apart from these, the low life expectancy, malnourished children, and low budget of the government in the health sector are worsening the condition further.

Impact of Drought on Health

The impacts of drought on human health are indirect in nature. It has been stated that drought will increase in some areas of Bangladesh due to changes in rainfall patterns as a result of climate change. Prolonged drought in different regions limited freshwater supplies and deteriorated water quality, compounding risks to malnutrition, deaths and other water-borne diseases. Some infectious diseases and respiratory diseases are also exacerbated because of heat and poor air quality. Additionally, the prevalence of drought may also influence mosquito-borne diseases.

Impact of Increasing Heat Waves on Health

According to several studies, climate change is becoming more common in Bangladesh. Different kinds of health problems may arise when the temperature changes. Rahman (2008) described that the health consequences associated with heatwaves, including heatstroke, dehydration, and exacerbation of cardiovascular illnesses in the elderly, are escalating significantly. Although Bangladesh lacks documentation on illnesses and fatalities associated with heatwaves, the incidence of infection with diarrhoea has risen during extreme temperatures and heatwaves, predominantly affecting adolescents.

Impact on Vector-Borne Diseases

Wide-scale change in ecology may occur due to a warm climate, which may affect the disease pattern. Climate change may affect health in three major ways: by creating conditions favourable to epidemics of infectious diseases, increasing the potential for transmission of vector-borne disease and deterring the future control of the disease. Vector-borne diseases (VBD) are contagions spread by the bite of infected arthropod species, such as mosquitoes, ticks, bugs, sandflies and blackflies. Climate directly affects the expansion of the vector of malaria-dengue. Climate also has an unintended effect on malaria and dengue through its influence on suitable vegetation and vector breeding sites. Precipitation is important because mosquitoes require water to lay their eggs, as well as for the subsequent development of larvae. Projections indicate that, in the future, malaria is most likely to extend its range into the fringes of established endemic areas. It is also reported that the intensity and extent of malaria's potential transmission would change significantly.

Impact of Sea Level Rise on Health

The salinity of water and its distribution in coastal regions are escalating due to rising sea levels. Sea level rise on the coast has a great impact on human health. The bacterium Vibrio cholera is responsible for cholera, capable of surviving longer in saline water. Increasing salinity in coastal areas increases the risk of cholera on the coast. Studies indicate that there is a close relationship between coastal waters and a saline environment to cholera infections. The majority of cholera epidemics during the past 50 years originated in coastal regions (Colwell and Huq, 2001). The majority of cholera epidemics arise after the contamination of water bodies during floods. Moreover, salinity exacerbates hypertension in coastal regions, resulting in different health complications, particularly for pregnant women, and may even lead to involuntary fetal abortion (MoEF, 2009).

Impact on Water and Food Contamination

Rising temperatures and increased precipitation accelerate the spread of bacteria, viruses, and phytoplankton in aquatic environments, resulting in different waterborne diseases such as diarrhoea and cholera. The intensity and frequency of natural disasters are increasing day by day. Severe weather events, such as floods, transmit industrial waste, sewage, pesticides, and heavy metals into rivers, ponds, and groundwater, thereby deteriorating water quality and making it unsafe for drinking, irrigation, and use in households. Agricultural production and food security are also affected by the variations in precipitation patterns. Crops that are irrigated with polluted water are contaminated with toxic substances, including arsenic, pesticides, and microbial pathogens, rendering them unsuitable for consumption. Prolonged heat waves and moisture facilitate fungal reproduction in stored grains, increasing the risk of aflatoxins, which are highly carcinogenic contaminants which threaten food safety.

Impact on Air Quality

Climate change is predicted to have a significant and harmful impact on air quality. Rising temperatures contribute to a significant air pollutant, namely ground-level ozone, which is generated when sunlight interacts with nitrogen oxides and organic molecules, resulting in smog formation, particularly in urban and industrial regions, and leading to respiratory issues such as asthma, bronchitis, and decreased lung function. Furthermore, higher humidity and temperature facilitate the persistence and dissemination of airborne allergens, including pollen, mold spores, and fungal particles, worsening allergies and respiratory illness. In coastal regions, rising temperatures of the sea may induce aerosol production and chemical reactions, resulting in air pollution.

Impacts on Infrastructure

Climate change is going to have significant impacts on society and the infrastructure that supports development. Global warming could impact not only agriculture and human health, but also patterns of human settlement, energy use, transportation, industry, environmental quality, and other aspects of infrastructure that affect our quality of life (IPCC 1990). Climate change is altering regional agricultural and industrial potential, triggering large-scale migrations and redistributions of people. Such population displacements can result in serious socioeconomic disruptions, negative health impacts, and increased human suffering. Industrial or agricultural relocations in response to climate change will require additional investments in transportation – from new highways or rail links to new shipping ports.

Climate change will exacerbate many of the current problems and natural hazards the country faces. Floods, droughts, tropical cyclones, and storm surges are expected to increase in frequency and intensity in the forthcoming years. These shifts will make it harder for Bangladesh to reach the Millennium Development Goals and will undermine Bangladesh's substantial progress during the past two decades. According to IPCC’s 4th Assessment Report, global warming will result in sea level rises between 0.18 and 0.79 meters. This has major implications for coastal infrastructure concerning storm surges and salinity intrusion. Direct Impacts There will be more days with extreme temperatures (hot and cold) compared to the past, which will cause existing road surfaces and materials used in railway systems (tracks, signals, etc.) to be worn down more quickly.

There will be monsoon days with more intense rainfall, which will also cause existing roads and rail tracks to weaken. Increased rainfall will lead to more river floods and flash floods that can damage roads and rail lines, including erosion of the embankment on which these infrastructures are located. Increased high winds from more frequent and more intense cyclones can cause debris (like trees and electricity poles) to damage and block roads and rail lines. More intense cyclones will lead to higher storm surges that can cause damage to roads and rail tracks and their embankments in coastal areas. Exposure to saline water from storm surges and flooding by saline river water can cause damage to road surfaces and rail tracks. Use of road and rail embankments by people affected by increased natural disasters, such as floods, has indirect impacts. Decrease in maintenance funds due to reallocation of central budget for other needs, e.g., disaster relief, ensuring food security, etc. Increased usage of groundwater, due to a lack of surface water in the dry season, can lead to localised subsidence that can damage roads and railways. As the impacts of climate change are felt, the demands on the rural infrastructure can shift to less-impacted or less vulnerable areas. As mentioned in the 2005 NAPA, in the future, more roads and rail lines can impede natural drainage in the floodplains, worsening the impact of increased floods caused by climate change.4 River flooding is a widespread concern. Extreme temperature issues are expected mainly in the northwest region. Flash floods may increase in the northeast and southeast regions. Near the coast, one can expect salinity, storm surges and cyclone impact to increase.

Impacts on the Coastal Area

Coastal areas in Bangladesh are among the most vulnerable in the world to climate change. The low-lying areas along the Bay of Bengal are directly affected by natural calamities like storm surges, sea level rise, flash floods, salinity and ocean heat. Meanwhile, the vast majority of the land area is situated at ten meters above sea level. Sea levels are expected to rise by an average of two to three mm per year during the first part of this century. A number of major changes occur in coastal areas, affecting ecosystems, infrastructure, livelihoods, and communities. The major effects of climate change on the coastlines of Bangladesh are erosion, subsidence of the land, drainage of river waterways, lower sedimentation, waterlogging, and saltwater intrusion. Furthermore, the coastal area of Bangladesh and the Bay of Bengal are located at the tip of the northern Indian Ocean and the region is often impacted by intense cyclonic storms, which produce extensive tidal waves. Reports show that the infrastructure and livelihoods of thirty districts were severely affected and damaged by Cyclone Sidr. One of the most noticeable effects of coastal climate change is salinity intrusion. During the dry season, saltwater from the Bay of Bengal flows into the land. The availability of freshwater, particularly during the dry season, is reduced due to excessive demand on groundwater, which is a problem for both households and businesses (Huq et al., 2008).

A one metre rise in sea level can cause huge land loss and generate climate refugees. Study predicts that sea level rise can inundate fifteen per cent of land in coastal Bangladesh with 30 million climate refugees. These will affect the agriculture, industry, infrastructure, and livelihood and might result in a GDP loss of 27 to 57 per cent. Moreover, climate change has significant impacts on the lower-income population and women. A significant number of individuals with agricultural expertise switched to non-agricultural employment and were forced to migrate to urban areas with inadequate housing, sanitation, water, and energy service (Huq et al., 2008).

An Overview of Climate Change Impacts on Different Sectors in Bangladesh

Sectors	**Climate Change Trends**	**Impacts**
Agriculture **Fisheries** **Livestock** **Water Resources and Hydrology** **Forestry and Biodiversity** **Human Health**	Sea level rise Changes in Precipitation Patterns Increased Temperature Increased frequency of cyclonic storms Salinity Intrusion Increased flooding Drought Acidification Light Intensity	Reduce CO_2 Effects Decrease Crop Productivity Loss of Cultivable Land Pest infestation and disease outbreaks Harvesting and storage problem Cropping pattern change Less suitable irrigation water Low crop yields Changes in Fish Population Disruption of Reproductive Development Disturbance in Water Diversity Reduction of Freshwater Supply Effects on Fish Metabolism, Growth, and Reproduction Changes in Migration Patterns Decrease the Grazing Areas Enhance Metabolic Rates Affects the Riverbed Levels

		Inundated the Forest Land Areas Increase in Infectious Diseases Increase Risk of Heat Strokes Deteriorate the Water Quality Increase Water-Borne Diseases

Conclusion

Unexpected climate changes are taking place. The changes in the composition of greenhouse gases are radiatively vital because they regulate the radiation balance or net heat balance of the Earth. Sun-earth orbits, solar output, volcanic activity and ocean circulation are the natural causes of greenhouse gas concentration. Thus, greenhouse gas concentrations cause global warming. In addition, we humans, during the past 100 years, as a result of burning coal, oil, and gas and clearing forests, have greatly altered the biochemical arrangement of the atmospheric layer. As a result, the greenhouse gases, e.g. carbon dioxide (CO_2), methane (CH_4), carbon monoxide (CO), nitrogen oxides (NO_x), chlorofluorocarbons (CFCs), and ozone (O_3) that have the greatest effect on our climate, are increasing day by day. These climate changes have a great impact on the Earth. It may change the average weather or the distribution of weather events around the world. The impacts of climate change may be limited to a specific region or may occur across the whole earth. Climate change has a great impact on Bangladesh. Bangladesh has been recognised as one of the most vulnerable countries to climate change due to its geographical location, physiographic characteristics, and inadequate adaptive capacity. The country is prone to many natural disasters, including floods, droughts, storm surges, saltwater intrusion, river erosion, and more. It is also likely to be affected by future changes in the climate (BCCSAP, 2009). These global warming-induced changes and vulnerabilities have potential negative impacts on food agriculture, human health, fisheries, biodiversity, water, economic activities and other natural resources, which require adaptation in the context of development (Islam, 2012).

Chapter Five

Policy Initiatives and Institutional Framework for Climate Change Adaptation in Bangladesh

*"**Climate change is a huge challenge**, but it can be brought in line if governments, businesses and individuals work together."*

Sir Richard Branson, Founder of Virgin Group

Chapter Summary

The objective of this section is to take a look at the institutional structures and national and international legal frameworks that are assisting Bangladesh in addressing the current and future challenges associated with climate change

- *Introduction*
- *Climate Change Adaptation in Bangladesh: Policy Perspectives*
- *Institutional Arrangements for Addressing Vulnerability of Climate Change*
- *Role of Institutions in Climate Change Adaptation*

Introduction

In order to lessen the impact of climate change, adaptation measures are required. As a country, Bangladesh has an extensive record of adaptation to different climatic situations. There would be immediate benefits and long-term benefits to incorporating traditional knowledge with further steps to make Bangladesh more resilient to current climate extremes, such as floods, droughts, and tropical cyclones. Such calamities are predicted to become more frequent and intense as a result of global warming. It is well recognised that increasing emissions of greenhouse gases will affect the global climate, while the pace and the regional characteristics of these changes remain inadequately comprehended. Significant uncertainties and deficiencies exist in scientific comprehension. But policymakers can't wait until all the unanticipated and information gaps have been addressed before taking action. Bangladesh must respond swiftly, as the country may be particularly vulnerable to the consequences of the increased greenhouse effect, for which it has no responsibility. Responses can be categorised into three distinct forms: *passive adaptation*, which includes a non-anticipatory strategy that enables society to adjust to changes as they arise; *active adaptation*, which involves preventive measures aimed at either mitigating vulnerability or distributing impacts; and *emission reduction*, which focuses on reducing climate change by decreasing emissions of greenhouse gases(Warrick, 1994).

The topographical profile of the nation probably makes it more exposed to frequent environmental hazards and natural effects of climate change, including variations in temperature and rainfall, increased intensity of floods, droughts, cyclones, and storm surges. The recent report shows that the temperature of Bangladesh is normally growing in the monsoon, especially in June, July, and August, while the average winter temperatures in December, January, and February are maximum and minimum show a declining and a growing tendency (Rahman et. al., 2003). In the recent past, high temperatures, augmented temperatures, particularly in the months of the pre-monsoon season (March to May), have been a major concern in the coastal zone. Recent studies show that almost all the regions of the country are experiencing erratic precipitation patterns characterised by early rainfall, late rainfall, and excessive rainfall within a relatively brief time frame. Over the past four decades, the coastline of the country has been affected by at least two super cyclones and nineteen severe cyclones. Moreover, the saltwater level is increasing and is invading freshwater in different coastal districts, including Patuakhali, Pirojpur, Satkhira, Bhola, Khulna, Feni, and Noakhali. Additionally, drought becomes common in the northwest region during March, April, and May (Huq et al., 2011). Floods can be a blessing for soil fertility and moisture, but extreme floods inundate extensive areas and cause significant damage to crops as well as properties in Bangladesh. In addition, the World Bank reports state that Bangladesh would face 30 CM and 50 CM sea level rise in 2030 and 2050, respectively, which has already measured a 5.5mm rise at Hiron point in Sundarban. It is important to protect the low-lying coastal areas from the devastating effects of sea level rise on agricultural production, water resources, sanitation systems, infrastructure, etc., before their overwhelming effects engulf them. The impacts of climate change and associated hazards on agricultural production, Safe drinking water, proper sanitation and hygiene practices, as well as on human health, are becoming more challenging day by day. Waterlogging, salinity, increasing sea surface temperatures, and the severity and frequency of recent storms have been devastating for coastal islands.

The role of Bangladesh in formulating climate change strategies and policies is limited, and it had no specific climate change plan before 2005. Afterwards, the country initiated several initiatives as part of its key policies to make the country less vulnerable to climate change (Groom, 2012; Tanner et al, 2007). The Government of Bangladesh, through the Ministry of Environment and Forests (MOEF), has taken a number of policy and institutional decisions to address climate change and climate variability issues in Bangladesh. The following sections provide a brief description and synthesis of policy and institutional aspects at the national level in relation to climate change adaptation. The objective of this chapter is to examine both national and international legal contexts and institutional arrangements assisting Bangladesh in addressing the current and future climate change challenges.

Climate Change Adaptation in Bangladesh: Policy Perspectives

To address current impacts and manage future risks of climate change and variability towards the development of a climate-resilient Bangladesh, the government has undertaken several direct adaptation policies, such as plans, policies, strategies, and action plans in recent years. These are presented in the following:

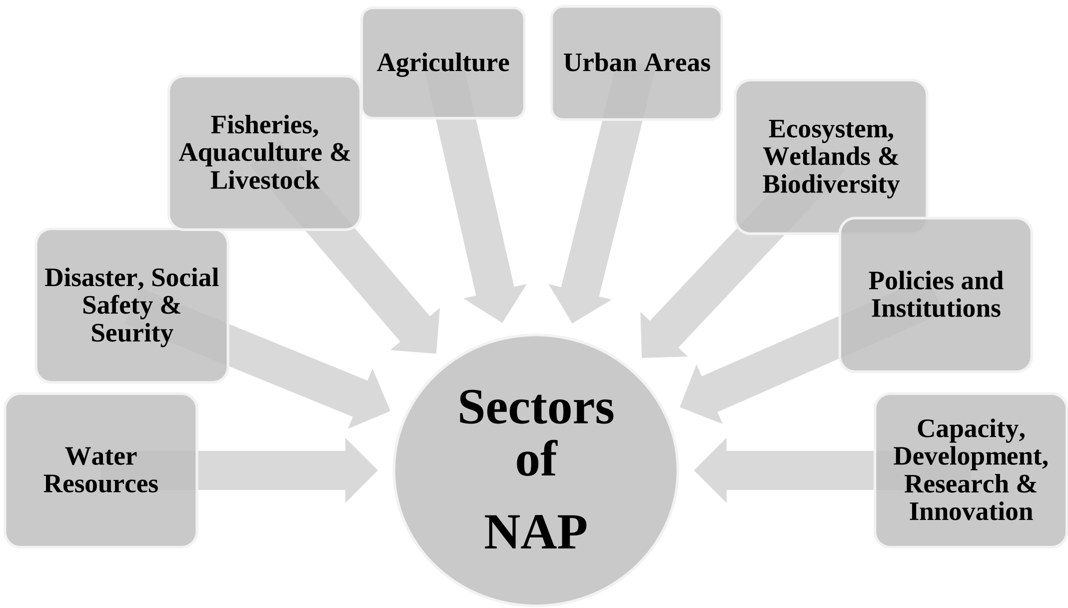
Table 21: National Adaptation and Sectoral Policy

National Adaptation Policies
• The National Adaptation Programme of Action 2005 (NAPA)
• Bangladesh Climate Change Strategy and Action Plan 2009 (BCCSAP)
• Vision 2021
• Eighth Five-Year Plan (2021-2025)
• Climate Change Trust Fund Policy (2009)
• Climate Change Trust Act 2010
• Delta Plan 2100
• Perspective Plan
National Level Sectoral Policies
• National Agricultural Policy (2010)
• National Water Policy 1999
• National Water Management Plan 2001
• National Coastal Zone Policy (2005)
• National Environmental Management Action Plan (NEMAP)

National Adaptation Programs of Action (NAPA)

For the least developed nations (LDCs), NAPA offers a method for determining priority initiatives that address their pressing requirements in relation to climate change adaptation. The NAPAs are founded on evidence indicating that LDCs can't handle the bad effects of climate change effectively. Since grassroots communities are the primary stakeholders, community-level contributions are prioritised as a significant information source throughout the process. Bangladesh formulated its NAPA in 2005, in response to the UNFCCC's Seventh Session Conference of the Parties' decision (COP7), and subsequently revised it in 2005. The Ministry of Environment and Forest (MoEF) prepared NAPA for Bangladesh following the broad supervisory principles arranged by the LDC Expert Group (LEG). The authority formulated fifteen adaptation measures to mitigate the effects of floods, salinity intrusion, and droughts, which are considered the most damaging consequences of climate change, across major sectors, including water, agriculture, fisheries, livestock, human health, forestry, land use, and infrastructure. In addition, coastal areas, natural disasters, biodiversity, food security, livelihoods, gender, local governance, policies, and institutions are also considered vulnerable sectors that require adaptation. The NAPA was restructured in 2009 following denunciation from several stakeholders who considered it inadequate to confront climate impacts in the country (Nachmany et al., 2014). The 2009 NAPA objects to "*combine potential adaptation procedures into overall development planning processes, make development resilient to climate change, and promote sustainable development of Bangladesh*" (MoEF, 2009, p. iii). It perceives major initiatives in eight thematic categories, encompassing research and knowledge management, agriculture, fisheries, livestock, health, climate-resilient infrastructure, disaster management, livelihoods, biodiversity, policy, and institutional capacity building (MoEF, 2009).

Figure 20: Sectors Focuses by NAP



The National Adaptation Action Plan (NAPA) mainly focuses on--

- Increasing community participation, coastal afforestation, and mangrove restoration to reduce coastal hazards like cyclones and tidal surges.
- Rainwater harvesting for irrigation and drinking water in coastal areas to combat the salinity intrusion
- Development of the heat, salinity, and submergence-tolerant crop varieties for sustainable agricultural production and food security
- Development of Water Resource Management to incorporate climate change into infrastructure design, land zoning, and conflict management for capacity building of water management institutions.
- Disseminating information on climate change and adaptation to communities at risk to increase knowledge of escalating climate catastrophes and emergency preparedness measures.
- Building of flood shelters, information and support centres in key floodplain areas to deal with the increased frequency of floods.

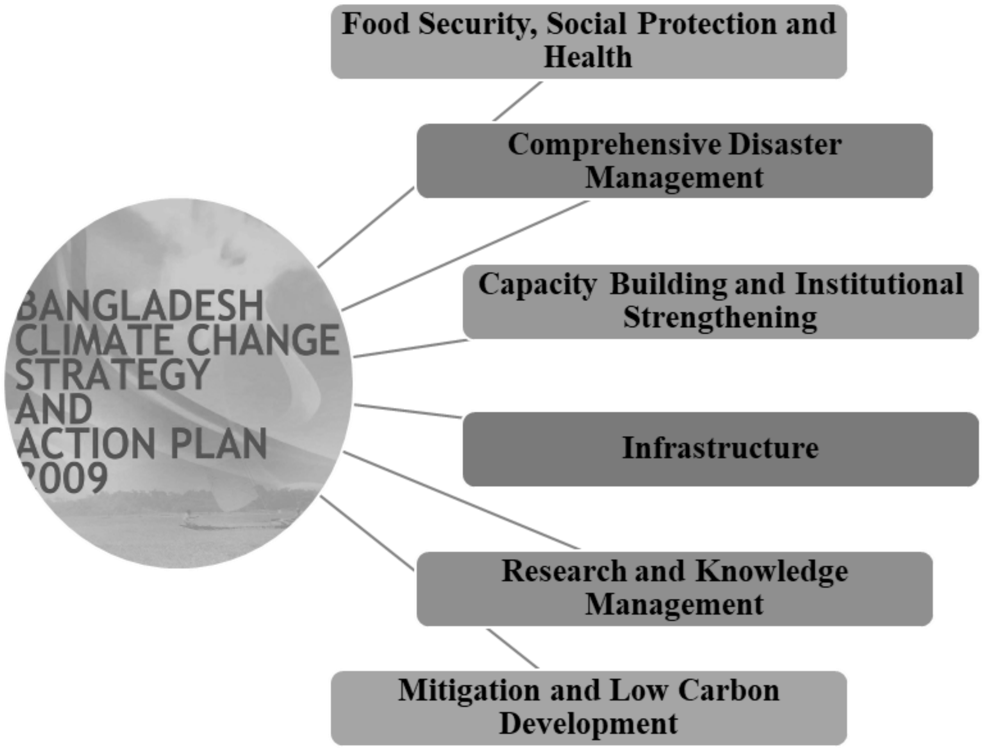
- The integration of adaptation to climate change into several sectoral policies and agendas, with an emphasis on agriculture, water, disaster, health, and industry
- Awareness building through the inclusion of climate change issues in educational institutions and local communities by developing eco-specific and indigenous adaptive knowledge on adaptation
- Training and research development to facilitate adaptation in areas prone to enhanced flash flooding for crop agriculture and fisheries in the future.
- Assessing emergency preparedness and insurance alternatives to deal with more frequent climatic disasters.
- The revised NAPA specifies priority initiatives engaging government bodies, NGOs, research institutions, and members of the community.

Bangladesh Climate Change Strategy and Action Plan (BCCSAP)

With the collaboration of local government, civic society, ministries, and departments, Bangladesh has begun implementing NAPA step by step. The government of Bangladesh prepared and adopted the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) in 2008, aiming to address both adaptation and mitigation for the period of the decade, 2009 to 2018. It was developed in 2009, concentrating on a decade-long action plan to address prospective problems and changing situations. Building on the revised NAPA, in 2009, the government developed a revised version of its BCCSAP, where expansion and erection of water resources through better organisation of river course and training, and mitigating policy directions, such as the low-carbon development path, were added, which is currently the principal national planning document for addressing climate change.

The BCCSAP emphasises climate-related disasters and their concerns, such as progressively recurrent and severe cyclones, erratic rainfall, the melting of the Himalayan glaciers, and rising sea levels. The main objective is to develop a comprehensive plan to combat climate change and its impacts in Bangladesh. In order to address the need for effective measures, this plan will lay out a number of programs and specify how and when they will be implemented (Carvalho, 2023). Identifying all climate-induced risks, such as flooding, drought, sea-level rise, saline intrusion, cyclones, storm surges, and variations in temperature and precipitation, along with their impacts on various sectors, BCCSAP identified a set of activities/measures under six major pillars.

Figure 21: Six Pillars of BCCSAP



The BCCSAP is a part of the overall development strategy of the country and substantially expands the National Adaptation Program of Action (NAPA), espoused in 2005. These six pillars are considered the country's roadmaps for climate resilience and low-carbon development that will provide a comprehensive guideline for climate change adaptation and mitigation to address the challenges of frequent cyclones, sea level rise, salinity intrusion, and natural hazards. The strategies and action plans focus on the protection of lives and livelihoods of vulnerable communities, strengthening disaster risk management, building climate-resilient infrastructure, promoting research and knowledge management, ensuring low-carbon development, and institutional capacity. Under these six pillars, BCCSAP outlines forty-four programs spanning thirty-four of which directly address the adaptation needs. A concise introduction to the six pillars of BCCSAP is briefly discussed in the table below.

Table 22: Thematic Areas of BCCSAP

Thematic Areas of BCCSAP	Adaptation and Mitigation actions
Food Security, Social Protections, and Health	• The first pillar of BCCSAP towards a climate change action plan to ensure the poorest and most vulnerable group in society, including women and children, are being protected from climate change hazards, and all the programs focus on the needs of this group's food security, employment, health, and basic citizen services. • To strengthen disaster management, social protection systems, and healthcare services against climate impacts.
Comprehensive Disaster Management	• To enhance the country's capacity to deal with increasingly frequent and severe natural catastrophes. • To improve the early warning systems, cyclone shelters, flood management, and disaster preparedness.

Infrastructure	• To strengthen existing infrastructure like roads, bridges, rivers and coastal embankments, cyclone shelters, urban drainage, and to ensure that the assets are well maintained.
Research and Knowledge Management	• To predict the scale and timing of the impacts of climate change on different sectors, and to underpin future investment strategies. • Building capacity in modelling, technology development and forecasting and establishing an information system for planning and decision making
Mitigation and Low-Carbon Development	• Promoting renewable energy, energy efficiency and sustainable transport • Exploring opportunities for carbon trading, green energy and reducing emissions.
Capacity Building and Institutional Strengthening	• Enhancing human resource capacity, institutional frameworks, and coordination • Mainstreaming climate change into national and sectoral planning • Strengthening the capacity of government ministries, local governments, civil societies, and the private sector to address the challenges of climate change.

Eighth Five-Year Plan (2020-2025)

The 8th Five-Year Plan (FYP) of Bangladesh was prepared by the Planning Commission of Bangladesh and approved in 2020 to achieve the goals of the Perspective Plan 2021-2041 and the Sustainable Development Goals (SDGs) framework. Currently in effect, this mid-term national development plan encompasses the months of July 2020 through June 2025. The plan focuses on poverty reduction, accelerating growth and recovering from the COVID-19 pandemic, along with empowering every citizen to participate in the development process and sustainable agricultural development for food security. The plan focuses on six major target areas to achieve the goals of recovering from COVID-19, accelerating GDP growth, quality employment, strengthening human capital, reducing poverty and inequality, and ensuring sustainable and climate-resilient development. The targets of the 8th FYP major indicators are presented in the Table below.

Table 23: Targets of Macroeconomic Indicators in EFYP

Category	**Projection**
Timeline	July 2020- June 2025
Budget	64959.8 billion Estimated Cost: 18.9% Public Sector, 81.1% Private Sector Sources of Funds: Domestic: 88.5% Foreign: 11.5%
Average GDP Growth	8.51%
Poverty Reduction	15.6% (7.4% extreme poverty)
Employment Generation	11.3 million new jobs
Human Development Index	0.71

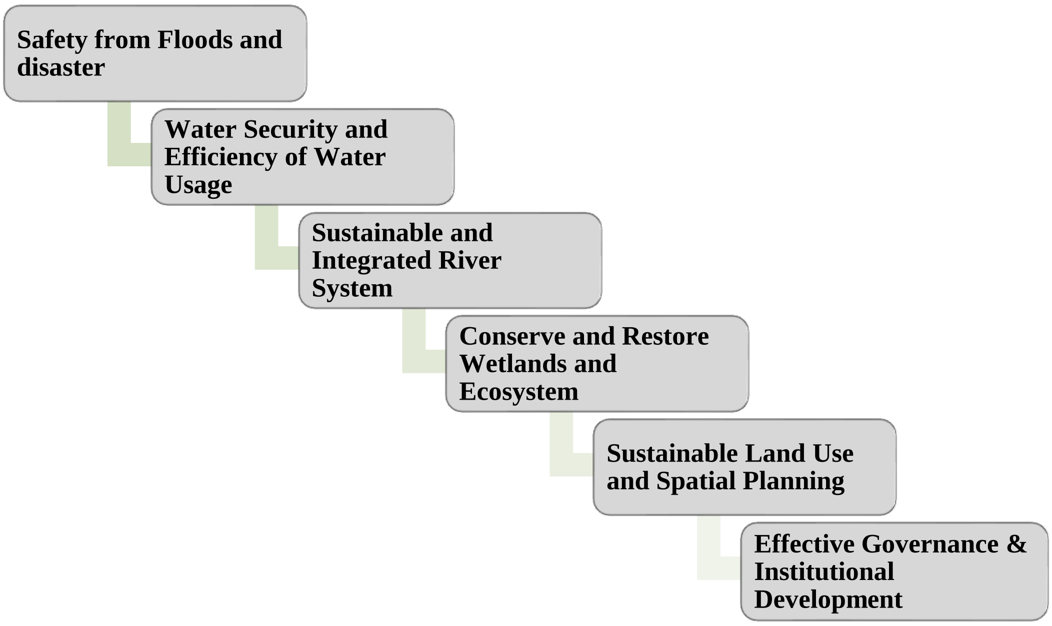
The plan strongly emphasises climate-smart agriculture, low-carbon development, green climate resilience, promotion of green budget and accounting, renewable energy contribution, early warning systems for disasters, and building institutional capacity. According to EFYP, the construction of desalination plants and rainwater harvesting systems for community water supply, tube wells with appropriate treatment units for arsenic and iron and pond sand filters to treat water from the pond surface are the recommended technologies to address the salinity in the coastal areas. However, ensuring total coverage of disaster-prone areas with shelter facilities and warnings and strengthening the capacity of the vulnerable groups, especially women, are prioritised under the EFYP (GED, 2020).

Bangladesh Delta Plan 2100 (BDP 2100)

The Bangladesh Delta Plan (BDP), 2100 is a long-term integrated development plan adopted by the Government of Bangladesh in 2018 to ensure synergy between development and economic growth by providing a comprehensive roadmap for climate resilience and economic growth. The objective of the government is to eliminate severe poverty by 2030, attain upper-middle-income status by 2030, and convert Bangladesh into a climate-resilient, secure, and wealthy delta by 2100. The plan was prepared with technical support from the Government of the Netherlands and the World Bank, inspired by the Dutch experience in delta management.

There are six specific strategic goals of BDP 2100. For ensuring the safety from floods and climate-related disasters, the BDP 2100 emphasises constructing and strengthening the embankments, polders, and early warning systems. The plan recommended that the key solutions for ensuring sustainable and integrated river systems and estuaries involve excavating the silted rivers, restoring natural river flows, and reducing erosion. In order to promote water security and water consumption efficiency, the framework recommended managing transboundary water concerns, conserving wetlands, and upgrading irrigation. In addition, the BDP 2100 determined that minimising unplanned urbanisation, protecting biodiversity, and bolstering national and local government institutions are the key components that promote sustainable land use and institutional development.

Figure 22: Six Specific Strategic Goals of BDP 2100



The Delta Plan 2100 is a substantial national policy for providing food, water, and energy security for a rising population. It integrates climate change adaptation, water management, economic growth, and environmental protection into a single long-term vision. The plan is coordinated by the General Economic Division (GED) of the planning commission, and an initial short-term phase (ending in 2030), a medium-term phase (ending in 2050), and a long-term phase (ending in 2100) are planned for the strategy's implementation.

Perspective Plan of Bangladesh (2021-2041)

The Perspective Plan of Bangladesh is the country’s long-term framework for socio-economic development, prepared by the General Economics Division

(GED) of the Planning Commission. The plan provides the strategic vision, goals, and policy direction for national development. The first plan (2010-2021) targeted middle-income status and poverty alleviation, while the second Perspective Plan was launched in 2021, aspires to make Bangladesh a developed, high-income, digitalised, and knowledge-based economy by 2041. The plan is approved to eradicate severe poverty and reach high-income nations by 2041 and upper-middle-income nations by 2031.

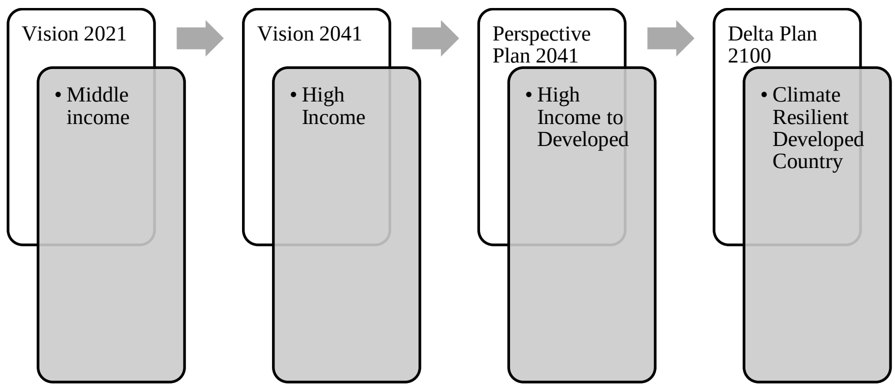
The Perspective Plan is closely linked with the Sustainable Development Goals (SDGs) and the Delta Plan 2100. The priority areas of the plan are poverty reduction, lowering inequality, accelerating economic growth, expanding energy, power and infrastructure, promoting education, women's empowerment and health, ensuring good governance, and environmental sustainability. The primary goals of PP2041 are to achieve developed country status with a per capita income of USD 12,500 and to reduce poverty (GED, 2020). The economic growth and poverty targets for PP 2041 are summarised in the table below.

Table 24: Growth and Poverty Targets for PP2024

Indicator	**FY21**	**FY31**	**FY41**
GDP Growth (%)	8	9	9.9
Extreme Poverty (%)	9.4	2.3	<1
Poverty (%)	18.8	7	<3

The Plan provides a long-term vision for the country beyond electoral cycles. For growth and transformation, as well as for inclusive and quick development, PP2041 has a greater vision of strong and effective institutions. It described the four pillars of a developed country as capacity building, decentralisation, democratisation, and governance. The plan emphasises providing a minimum standard of living for every citizen by assuring a knowledge-based economy, an uninterrupted literacy rate, free education up to twelve years, and affordable health insurance coverage to confirm a zero-poverty country and human development. Along with the production and diversity of rice, other nutritious foods, such as vegetables, fruits, pulses, oilseeds, meat, fish, eggs, and milk, have also expanded to provide food security and nutrition. Several strategies, like sustainably intensifying agriculture, resilient crop and livestock production systems, were undertaken to cope with the growing risk of climate change. By developing the least-cost path for the expansion of power generation, ensuring power policy, and strengthening power institutions, the plan aspires to distribute the benefits of power production throughout Bangladesh. In order to attribute the growth, the plan focuses on the acceleration of economic growth through trade and industrialisation by supporting high-value and manufacturing businesses. Digitalisation, innovation, and technology have also become the highest priorities of PP2041 in order to create an innovation economy by delivering services right to the citizens' doorsteps.

Figure 23: Chronology of National Plans



National Agricultural Policy (2018)

The first agricultural policy was adopted in 1999 to achieve a generous, profitable, and sustainable agricultural system in Bangladesh by ensuring food security and nutrition security for all. To cope with the needs of the time, the existing agricultural policies have been updated, and the latest version is in the

National Agricultural Policy 2018. The foremost objective of the NAgP 2018 is to address the challenges of climate change, food security, and technological innovation, and to ensure compliance with national action plans and international accords. The policy's priority areas include strengthening seed systems, expanding irrigation efficiency and water-saving technology, developing hybrid and tolerant varieties, and cultivating high-value crops. The Ministry of Agriculture is entirely responsible for policy formulation and serves as an umbrella institution for other relevant agencies like DAE, BADC, BARC, BRRI, BARI, SCA, etc. (NAgP, 2018).

The significant features of the policy are food security and nutrition by producing cereal and non-cereal crops, vegetables, fruits, pulses and oilseeds, sustainable agriculture through conservation agriculture, integrated pest management and organic farming, climate change adaptation through tolerant variety development, development of research and extension by strengthening collaboration among research institutes, DAE and educational institutions. NAgP 2018 also emphasises the growth of agricultural markets, the participation of women in agriculture, and the private sector involvement.

Figure 24: The Significant Features of the National Agricultural Policy (NAgP 2018)

The policy identified the main obstacles to crop production in the coastal south and southwestern regions as the intrusion of salinity in soil and water. To address the challenges of coastal crop production, the introduction of salinity-tolerant crops along with sustainable agricultural technology is recommended.

National Water Policy (NWP) 1999

The National Water Policy (NWP) of Bangladesh was formulated in 1999 to ensure the proper management, development and distribution of the water resources in the country and to address the water-related challenges like floods, droughts, salinity intrusion and water pollution issues. Bangladesh is a riverine country with high dependence on water for agriculture, fisheries, livestock, domestic chores, navigations and industries. The policy aims to manage and ensure the best use of surface and ground water resources of the country proficiently and impartially. It emphasises sustainable development, poverty reduction, and environmental protection.

Figure 25: Key Objectives of National Water Policy

Key Objectives of National Water Policy (NWP)
Efficient Water Management
Equity and Social Justice
Food Security
Environmental Protection
Flood and Drought Management
Institutional Reform
Public Participation
Regional and Transboundary Cooperation

The several areas identified by the NWP are ensuring safe and adequate drinking water and sanitation facilities for all especially for the women, children, poor and communities of the vulnerable areas, promoting efficient irrigation practices for ensuring food security, maintaining ecological balance by preserving wetlands, combining structural and non-structural measures to mitigate flood risks, monitoring and controlling pollution to ensure safe drinking water, encouraging the community to involve in decision making and water management and strengthening and clarifying the roles of various agencies and departments involved in water management like Bangladesh Water Development Board (BWDB), River Research Institute (RRI), Department of Bangladesh Haor and Wetlands Development (DBHWD), and Water Resources Planning Organization (WARPO). The National Water Policy describe specific strategies to achieve its priority areas and clarifies the roles of the agencies involved in water resources management (MoWR 2019).

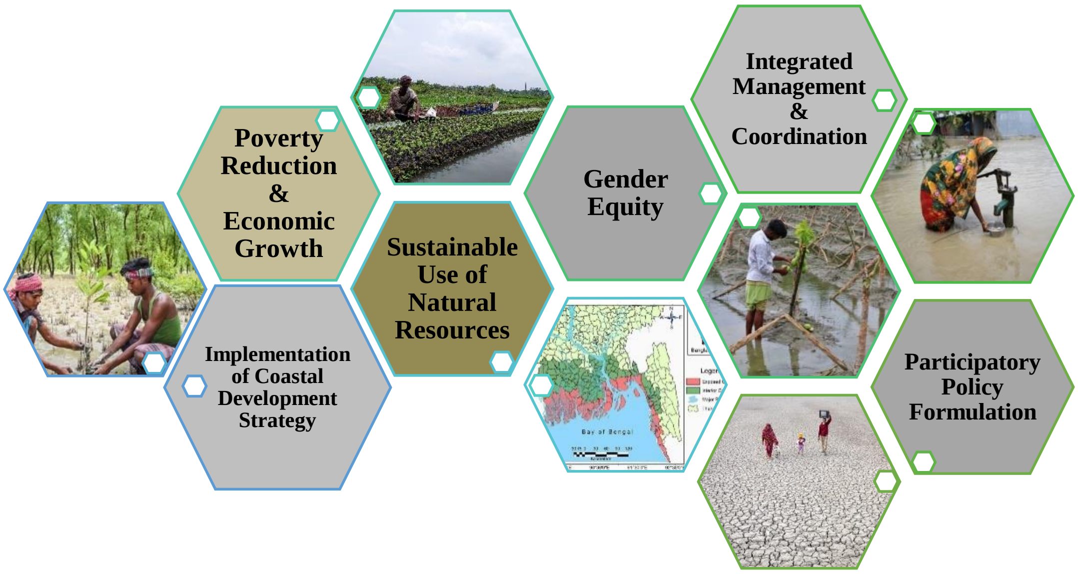
Figure 26: Focused Areas of National Water Policy 1999

Bangladesh Coastal Zone Policy (2005)

The Coastal Zone Policy was formulated by the Ministry of Water Resources and approved by the Cabinet in 2005. The policy thoroughly outlines the framework for coordinating the development and maintenance of coastal zones by government departments and agencies, non-governmental organisations, the commercial sector, and civil society. The policy's main objectives are to reduce vulnerabilities and achieve coordinated, sustainable development of coastal regions. The objectives of the Coastal Zone Policy are aligned with the national goals of achieving economic growth, poverty reduction and social development.

The strategy focuses on poverty reduction by promoting economic growth in the coastal zone and supporting local livelihoods through investments in enterprises such as agro-industries, tourism, shipbuilding, marine fisheries, shrimp/crab farming, and EPZs. In several crucial sectors, including education, health, energy, water and sanitation, agriculture, and biodiversity, the coastal zone is lagging. The policy provides direction for the sustainable use of natural resources, such as aquaculture, mangroves, capture fisheries, wetlands, land, agriculture, livestock, afforestation, water, and renewable energy, in order to satisfy the fundamental needs of the coastal community.

Figure 27: Key Areas of The Coastal Zone Policy



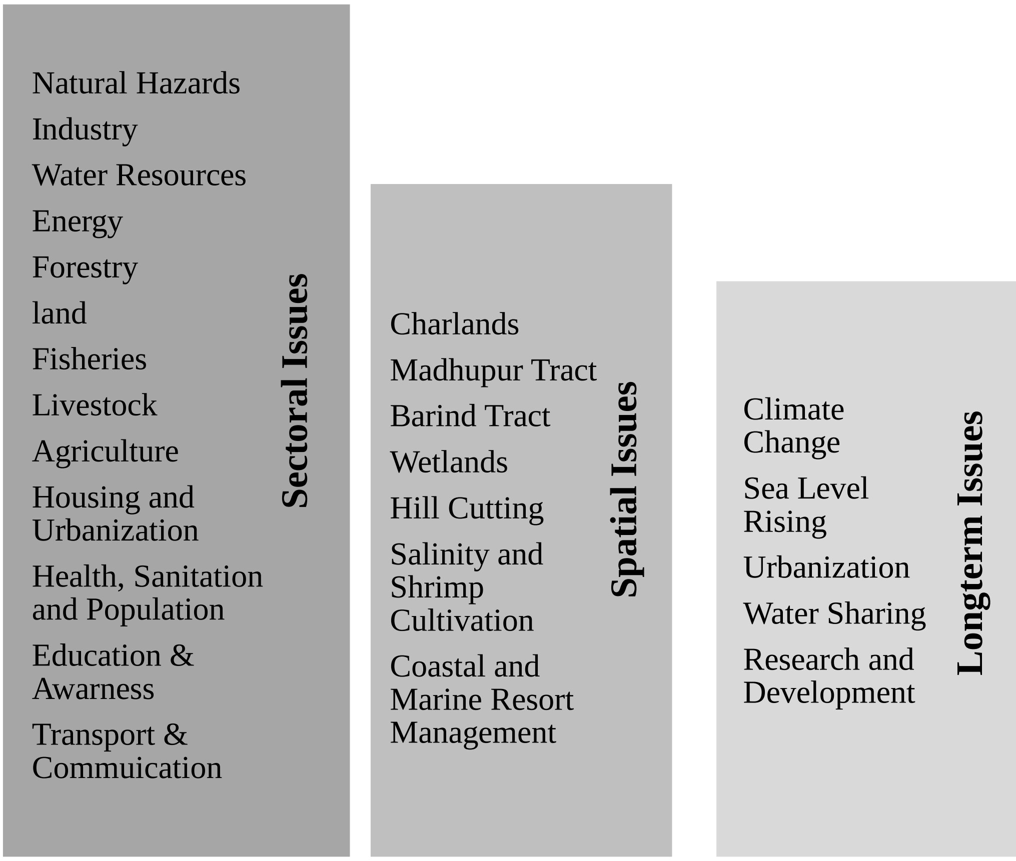
The measures adopted for consideration in CZP to harmonize and coordinate all development efforts in the coastal areas include: conservation and enhancement of critical ecosystems; equitable distribution of natural resources to the neglected and disadvantaged groups; investment in women's education, training, and employment to narrow gender gaps; equal participation of all stakeholders for mainstreaming coastal people; and integrated management and coordination of, enabling an institutional environment.

National Environmental Management Action Plan (NEMAP)

The National Environmental Management Action Plan (NEMAP) was formulated by the Government of Bangladesh in 1995 with the support of UNDP, WB and other partners. The plan was developed after the formulation of the Environmental Policy 1992 to integrate environmental concerns into all sectors of national development, ensuring sustainable development while reducing environmental degradation. It's a participatory plan involving inputs from communities, NGOs, experts, and government agencies.

The primary objective of NEMAP is to integrate development and the environment by ensuring that natural resources are not adversely affected by economic growth. The NEMAP highlighted several key problem categories, including: natural disasters and hazards such as floods, cyclones, riverbank erosion, industrial effluents, urban waste, air and water pollution, and sanitation; institutional and policy deficiencies; lack of coordination; inadequate enforcement of the law; and the degradation of natural resources, including deforestation, soil erosion, and biodiversity loss. The NEMAP selected thirteen sectors, seven spatial issues and five long-term issues. Each sector was the subject of a discussion on its sectoral strategy, major issues, and action plans.

Figure 28: Scope of NEMAP



The NEMAP has undergone several stages of preparation since 1992. Initially, national and international specialists were involved to determine which ecosystems and regions were most at risk and to work on priorities of sectoral issues. Later, all the stakeholders were involved in the consultation process. The NEMAP committee identified seven primary concerns, which are highlighted in the report: population, poverty, illiteracy, lack of afforestation, natural catastrophes, agrochemicals, water-related dangers, and lack of sanitation and drinking water and were divided into different concerned groups. Additionally, certain actors were identified to execute the committee's advice (Islam, 2012). NEMAP suggested that institutional development might be achieved by enhancing collaboration among the government, NGOs, and the private sector, as well as by strengthening the MOEF and the DOE. NEMAP aims to promote sustainable practices by mainstreaming the environment into agriculture, industry, energy, transport, and health, enhancing community-based management of natural resources and involvement in decision-making, and increasing environmental awareness and education through the implementation of media campaigns and curriculum development.

Donor Support and Climate Change Trust Funds

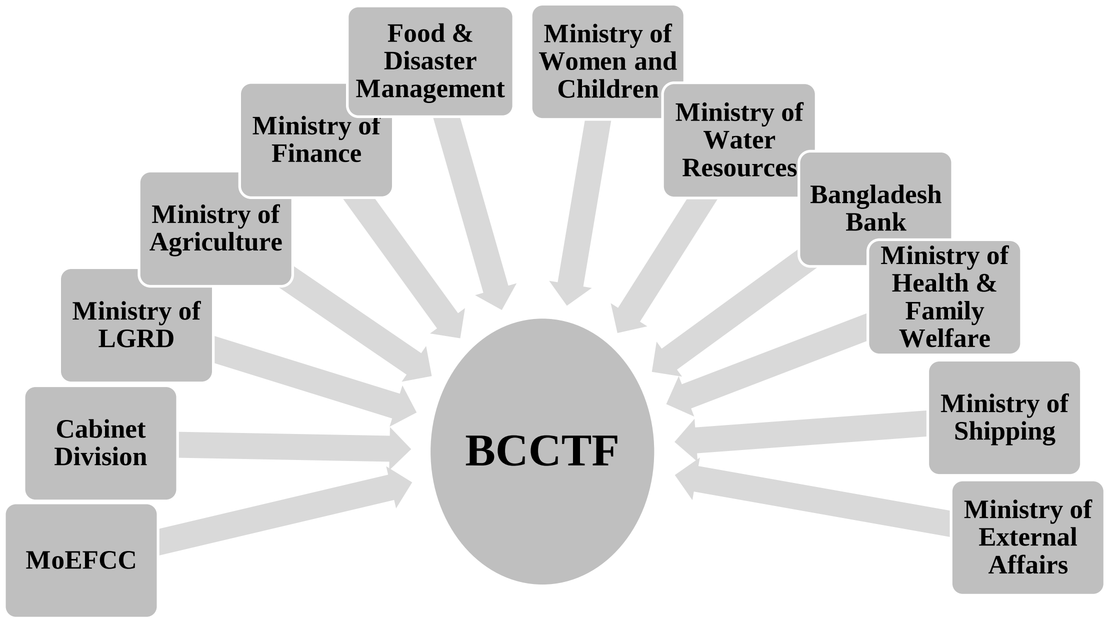
The Bangladesh Climate and Development Platform connects multiple global donors to facilitate climate investments. It is indispensable to sidestep donor support for climate change adaptation in Bangladesh. Bilateral and multilateral international donors are crucial for addressing the issues posed by inadequate domestic resources, as well as for offering sustained adaptation and technical assistance. Donor support significantly contributes to enhancing institutional capacity by offering financial assistance and technical knowledge. The Green Climate Fund has designated about forty million dollars for the development of flood-resilient infrastructure, whilst the BCCRF has secured approximately 170 million dollars from other contributors (UNDP, 2022).

Bangladesh Climate Change Trust Fund (2009)

Two dedicated financing mechanisms, the Bangladesh Climate Change Trust Fund (BCCTF) and the Bangladesh Climate Change Resilience Fund (BCCRF), were established by the government of Bangladesh in order to support the implementation of the action plans and to achieve the strategic goals of BCCSAP.

Bangladesh Climate Change Trust Fund (BCCTF) was established in 2010 by the government in Bangladesh under the Climate Change Trust Act 2010. The BCCTF is considered the key mechanism to implement the strategies and action plans of BCCSAP. The main objective of the BCCTF is to provide financial resources for adaptation and mitigation projects in line with the aims of BCCSAP and to build the resilience of vulnerable communities by reducing climate risks.

Figure 29: Institutional Arrangement for BCCTF



The BCCTF is funded entirely by the national budget of Bangladesh, and the fund is allocated by an autonomous body termed the Bangladesh Climate Change Trust (BCCT), established under the 2010 Act. The trustee board is chaired by the Minister of Environment, Forest and Climate Change (MoEFCC) and the technical committee, which evaluates project proposals, is headed by the secretary of MoEFCC. It mainly supported projects like the construction of cyclone shelters, embankments, coastal polders, climate-resilient agriculture, flood management and salinity control projects, capacity building, and renewable energy initiatives. It complements international funding sources such as BCCRF and demonstrates Bangladesh’s commitment to tackling climate change using its own resources.

Bangladesh Climate Change Resilience Fund (BCCRF)

Bangladesh Climate Change Resilience Fund (BCCRF) is established to support the implementation of BCCSAP by providing predictable, coordinated and long-term support for climate change adaptation and mitigation in Bangladesh, to reduce the vulnerability of communities and to complement the national financing with international support. The BCCRF is funded by several development partners, including the European Union (EU), the United Kingdom (UK), Sweden, Denmark, Switzerland, and USAID. The fund was managed through a partnership model involving the MOEFCC, as a part of the Government of Bangladesh, World Bank (WB), Palli Karma Sahayak Foundation (PKSF) and the Donor partners. The MOEFCC provided the overall leadership, and WB served as the trustee and administrator, managing financial flows and technical support, while PKSF implemented community-based adaptation projects for vulnerable groups. The BCCRF finances the projects aligned with the BCCSAP targeted areas.

The main objectives of the fund are to represent a unique global example of pooling climate financing in developing countries and to complement the BCCTF by bringing international resources to finance adaptation, mitigation and capacity building projects to strengthen Bangladesh's resilience to climate change.

Climate Change Trust Act 2010

The Climate Change Trust Act 2010 is the legal foundation of BCCTF to ensure transparency and accountability to institutionalise the climate finance to address the impacts of climate change. The Act is considered a significant action taken by the government to enhance the country's ability to respond proactively to climate threats. The enactment of the act established Bangladesh as a pioneer in climate finance legislation among developing countries and institutionalised good governance in managing climate finance through legal safeguards.

The purposes of the act are to provide a legal framework for mobilising, administering, managing and allocating the resources from the national budget to the climate-related activities and to institutionalise the governance, accountability and transparency in climate finance for climate change adaptation and mitigation. The act elaborately describes the aims of the BCCTF to make a necessary action plan and measures for adaptation, mitigation, technology development and transfer, capacity building and funds for the adjustments of the people or groups of people of the affected and vulnerable areas. As well as the act articulates the responsibilities of the Trust to initiate the funds for resilient plans and projects, climate research and technology, and to assist the focal point in different ministries and climate change cells. In addition, the act clearly articulates the constitution and the functions of the Board of Trustees.

Institutional Arrangements for Addressing Vulnerability of Climate Change

Climate change is engendering adverse environmental impacts in Bangladesh, and as a nation, Bangladesh is intended to implement adaptation policies like NAPA, BCCSAP to overcome the challenges of increased temperature, erratic and uneven precipitation, soil salinity, flood and drought. Institutions are considered the most important actors in the adaptation process, and the government play a vital role in building a platform for building adaptive capacities by interrelating the international guidelines and interrelated local actors, including public, private and societal institutions. Under these circumstances, agriculture in Bangladesh is severely affected by the impacts of climate change in terms of crop yield loss, decline of productivity, nutrient depletion, shifts in harvesting calendars, pest, disease, and insect outbreaks (World Bank, 2013; Amin et al, 2015; MoEF, 2009; Bates, 2008). Furthermore, agricultural production contributes approximately 11.02% to GDP, and nearly 44.42% of the total employed population in Bangladesh is engaged in agricultural activities (BBS, 2023). The sector has immense influence on the country's economic development and food security. In an effort to lessen farmers' vulnerability in agriculture, the government of Bangladesh has introduced several adaptation policies and action plans. The Ministry of Agriculture (MoA) is the key institution that plays a vital role in shaping climate adaptation in the agricultural sector in Bangladesh. Besides, the Ministry of Environment, Forest and Climate Change, and the Ministry of Water Resources have also developed agricultural adaptation action plans to cope with the vulnerabilities. Here is the list of institutions that directly and indirectly practice agricultural adaptation in Bangladesh.

Table 25: List of Public Institutions for Agricultural Adaptation

Name of the Institutions
1. Ministry of Environment, Forest and Climate Change (MoEFCC)
2. Ministry of Agriculture (MoA)
3. Bangladesh Agricultural Development Corporation (BADC)
4. Department of Agriculture Extension (DAE)
5. Department of Environment (DOE)
6. Department of Agricultural Marketing (DAM)
7. Agricultural Information Services (AIS)
8. Bangladesh Agricultural Research Council (BARC)
9. Bangladesh Agricultural Research Institute (BARI)
10. Bangladesh Rice Research Institute (BRRI)
11. National Agricultural Training Academy (NATA)
12. Seed Certification Agency (SCA)
13. Bangladesh Water Development Board (BWDB)
14. Bangladesh Krishi Bank

Role of Institutions in Adaptation

Nowadays, climate-adaptive agriculture is largely implemented by the temperature, saline and drought-resistant varieties, climate change resilient technologies, sustainable irrigation, climate information access, community awareness building and capacity building of the institutions. Boosting agricultural production and attaining self-sufficiency in food security, a well-trained and well-equipped manpower with developed physical infrastructure can play a vital role. The main objective of this section is to provide a brief description of the services provided by the different departments, research institutions and credit organisations to the climate-vulnerable areas for an effective agricultural adaptation.

Ministry of Environment, Forest and Climate Change (MoEFCC)

The Ministry of Environment, Forest and Climate Change (MoEFCC), formerly known as the Ministry of Environment and Forest, or MoEF, is a pivotal ministry of the government of Bangladesh, mainly responsible for the policy formulation on environmental conservation, pollution control, forest management, addressing climate change and its adaptation. It leads the discussions, planning, policy, and program development on climate change issues and takes the issue forward at the international level (Huq & Rabbani, 2011). The ministry was established on 03 August 1987 and was renamed on 14 May 2018. The ministry is a permanent member of the Executive Committee of the National Economic Council (ECNEC) and participates in international bodies like UNEP and leads Bangladesh by acting as the operational focal point to the UNFCCC and the Global Environment Facility. In 2010, the MoEFCC established the Climate Change Unit (CCU), which is in charge of coordinating the various climate change cells established within each ministry to help mainstream climate change across sectors as well as build capacity across government for climate change research, covering modelling and adaptation (Ayers et al., 2014). The CCU has now been replaced by the Bangladesh Climate Change Trust (BCCT), which helps to manage the Bangladesh Climate Change Resilience Fund (BCCRF) and the Bangladesh Climate Change Trust Fund (BCCTF).

The MOEFCC operates as the principal decision-making authority for policy issues and is responsible for the planning, evaluation, and coordination of action plan implementation. The ministry collaborates with other ministries to ensure that environmental issues receive appropriate acknowledgement in their development plans (Islam, 2012). The ministry comprises the Department of Environment (DoE), Forest Department, Bangladesh National Herbarium, Bangladesh Climate Change Trust, Bangladesh Forest Research Institute (BFRI), Bangladesh Rubber Board, and Bangladesh Forest Industries Development Corporation (BFIDC) (MoEFCC, 2020). The ministry, along with its departments and agencies, has been assigned for the conservation and development of forests, environments, and ecology, managing issues related to environmental pollution control, stimulating inter-institutional collaboration for sustainable development and climate governance, and coordinating with international organisations regarding treaties and agreements.

Mission and Vision of MOEFCC

In order to mitigate the effects of climate change, MOEFCC's main goal is to ensure a sustainable forest and environment. The mission of the institution is to guarantee a sustainable environment that is adequately habitable for current and future generations. It is essential to protect and conserve ecosystems and biodiversity, mitigate environmental pollution, address climate change risks, conduct botanical surveys, implement forest resource development activities, and pursue research across various sectors related to critical environmental issues.

Functions of MOEFCC

The function of the MOEF is endorsed by several laws to protect the environment, climate change and ecologically critical areas. The National Environment Policy 2018 was prepared by MOEF, and the Bangladesh Environment Conservation Act 1995 and Climate Change Trust Act 2010 are the key laws to establish the Bangladesh Climate Change Trust (BCCT). Aligning with the targets of SDGs, the action plans of the MOEF are intended to accomplish this. The Climate Vulnerability Index and Map preparation, community-based adaptation through coastal afforestation, adaptation initiative for offshore islands, and riverine char lands are the most focused arenas of action by MOEF, DOE and BCCT operate under the MOEF and are considered the focal points for activities such as adaptation and mitigation initiatives, capacity building, legal frameworks, and environmental issues.

The major functions delineated to MOEFCC are in the following way:

- Formulation and implementation of national environmental, forest, wildlife, and climate change policies
- Conservation, management, and sustainable use of forest resources and biodiversity
- Protection and improvement of the environment, including air, water, soil, and ecosystem quality
- Climate change mitigation and adaptation planning, including NAP and NDC coordination
- Management of protected areas, national parks, wildlife sanctuaries, and ecologically critical areas
- Oversight of environmental impact assessment (EIA) and environmental clearance processes
- Regulation and monitoring of pollution control through the Department of Environment
- Implementation of international environmental and climate agreements (e.g., UNFCCC, CBD)

- Promotion of afforestation, reforestation, and social forestry programs
- Research, data management, and environmental monitoring related to climate and ecosystems
- Capacity building, public awareness, and environmental education
- Coordination with other ministries and stakeholders on sustainable development and climate governance

Table 26: Projects of MOEF (Annual Report, MoEFCC, 2024)

Name of the Project	**Authority**
Strengthening Capacity for Monitoring Environmental Emissions Under the Paris Agreement in Bangladesh	DoE, January 2020 to December 2023
Pesticide Risk Reduction in Bangladesh	DoE, Ongoing
Building Climate Resilient Livelihoods in Vulnerable Landscapes in Bangladesh	DoE, Ongoing
Climate Change Adaptation in Vulnerable Coastal Regions and Char Lands	DoE, Ongoing

Ministry of Agriculture (MoA)

Ensuring food security and adapting the country's agriculture to the impact of climate change, the Ministry of Agriculture (MoA) plays a pivotal role. Agricultural production is highly vulnerable to rising temperatures, erratic rainfall, floods, salinity, and drought. The MoA leads a key initiative to build resilient agricultural adaptation. The ministry is responsible for shaping and developing sustainable agricultural policies, regulations and strategies, promoting agricultural technologies and coordinating research institutes, monitoring the implementation of agricultural projects, enhancing the skills and capacity of the officials and employees through training, coordinating with stakeholders, donor agencies and development partners. There are eighteen departments or agencies under the Ministry of Agriculture (MOA) working to ensure food security by promoting climate-smart agriculture, supporting crop resilience and agroecological research.

Department of Agricultural Extension (DAE), Bangladesh Agricultural Development Corporation (BADC), Bangladesh Agricultural Research Institute, (BARI), Bangladesh Rice Research Institution (BRRI), Bangladesh Agricultural Research Centre (BARC), National Agricultural Training Academy (NATA), Agricultural Information Services (AIS), Seed Certification Agency (SCA), Department of Agricultural Marketing (DAM), National Institute of Biotechnology (NIB), Cotton Development Board (CDB), Bangladesh Sugercrop Research Institute (BSRI), Bangladesh Jute Research Institute (BJRI), Horticulture Export Development Foundation (Hortex Foundation), Soil Resource Development Institute (SRDI), Bangladesh Wheat and Maize Research Institute (BWMRI), Barind Multipurpose Development Authority (BMDA) and Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN) are the agencies working on different sectors of agricultural development (MOA, 2023).

Table 27: The Major Projects under the Ministry of Agriculture (Annual Report, MoA, 2023)

Title	**Institutions**
Floating Vegetable Farming and Spice Production Technology Expansion Project as a Climate Change Adaptation Strategy in Flood and Waterlogged Areas.	MoA
Program on Agricultural and Rural Transformation for Nutrition, Entrepreneurship and Resilience (PARTNER)	DAE
Strengthening Research Activities in BINA	BINA

Flood Reconstruction Emergency Assistance for Agriculture (FREAP)	DAE

Department of Agricultural Extension (DAE)

In Bangladesh, the Department of Agricultural Extension (DAE) is considered the key government agency under the Ministry of Agriculture, overseeing the provision of agricultural consultancy and extension services to farmers across the country. In 1975, to strengthen the agricultural extension services and programs after independence, the government of Bangladesh established the Agricultural Directorate. Later, through the unification of the DAE, DA, Plant Protection Directorate, Horticulture Board, Tobacco Development Board, and Central Extension Resource and Development Institute (CERDI), the present Agricultural Extension Department was formed in 1982. At first, the DAE conducted the various training programs for farmers as a part of extension services from 1977 to 1990. Still, with the Agricultural Extension Policy (NAEP), DAE became one of the most important and well-planned bodies for effective, efficient, decentralised, location-specific, and comprehensive agricultural extension services to all types of Bangladeshi farmers in order to promote sustainable agriculture along with improving socio-economic growth (DAE, 2015).

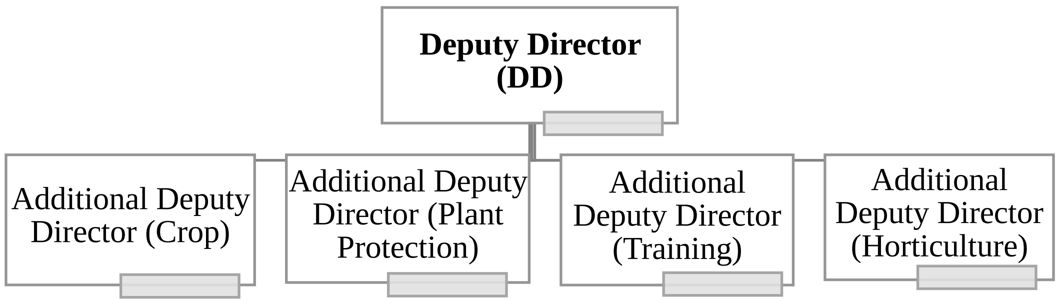
Mission and Vision of DAE

The Department of Agricultural Extension aims to provide environmentally sustainable, safe, climate-resilient agricultural practices that preserve natural resources, ensuring food security and promoting agricultural production in order in order to accelerate the country's socio-economic development. To ensure socioeconomic development, the Department of Agricultural Extension is committed to providing all types of farmers with efficient, effective, decentralised, location-specific, demand-responsive, and integrated extension services. These services will help farmers access and use better knowledge to increase sustainable and profitable crop production.

Staffing of DAE

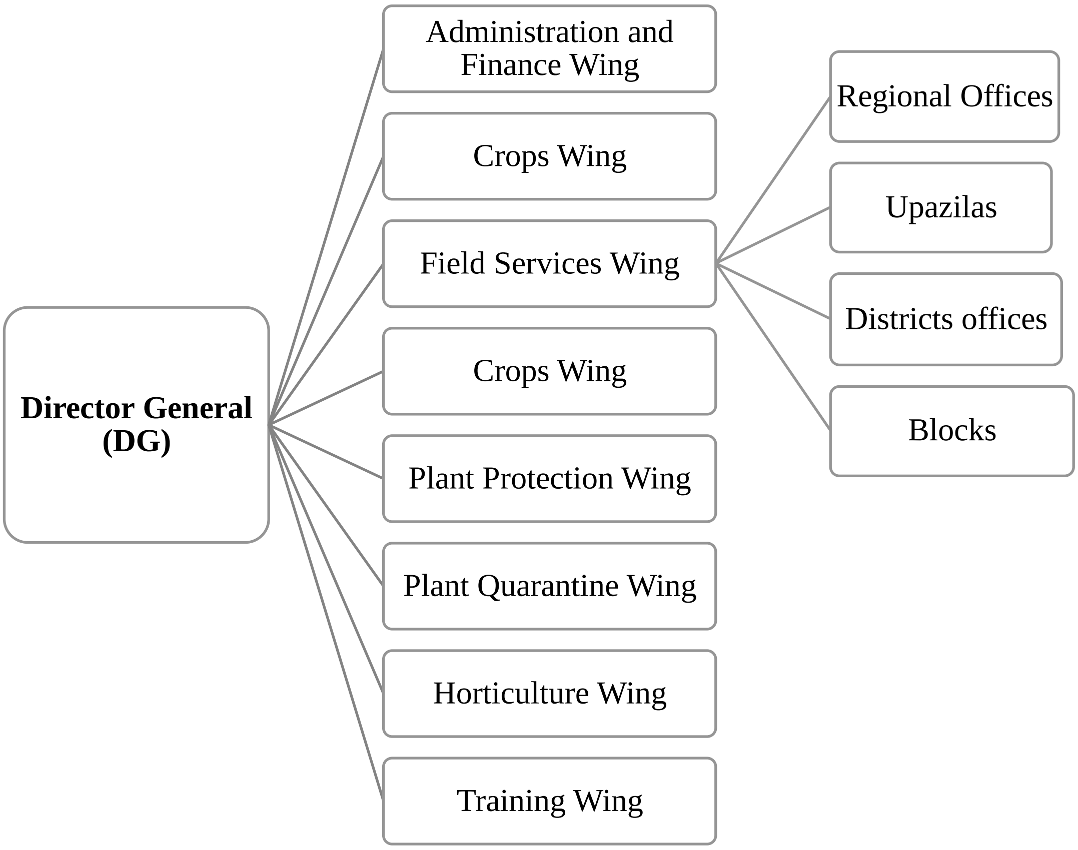
There are fourteen agricultural zones in Bangladesh at the regional level. They are- Dhaka, Mymensingh, Barisal, Faridpur, Khulna, Jessore, Rajshahi, Rangpur, Bogra, Dinajpur, Comilla, Sylhet, Chittagong, and Rangamati regions. The regional offices, headed by ADAEs, are responsible for administrative and technical support within the regions and collaborate with the research institutes and extension offices at the district level. There are sixty-four district Agricultural Extension offices in sixty-four districts, headed by the Deputy Director (DD).

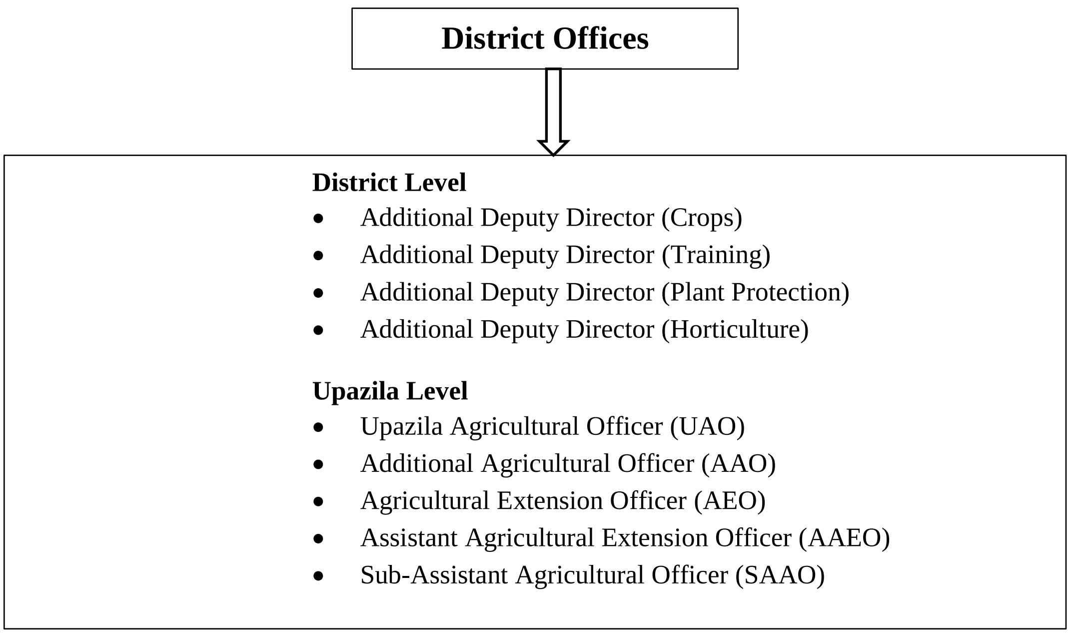
Figure 30: Structure of DAE (Annual Report, DAE, 2023)



DAE is mainly responsible for the conveyance of modern technologies and practices to farmers, providing technical support and training to the farmers and extension employees, promoting climate-smart technologies for sustainable agriculture, supporting crop diversification and integrated pest management, encouraging organic farming, coordinating with research organisations and educational institutions to bridge the gap that exists between field and research practice to expressively increase agricultural yields and secure food security. DAE has an exclusive field network with offices and personnel that ensures grassroots-level engagement with farmers. The main responsibility of the district office is to supervise the Upazila activities and monitor district-wide programs, and uphold coordination with the district administration and NGOs.

Figure 31: Different Wings of DAE (Annual Report, DAE, 2023)





Functions of DAE

The Department of Agricultural Extension (DAE) has a nationwide network of offices that deliver agricultural services directly to farmers, from the national to the union level. The DAE has block supervisors, or Sub Assistant Agricultural officers (SAAOs), at every station to provide information and services to farmers, issue pest or disease alerts, and organise group-based learning to ensure door-to-door services. One block supervisor serves almost fifteen thousand farm families in one or two blocks. The block supervisors mainly coordinate and are supervised by the Assistant Agricultural Extension officers (AAEOs) and by the Upazila Agricultural officers (UAOs). The Deputy Director (DD) at the district level is responsible for the supervision of Upazila activities and coordinates the district-wide programs with the district administration and NGOs working on agricultural practices. The Upazila Agricultural Officer (UAO) primarily provides local extension services in almost all Upazilas in Bangladesh. In addition, they are responsible for conducting farmers' training, field demonstrations, crop planning, and delivering information and advice.

- The department is mainly responsible for disseminating the modern, research-based agricultural technologies to farmers.
- Organising training programs for promoting sustainable farming practices
- The agency provides technical information and advice, offers seasonal crop calendars and ensures timely guidance for crop selection, planting and harvesting.
- It mostly encourages the high-value crops, vegetables and fruits and ensures the adaptation of tolerant variables.
- Assess the training needs of all levels of the department, and plan the training schedule and its implementation based on needs and time.
- The crop wing of DAE is responsible for planning and developing the cultivation and production of all field crops and assessing the usage of crop production technologies.

- The plant protection wing is largely responsible for performing the duties regarding pesticide registration and licensing, as well as quality control of the pesticides.

Figure 32: Functions of DAE (Annual Report, DAE, 2023)

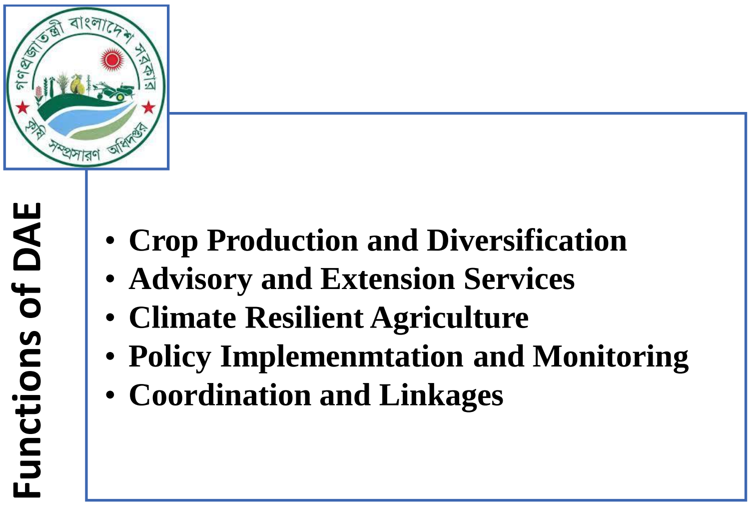


Figure 32:

- The main role of the field wing is to contribute to selecting the targeted crop production and taking necessary actions to achieve those targets. It also plays an important role in building a linkage among the farmers, extension work, research and educational institutions, market, and establishing a supportive environment.
- The department also prepares projects on climate-smart agriculture and disaster risk reduction.

Bangladesh Agricultural Development Corporation (BADC)

Under the Agricultural Development Cooperation Ordinance 1961, an autonomous corporate body under the Ministry of Agriculture (MOA), Bangladesh Agricultural Development Cooperation (BADC) was established in 1975. Before being renamed as Bangladesh Agricultural Development Corporation (BADC) in 1976, it was known as Bangladesh Agricultural Inputs

Supply and Services Corporation (BAISSC). The corporation is headed by the chairman, and the operations of the corporation are conducted by five different wings- Seed and Horticulture Wing, Minor Irrigation Wing, Fertiliser Management Wing, Finance and Administration Wing.

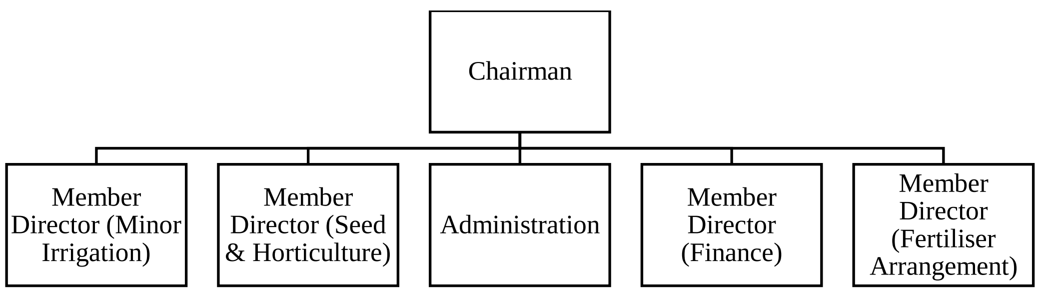
Mission and Vision of BADC

BADC aims to provide efficient irrigation management and quality agricultural inputs by providing high-quality seeds of different crops, developing the irrigation technology and supplying the best quality fertiliser. The corporation works to ensure enough production, procurement, transport, storage, and proper distribution of agricultural products (BADC, 2023).

Staffing of BADC

The **Bangladesh Agricultural Development Corporation (BADC)** is staffed through a multi-tier structure comprising Minor Irrigation, Seed and Horticulture, Administration, Finance and Fertiliser arrangements. At present, there are five specialised wings to implement the mandated functions of BADC in agricultural development. The corporation is headed by the chairman, and he is assisted at the headquarters by the member directors from the five wings. In total, 6800 (1700 officials and 5100 staff) personnel are working in BADC, among them 2044 in the minor irrigation wing, 3184 in the seed and horticulture wing, 316 in administration, 716 in finance and the remaining 540 in the fertiliser arrangement wing.

Figure 33: Departments of BADC (Annual Report, BADC, 2022)



Core Activities of BADC

The primary functions of BADC are seed development and supply. The principal activities of BADC comprise the following:

- The corporation produces, processes, preserves, and distributes quality seeds of rice, cereals, pulses, oilseeds, vegetables and other crops. It maintains the seed processing centres and ensures the availability of certified seeds to farmers. Through the Quality Cereal Seed Production Program in seed breeding farms in twenty-one Upazilas, the corporation produced 11344.31 metric tons of cereal seed in 2022, which achieved 96 per cent of the seed production target.
- Another key purpose of BADC is to establish and develop the irrigation system by establishing deep tube wells, low lift pumps, a canal irrigation system, buried pipes, dug wells and an Artesian well irrigation in hill tracts, a climate-resilient and renewable irrigation using solar energy, surface water and harvesting rainwater.
- In addition, the supply of fertiliser and the timely distribution of chemical fertilisers like urea, TSP, DAP to the farmers across the country is conducted by the BADC Fertiliser Management Wing.
- The corporation constructs and develops rural agricultural infrastructure and maintains warehouses, cold storages, water channels, rubber dams, hydraulic elevator dams, drips, portable irrigation, and AWD (Alternate Wetting and Drying) for minimising irrigation cost and improving the irrigation system.
- Apart from these, BADC provides several trainings, demonstrations and advisory services to the farmers on seed production, irrigation and use of non-nitrogenous fertilisers. In 2022, BADC produced 1315.77 metric tons of salinity-tolerant rice, 388.86 metric tons of drought-tolerant rice, 2827.17 metric tons of Submergence-tolerant rice, and 58.57 metric tons of salinity-tolerant oilseeds. An ecological park is established in Subarnachar, Noakhali, to address the impacts of climate change on crops and livestock (BADC, 2022).

- Making fertiliser available at the farmer level and controlling the market price of fertiliser by creating a buffer stock of non-nitrogenous fertilisers.
- Construction of various types of physical infrastructure to increase the use of surface water.
- Prevent waterlogging by re-excavating the canals to expand the area of cultivable land.
- Expanding the acquisition of irrigation equipment and its accessibility at the agricultural level;
- Improving irrigation efficiency, expanding irrigated areas and arable land, and offering irrigation services at affordable prices;
- Production, processing, storage, and distribution of seeds from stress-tolerant types, specifically species resistant to salinity, drought, temperature, and waterlogging.

Bangladesh Agricultural Research Institute (BARI)

The largest multi-crop research institute in Bangladesh is the Bangladesh Agricultural Research Institute (BARI), which has emerged as an autonomous research organisation under the Presidential Order No. LXII in 1976. The institution is responsible for conducting research on a wide variety of crops, such as cereal, tubers, pulses, oilseeds, vegetables, fruits, spices, flowers, etc. It mainly focuses on developing high-quality, improved and stress-tolerant varieties of different crops except rice, jute, sugarcane and tea, which have their specialised institutes to develop. The major part of the development work is based on soil fertility development, integrated crop management system development, water management and irrigation, development of farm machinery, and climate-smart agriculture. The institute is headed by the director general as the chief executive, along with the directors of four wings, such as the research wing, support service wing, training and communication wing and planning and evaluation wing. The research wing is largely responsible for executing and monitoring all the research programs through six regional research centres, seventeen research divisions, eight regional research stations, and twenty-eight substations. In addition, the institute produces breeder seeds for multiplication by the BADC and other private companies and operates the substations to test and adapt technologies for different agro-ecological zones.

- The mission of the Bangladesh Agricultural Research Institute is to improve agricultural productivity and effectiveness.
- Development of crop types that are economically satisfactory, ecologically adaptable, and produce high yields
- Advancement of innovative, sustainable agricultural production technology and identification of optimal cropping patterns.
- Develop sustainable agricultural pest management technologies
- Enhance agricultural mechanisation by innovation and the advancement of sustainable agricultural machinery.
- Develop sustainable technologies to mitigate post-harvest losses.
- Perform market management analyses on agricultural products
- Socio-economic advancement of the country via the dissemination of innovative varieties and technologies.

Bangladesh Rice Research Institution (BRRI)

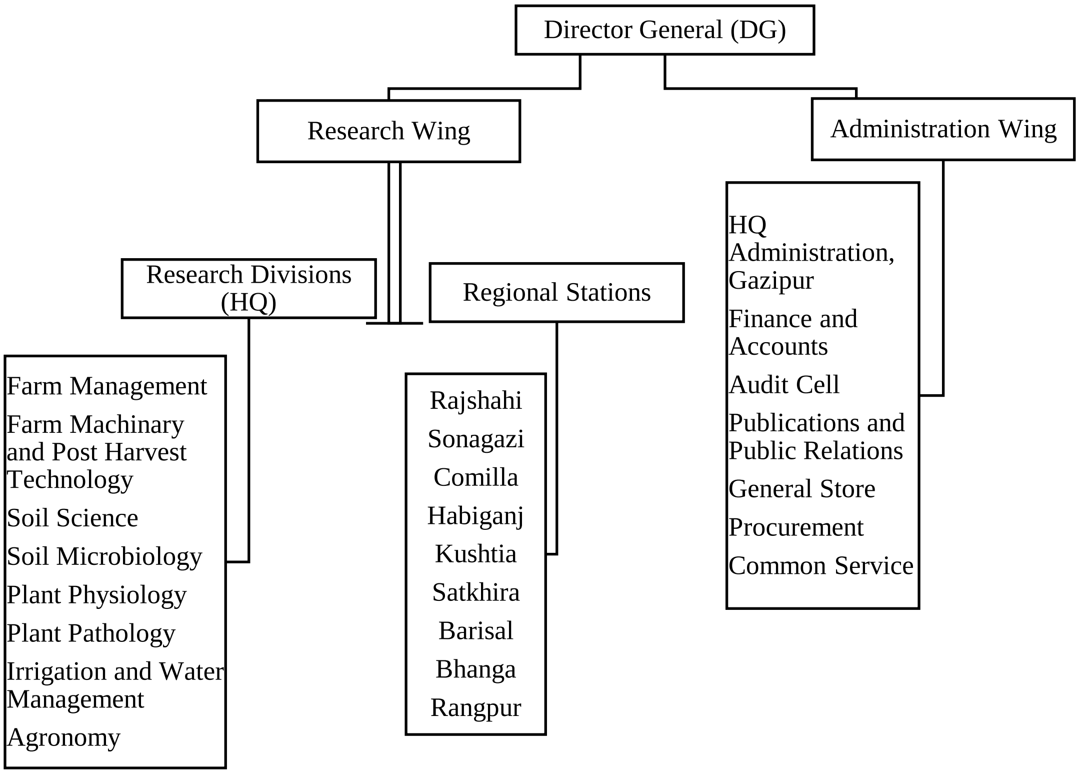
Bangladesh Rice Research Institution (BRRI) is a specialised institution for rice research development in Bangladesh, established on October 01, 1970. The institutions started their journey to eradicate the deficits of food and to ensure food security. BRRI is an autonomous body functioning under Act XIX, 2017, beneath the Ministry of Agriculture. It is part of the National Agricultural Research System (NARS), which is dedicated to improving rice production in Bangladesh. The major responsibility of the institutions is to conduct research for the development of modern high-yielding rice varieties and the dissemination of improved rice technologies to farmers for sustaining food security. The institute is headed by the Director General (DG) along with the directors of the research wing and the administration wing. The research functions are conducted throughout Bangladesh by nineteen research divisions and eleven regional stations. In recent years, BRRI developed the salinity-tolerant rice BRRI dhan 40, 41, 47, 54,57,73 and regenerated BRRI 86, 87, 89, submergence-tolerant BRRI dhan 51, 52, 79, drought-tolerant BRRI dhan 56, 57, 71, 75, cold-tolerant BRRI dhan 36, 37, 38, and heat-tolerant 64, 84 and improved their nutritional content as a part of the adaptive research program. The institution is working on the development of rice production through the water management and irrigation system development in the coastal areas and the haor areas.

Functions of BRRI

The principal activities of BRRI comprise the following:

- Perform an investigation of every aspect of rice improvement and production.
- Establish research institutes and substations across various regions of Bangladesh to investigate numerous problems related to rice.
- Conduct Training for agricultural extension personnel and progressive farmers on modern techniques of rice production;
- Establish locations for the exhibition of experimental rice varieties produced by the institute and for the training of farmers in their production.

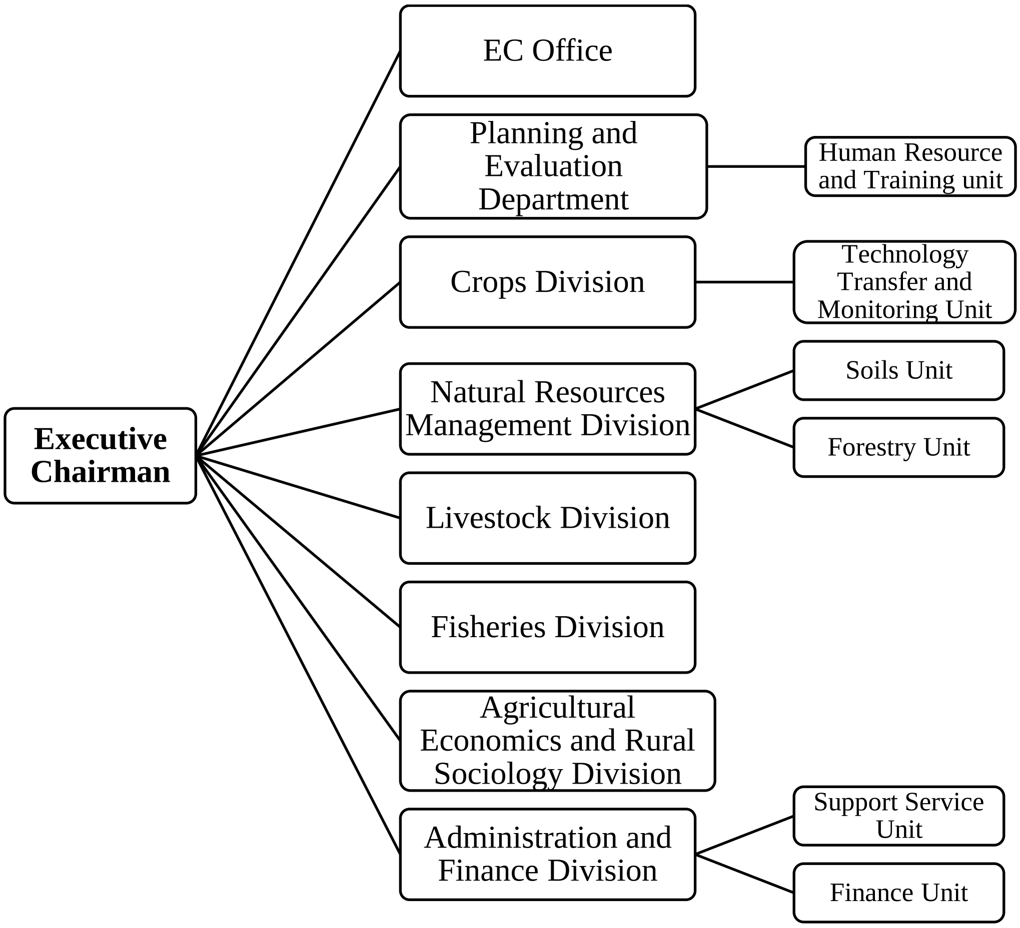
Figure 34: Structure of BRRI (Annual Report, MoEFCC, 2021)



Bangladesh Agricultural Research Centre (BARC)

Bangladesh Agricultural Research Centre (BARC) under the Ministry of Agriculture is considered the ultimate institution for the national agricultural research system was established in 1973 under the President's order XXXII of 1973. It is the parasol institution in agricultural development which is responsible for strengthening the national agricultural research capability through the coordination and integration of resources. It integrates the activities of 13 National Agricultural Research Institutions under NARS, such as BARI, BRRI, BFRI, BLRI, etc. The institution is responsible for preparing the national agricultural research policies and plans according to the national priorities, allocation of research funds to the institutions, conducting various trainings, and inter-institutional collaboration to ensure an effective, efficient and sustainable agricultural research system. In addition, the institution is developing client-oriented or demand-driven technology and software for both farmers and stakeholders.

Figure 35: Structure of BARC (BARC, 2023)



Objective and Functions of BARC

The mission of the council is to carry out research in the agricultural sciences and to collaborate with other relevant organisations in these fields. To accomplish the purpose of agricultural coordination, development and invention of a modern agricultural system, BARC categorizes the priority areas of agricultural research, formulates the essential plans, distributes the funds by evaluating the budget of all research proposals, coordinates with national agricultural research institutions and organizations of other countries for effective innovations and ensures the quality and effectiveness of agricultural research institutes by monitoring and evaluation process.

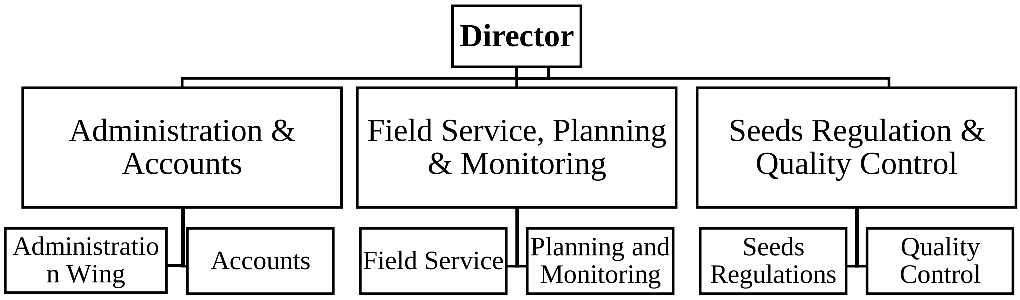
- Identify the areas of agricultural research based on the view of national agricultural policy and strategies.
- Advise the government regarding the challenges and opportunities in agricultural research and the effective use of external support in the agricultural sector;
- Examine and evaluate the budget for the research proposal and its execution process
- Monitor the transfer of agricultural technology at the field level and efficiently recommend to the relevant authority to remove the obstacles hindering the dissemination of research findings and technology and their application by the institutes and affiliated organisations.
- Undertake necessary steps to ensure that all employees and officers of the Council, Institutes, and Associated Institutes have the appropriate training and education in agricultural research and technology.
- Facilitate liaisons with agricultural research institutes or organisations from other countries to ensure the efficacy and applicability of their inventions and equipment in Bangladeshi agriculture through rapid evaluation, adaptation, and application.

Seed Certification Agency (SCA)

The Seed Testing Laboratory was established on 22nd January 1974, upgraded and renamed as the Seed Certification Agency in 1986 under the Seed Ordinance of 1977. Since then, the institution has been playing an important role in ensuring the quality control and certification of the seeds of notified crops. The mandate of the agency is to ensure that the seeds marketed in Bangladesh meet the prescribed standards for germination, physical and genetic purity, and seed health. It has seven regional offices and 64 district seed certification offices to operate the functions of seed certification agencies. According to the revised

Seeds Act 2018, the agency is responsible for seed testing and inspection for quality control of seeds of both public and private enterprises, advises the producers and the National Seed board (NSB) on disease and pest susceptibility, production, processing, quality control and collects information.

Figure 36: Structure of SCA (Provided by the Officer of SCA)



Objectives and Functions of SCA

The vision of SCA is to ensure the availability of quality seed. The agency provides seed certification services to stakeholders for the development and distribution of high-quality seeds and varieties resilient to adverse circumstances while enhancing market monitoring operations to assure the availability of quality seeds. The principal functions of the agency are:

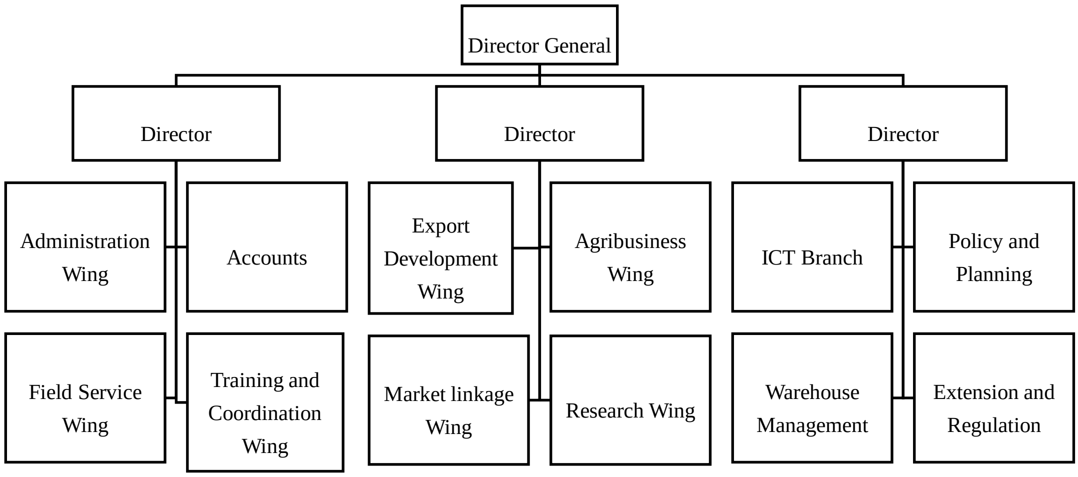
- Provide advocacy to the seed producers on production, processing and quality control of seeds
- Testing the seeds and inspection for the purpose of quality control of marketed seed.
- Certify the seeds of public and private enterprises, breeders
- Collect samples of labelled seeds and check their standard through appropriate tests.

Department of Agricultural Marketing (DAM)

Department of Agricultural Marketing is the core institution under the Ministry of Agriculture, which is responsible for agricultural marketing information management, formulation and implementation of agricultural pricing policy, and establishing rural and wholesale markets. The Department of Agricultural Marketing (DAM) was established in 1982 by reorganising the Agricultural Marketing Directorate. Together with three directors of three distinct wings for administrative, accounting, marketing, research, ICT, and field service operations, the department is headed by the director general. The institute has eight division offices, 64 district offices, fourteen training centres and four offices for regional managers.

The responsibility of DAM is to develop an efficient agricultural marketing system that is responsive to producers, merchants, and consumers, as well as agribusiness growth, in order to contribute to the national economy. The institute provides necessary information and support for creating market linkage and assists in value addition related to agricultural production. Connecting farmers with local and international buyers, DAM contributes to enlarging the domestic and global market for agricultural products.

Figure 37: Institutional Structure of DAM (DAM, 2024)



Objectives and Functions of DAM

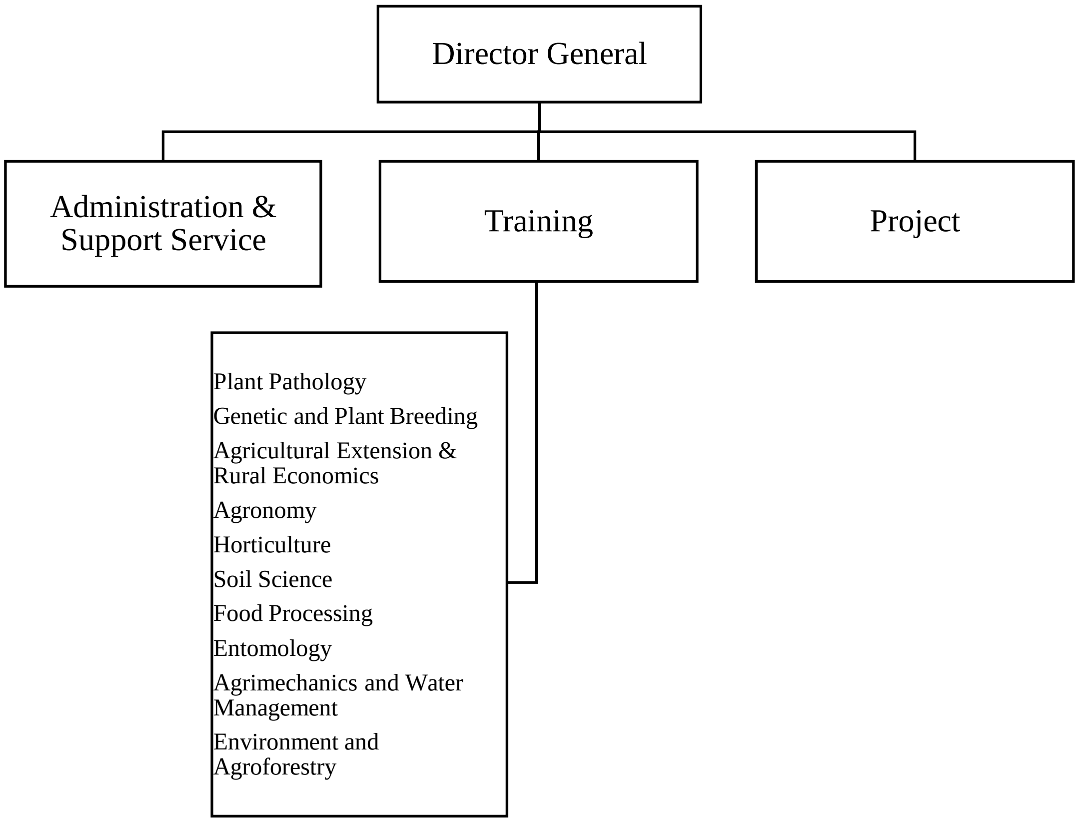
The DAM aims to strengthen the national economy by creating an effective agriculture marketing system and agribusiness growth that is beneficial to producers, traders, and consumers. Agricultural marketing involves managing marketing information, setting pricing policies, and developing agribusiness strategies. Its main goals include forming market linkages, conducting economic research, and modernising marketing systems by collaborating with farmers and traders. Key efforts focus on improving market infrastructure, managing storage conditions, and ensuring product quality, along with price determination, promotion of agro-based industries, and monitoring marketing practices. Registration and oversight of agricultural organisations, along with compliance with government directives, are crucial for effective marketing operations. For maintaining the quality and standards of agricultural products, the institution supports and strengthens the construction and management of market infrastructure, warehouses, cold storage, cool chambers, etc. The department is creating many agricultural entrepreneurs by providing several grants for processing machinery and transport, which has a great contribution to creating employment opportunities. The information regarding production, supply, demand, processing, storage, exports, market management and price of essential commodities is regularly provided by the institute through radio, television, newspapers, messages and e-marketing apps.

- It mainly focuses on the effective development, implementation, and marketing of agricultural products
- The key actions include fostering relationships among farmers, traders, and processors to enhance supply chains, conducting financial research, and extending modern marketing systems.
- It emphasises the establishment of essential marketing infrastructure, such as cold storage, cool chambers, and warehouses for strengthening market management.
- The management also involves monitoring product quality and pricing, ensuring reasonable minimum prices, supporting value-added processing, and facilitating both internal and export markets for agricultural goods.
- It encourages the establishment of agricultural business organisations and cooperative societies while overseeing compliance with quality standards and governmental responsibilities.

National Agricultural Training Academy (NATA)

The National Agricultural Training Academy (NATA) was established in 1975 as a part of agricultural training and initiatives. The academy was originally founded as the Central Extension Research Department (CERDI), which was renamed in 2013 and converted into the only national training academy under the Ministry of Agriculture. NATA campus is situated on 49 acres of land in Gazipur. The academy is established to serve as a centre of excellence for training agricultural professionals, policy makers, extension employees and farmers. Several training programs, capacity building sessions, and workshops related to modern agricultural technologies are organised and provided by NATA for human resource development and innovations. The most common programs are related to advanced training on GIS, remote sensing, smart agriculture, language skills, project management, etc. The academy collaborates with domestic and international institutions for research, education, agricultural extension, and Agri-support technologies for capacity development. Sixteen public and autonomous institutions, such as DAE, BADC, BARI, BRRI, BARC, DAM, BIRTAN, BINA, BJRI, BWMRI, SRDI, BSRI, BMDA, CDB, AIS, and SCA under the Ministry of Agriculture, are the core stakeholders of NATA.

Figure 38: Departments of NATA (MoA, 2012)



Objectives and Functions of NATA

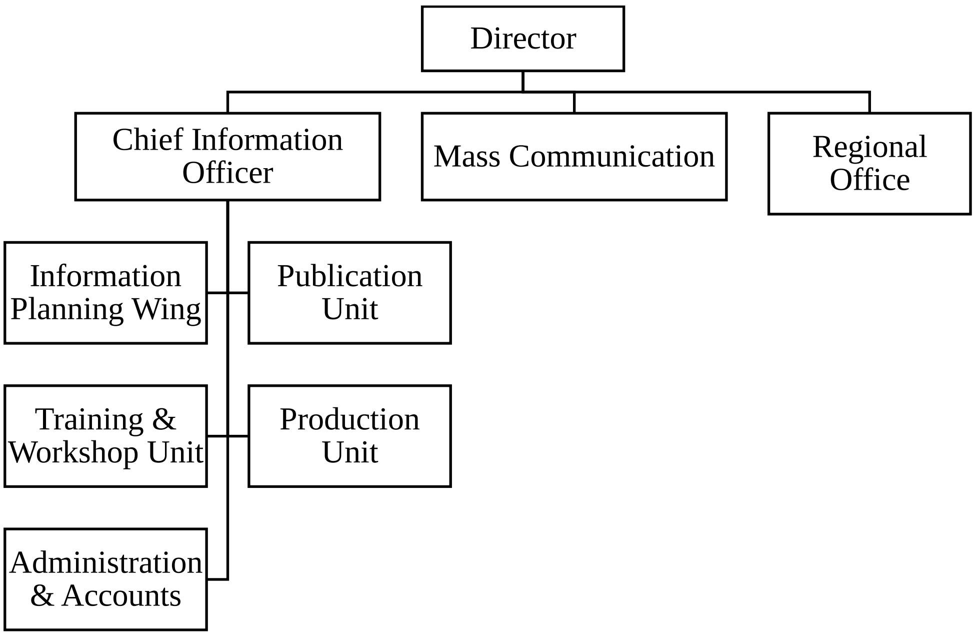
- Provide foundation, refresher, and advanced training for agricultural extension officers and other professionals under the Ministry of Agriculture.
- Enhance the technical, managerial, and leadership skills of officials involved in agriculture, irrigation, and rural development.
- Coordinate with DAE, BADC, research institutes, universities, and development partners for integrated training programs.
- Organise workshops, seminars, and conferences; document and share lessons learned.
- Facilitate foreign training, study tours, and collaboration with international organisations (MoA, 2020; BARC, 2023)

Agricultural Information Services (AIS)

Agricultural Media Services (AIS) was established in 1985 as a focal media point of the Ministry of Agriculture for collecting, processing and disseminating information on agricultural knowledge to stakeholders to ensure food security and sustainable farming practices. The main target of the institution is to collect and disseminate agricultural information and technologies to the doorsteps of farmers, extension employees, researchers and policy makers using print, electronic and ICT-based mass media. Farm Magazine and a monthly news bulletin like Krishikotha, Samprosharon Barta, leaflets, posters, folders, festoons, etc., play a dynamic role in broadcasting agricultural information. For sending early warning, a GIS-based geo data analysis system is developed in the context of smart agriculture. The institution is providing immediate professional solutions to the farmers through the Krishi Call Center-16123 and has developed a large web portal 'www.ais.gov.bd', two mobile apps, ten ICT labs in ten agricultural regions and eleven information kiosks.

The Agricultural Information Services (AIS) functions as a specialised wing under the Department of Agricultural Extension (DAE) and operates through a central office in Dhaka and seven regional offices in Rajshahi, Khulna, Chittagong, Sylhet, Mymensingh, Rangpur, and Pabna. The activities are directed by the National Agricultural Policy, 2018 and ministerial regulations. The regional offices mainly collaborate with the local administration and other agricultural fields and research institutions, NGOs, and private organisations.

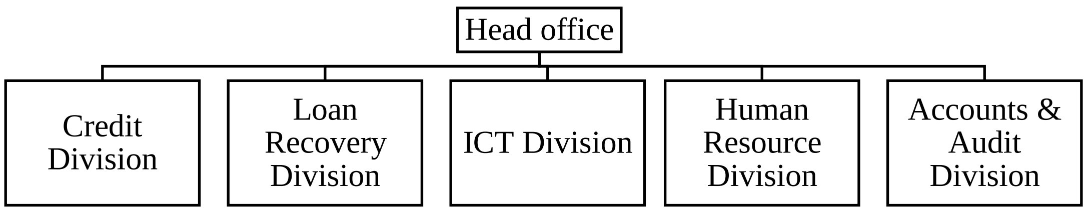
Figure 39: Structure of AIS (Annual Report, AIS 2023)



Bangladesh Krishi Unnayan Bank

Bangladesh Krishi Bank (BKB) is one of the largest state-owned specialised banks under the Ministry of Finance, and was established in 1973. The purpose of the bank is to provide credit and financial support to the agricultural sector, particularly for small and marginal farmers, to combat the climate-dependent uncertainties with the aim of increasing productivity and economic growth. With all sorts of commercial banking activities, including deposits, loans, and foreign exchange, the bank finances crop cultivation, irrigation, farm machinery, fertilisers, seeds, fisheries, livestock, poultry, forestry, marketing, and agro processing. With over a thousand branches mostly in rural areas, the bank provides more than 80% of its loans dedicated to agriculture and rural development.

Figure 40: Divisions of BKB (Provided by the Respondent)



Objectives and Functions of BKB

The primary objective of BKB is to provide loan facilities for achieving self-sufficiency in food production and strengthening the rural economy. In addition to providing banking services at people's doorsteps, offering loans for agriculture, small and medium enterprises, and agro-based industries to attain self-sufficiency in food production and eradicate poverty. The bank functions under a board of directors headed by the chairman and directors and operates by credit division, loan recovery division, ICT division, accounts and audit division and human resource division. The core activities are-

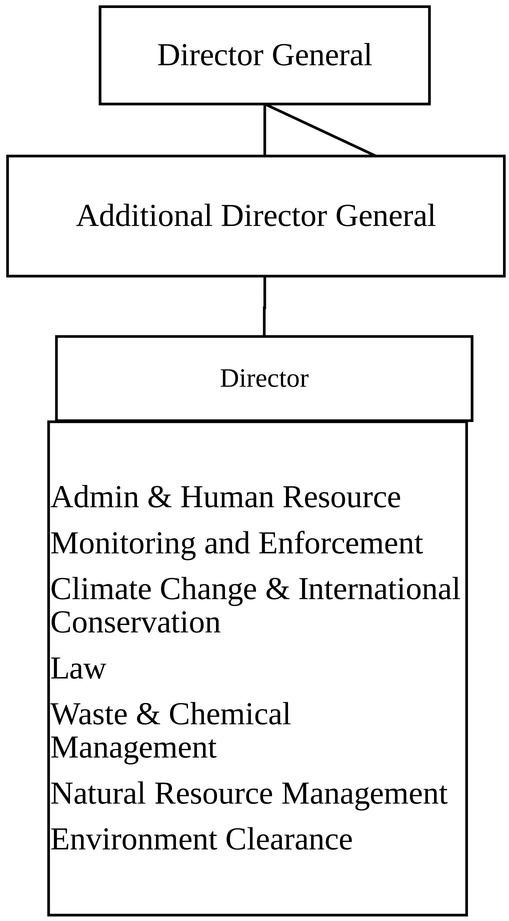
- Distribution of loans for agriculture, fishery, livestock, agricultural equipment, crop storage and marketing, poverty alleviation, agro-based businesses, and the climate change and small and medium enterprises sectors.
- Offering of several deposit schemes, including Current, Savings, SND, and term deposits.

Department of Environment (DOE)

The Department of Environment (DOE) is the key government agency that works to protect the environment and controls pollution for sustainable development. The department was established in 1989 under the Environmental Conservation Act, but its roots trace back earlier. The department is responsible for monitoring of air, water, soil and noise pollution and enforcement of emission and effluent standards. Issuing the environmental clearance certificates for industries and projects, and identifying the polluting industries, encouraging them to take necessary measures in pollution control through instructions, the department tries to regulate environmental pollution (Islam, 2012). The Department of Environment (DOE) acts as the frontline regulatory body for ensuring environmental conservation, protection, pollution control, environmental health, urban green progress, and protecting the Ecologically Critical Areas (ECAs) under the Environment Conservation Act 1995. The department provides advisory roles, enforces environmental laws and regulations, issues environmental clearance certificates for industrial and development projects, conducts environmental impact assessment, monitors air, noise and soil pollution and enforces emission standards (DOE, 2023).

The department has the authority to handle the polluters, to create public awareness, and to take legal actions against the violators by the enforcement of laws, acts, and rules. The Environment Policy 1992, NEMAP 1995, the Environment Conservation Act, 1995 are the supporting acts and rules of the activities of the departments. Along with the directors, the department is headed by the director general.

Figure 41: Structure of DoE (Web Portal, DoE)



Functions of DOE

The principal activities of DOE are-

- The institution is responsible for analysing the surface and groundwater quality, ambient air quality, and industrial wastes.
- Identify the polluting industries and encourage them to implement the requisite pollution control measures.
- Issuing environmental clearance to industries by assessing their impacts on the environment.
- Assesses pesticide residues and quantifies heavy metal concentrations in various surface water bodies.
- The work provides a follow-up to several international summits and conventions.
- Facilitating local seminars, conferences, workshops, and training programs addressing different environmental challenges.

Bangladesh Water Development Board (BWDB)

In the development of the water sector in Bangladesh, the Bangladesh Water Development Board (BWDB) plays a significant role across the country. The Bangladesh Water Development Board (BWDB) is a fully autonomous institution under the Bangladesh Water and Power Development Boards Order, 1972. The board is functioning under the National Water Policy 1999 and the Bangladesh Water Development Board Act 2000. It is responsible for planning, development, and management of water resources, as well as ensuring sustainable development by improving drainage systems, controlling floods, and managing irrigation and rivers. One of the most important determinations of the institution is to ensure food security and alleviation of poverty by addressing the impacts of climate change in coastal regions. Flood control and developing drainage systems by establishing and maintaining the polders, embankments, canals, and sluice gates constitute the primary function of BWDB. It also designs, constructs and maintains the irrigation to manage flood waters in the coasts. Based on the water resource planning of the government, the board works on addressing riverbank erosion, dredging, and upholding waterways for navigational stability.

Moreover, the board also formulates and implements the water sector initiatives aligned with national policies and laws, with cross-country water management policies and regulations, and collaborates with other domestic institutions for effective coordination. It also assists in drought, flood forecasting and warning systems, as well as conducts surveys, studies, and research for water resource development.

According to the Bangladesh Water Development Board Act, 2000, the board will be governed by a governing council which is headed by the Minister of Water Resources, including key persons from environment, finance and local government, professional experts, NGOs, University representatives, and the DG of the board. The governing council is mainly responsible for making major policy and operational decisions, overseeing overseas projects, and ensuring institutional autonomy. The activities of the board are functioned by the Director General (DG) along with the directors and additional directors of several divisions. Most of the regional offices are managed by the executive engineers and other technical and administrative staff.

Functions of BWDB

The mission of BWDB is to address the negative impacts of climate change in accordance with integrated coastal management, control flooding through strategic planning, develop drainage and irrigation systems, prevent river erosion, reclaim salinised land, manage food security, alleviate poverty, and manage water-related disasters; increase public engagement by encouraging active participation in integrated water resource management.

- Development and establishment of flood Control and drainage System (FCD)

- Construct, operate, and maintain embankments, regulators, sluice gates, canals, and hydraulic structures
- Coordinate with government agencies and stakeholders in integrated water resources management (IWRM)
- Manage surface water resources for agriculture, navigation, and salinity control
- Support coastal protection through polders and cyclone/flood risk reduction measures
- Provide technical support for river training, erosion control, and sediment management.

Conclusion

The Climate Change Adaptation is strongly influenced by national policy provisions, institutional frameworks and donor support for resilient buildings and adaptation initiatives. National policies, including BCCSAP, NAP, NAgP, and NEMAP, provide a strong strategic foundation for resilience, capacity building, and institutional arrangements for effective adaptation. Furthermore, the institutional setup, like BCCTF and BCCRF, reflects the establishment of domestic leadership to climate change adaptation with international donor support. However, the challenges of weak coordination, limited knowledge, inadequate resources, and occasional misalignment between donor priorities and local needs constraints overall effectiveness. From policy perspectives, Bangladesh has achieved notable progress in mainstreaming climate change adaptation into national development mandates and action plans. Nevertheless, the structural challenges, institutional fragmentations, financing gaps, limited coordination among agencies, and capacity constraints often reduce the efficiency of the adaptation initiatives.

Chapter Six

Major Findings of the Study

"Climate change is the single greatest threat to a sustainable future, but at the same time, ***addressing the climate challenge presents a golden opportunity*** *to promote prosperity, security and a brighter future for all."*

Ban Ki-Moon,
Former Secretary-General of the UN

Chapter Summary

The purpose of this chapter is to discuss the findings of the research and analysis based on the research questions and objectives. Government initiatives undertaken to address the impacts of climate change on agriculture and the institutional capacity index for three different categorised institutions are taken into light in this chapter. The criteria needed to be considered to increase the capacity are identified as well.

- ***Demographics of Sample***
- ***Analysis of Questionnaire results***
- ***Analysis of Interview Data***
- ***Summary of Findings***
- ***Chapter Summary***

Introduction

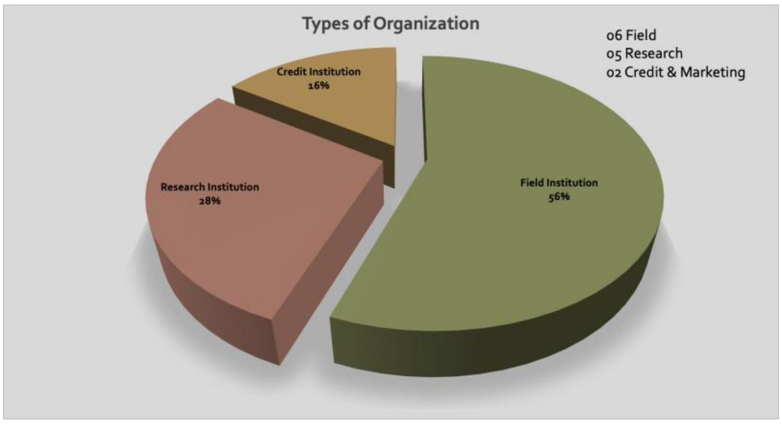
In this Chapter, the findings of the research are presented and analysed to address the research questions and objectives outlined in Chapter One. It begins by presenting the findings and analysis of each research question, followed by presenting the major findings addressing the broad objectives of the research. This chapter contains the results of the grounded theory methodology study conducted to answer the research questions mentioned in Chapter One. This part of the research is devoted to analyzing the collected information from primary and secondary data sources to achieve the objectives of the study which are to assess the capacity of public institutions, to comprehend policies and strategies in institutional plans and activities to engage stakeholders to adapt to climate change, to monitor and evaluate their progress and to implement the climate change adaptation approaches in the agricultural sector of coastal districts in Bangladesh.

The primary objective of the study, as stated in Chapter One, is to assess the capacity of public institutions (Field, Research, and Credit organisations under the MoA) for climate change adaptation in the agricultural sector of the coastal districts in Bangladesh, and the study consists of four separate specific objectives as such, this chapter presents the findings along with their description. At first, the chapter discusses the current climate vulnerabilities in the study area and their impacts on agricultural production. Secondly, the measures taken by the institutions working on agricultural adaptation are presented. Thirdly, the outcomes of the Institutional Capacity Index for 3 different categories of institutions are presented. To attain these objectives, key data from documents, questionnaires, and interviews with experts, employees, project directors, and senior management team members of the organisations are collected. This section presents and discusses the data collected through semi-structured questionnaires, interviews, physical observations, and document reviews.

Characteristics of the Respondents

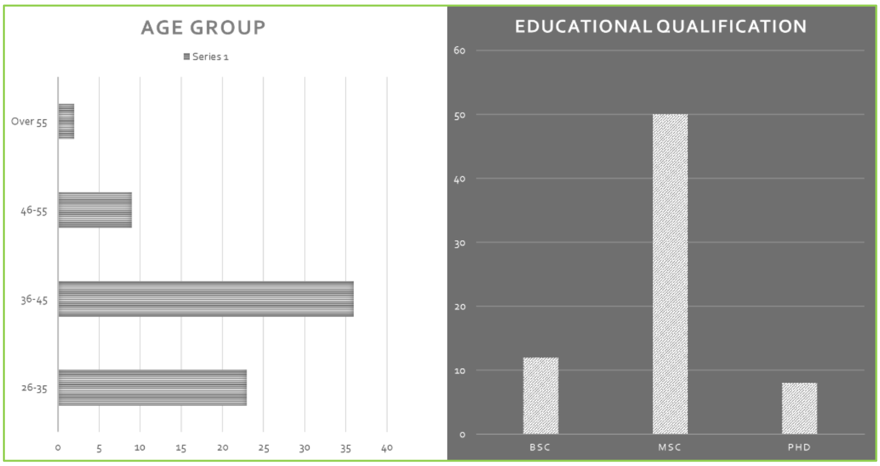
Table 01 indicates that 56 per cent of the respondents are affiliated with institutions related to public sector departments and cooperation, 28 per cent with research institutions, and 16 per cent with credit and marketing institutions.

Figure 42: Types of Institutions



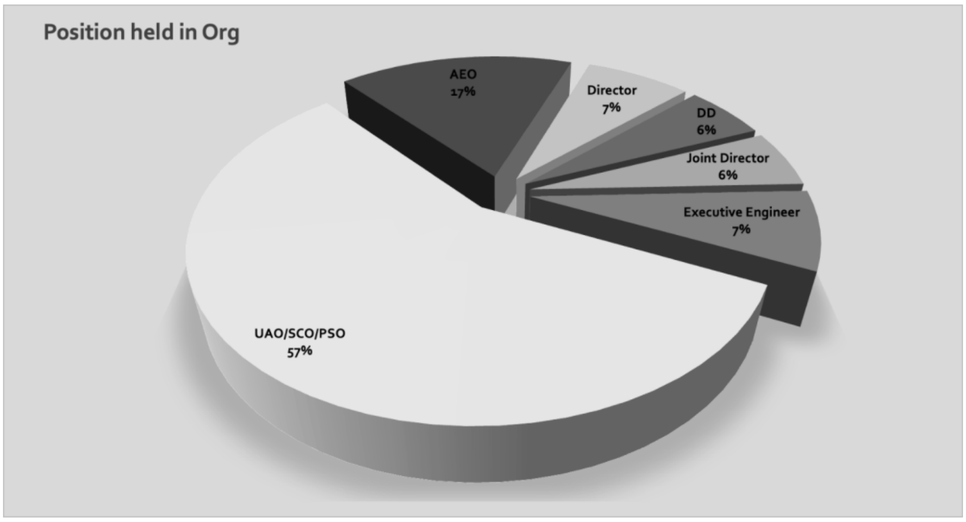
When we look at the respondents' educational backgrounds, we find that seventy-one of them have an M.Sc. degree, seventeen per cent have a B.Sc. degree, and twelve per cent have a PhD. All of the respondents held a first degree or higher, according to the data collected.

Figure 43: Age and Educational Qualification of Respondents'



Concerning work experience, 57 per cent of the respondents are working at the field level of the institution as UAO/SCO/PSO, and 17 per cent of the respondents are working as AEO and have served their institutions for more than 5 years. Regarding work experience, 6 per cent, and 7 per cent of the respondents are directors, DD, PD, Joint Directors, and Executive engineers respectively, and have served the institution for more than 15 years.

Figure 44: Respondent Distribution Across Organisational Positions

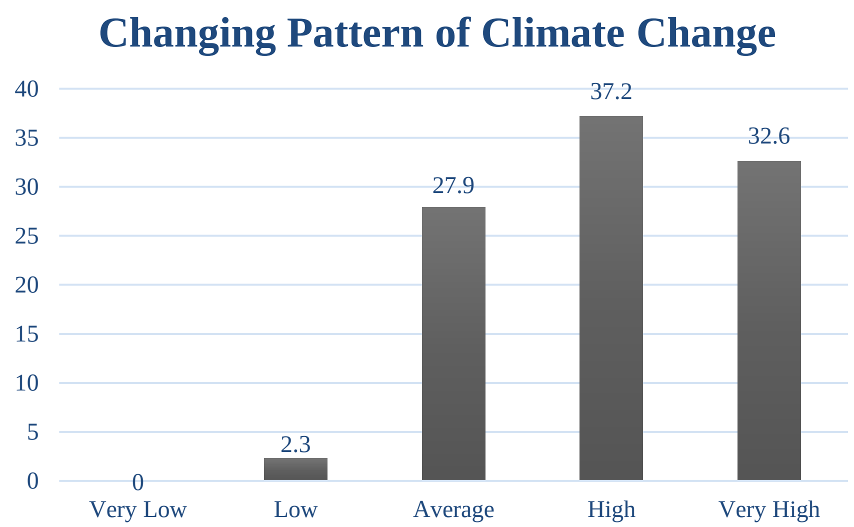


Climate Change and Its Impact on Agriculture: An Institutional Perspective

In Bangladesh, public institutions are considered pivotal in promoting agricultural adaptation and resilience, especially in the face of climate change and other environmental challenges. The Ministry of Agriculture (MoA) plays a central role in shaping the agricultural sector's development, sustainability, and resilience, which focuses on research, policy formulation, financial assistance, extension services, infrastructure, and international engagement. Public institutions under the MoA are regarded as significant benefactors in irrigated agriculture, including advising, financing, and marketing services; researching climate-resilient crop varieties; coordinating agricultural research and policy recommendations; providing information and training on farming methods; surface irrigation; managing water on farms; controlling pests and diseases; conserving resources; and more.

Regarding the observation of changes in the climate of the coastal area, the majority of the office conveyors who have firsthand involvement with the crop production process reported significant changes in temperature, irregular rainfall, sea level rise, shifting rainfall patterns, prolonged summer season, coastal flooding, and cropping season expansion over the last few decades. The respondent provides ratings on various aspects of changes in climate patterns observed in coastal areas. The scores range from one (very low) to five (very high). Regarding alterations in weather patterns, the coastal area's climatic changes were rated *highly* by 32.6 per cent of respondents, while 37.2% of office bearers thought that climate change had a *very high* impact on crop production. Based on these results, respondents seem to think that climate change is posing serious challenges to the production process, such as frequent and intense disruptions, significant financial losses, and substantial operational challenges. Notably, more than 27.9% of participants provided *mediocre* evaluations.

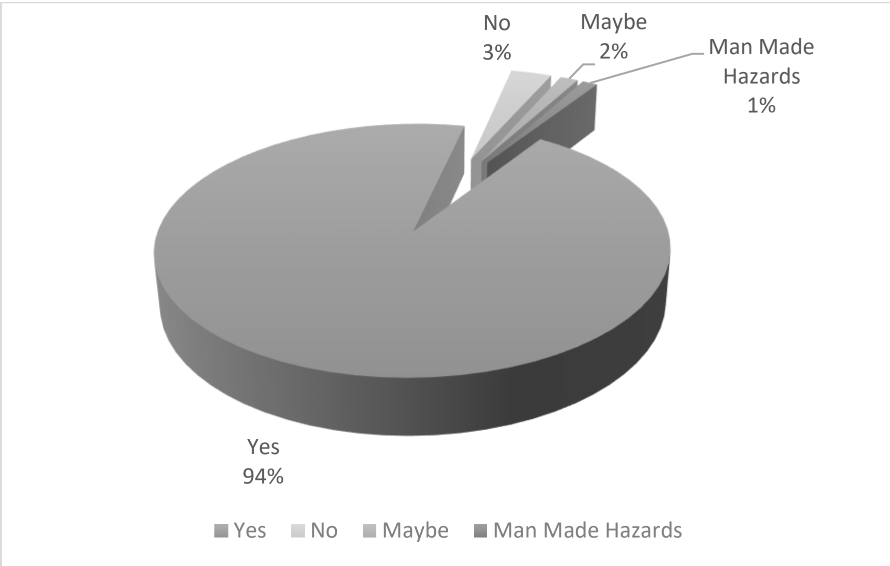
Figure 45: Respondents' Perceptions on Changing Patterns of Climate Change



A change in the climate pattern has a great impact. on crop production, especially in coastal areas in Bangladesh. Nearly 94.7 per cent of participants concur that climate change in coastal areas is having a tangible impact on crop production caused by various climate-related factors such as increased temperature, altered rainfall patterns, extreme weather events, and rising sea levels. Conversely, only

3% of participants think that technological advancements and the advent of several crop varieties that are climate-resilient contributed to increased productivity despite the detrimental impacts of climate change on coastal agriculture. Nevertheless, just 1% cite man-made hazards (disregard for sluice gates or dams, or their malfunction) as a primary source of productivity impediments.

Figure 46: Respondents' Opinion on Climate-Induced Production Impacts



Remarkably, substantial temperature escalation and precipitation pattern changes are observed. More specifically, nearly all respondents said that the three most notable changes in coastal climate patterns are rising sea surface temperatures, longer summers, and delayed rainfall.

Rising temperatures are a critical driver of declining crop productivity. Approximately 71 per cent of respondents' state that an increase in average temperature has several significant impacts on crops. They state that a considerable increase in temperature is observed in coastal areas. Specifically, many respondents were of the view that rising average temperatures and frequent heatwaves are accelerating crop maturation, reducing yields, and affecting quality. It also exacerbates water evaporation and reduces the availability of fresh water for irrigation, resulting in severe drought during the summer season. Higher temperatures are degrading the soil health by increasing the rate of organic matter decomposition, reducing soil fertility and structure, making it harder to sustain crops. Furthermore, warmer climates are expanding the range and lifespan of pests and pathogens that increase the incidence of crop disease and pest infestation, which reduces the yields and requires more pesticide use. Two respondents from DAE and BADC mentioned the whitehead problems in rice plants due to heat shocks in Patuakhali district. Furthermore, one respondent from DAE states that the difference in temperature between day and night is growing. As per his perspective, each crop has its specific temperature requirements, and crops are impacted by sudden drops or rises in temperature throughout the day and night, which can affect their physiological processes, growth patterns, yield, quality, and susceptibility to pests and diseases. One of the respondents from BADC mentioned that increasing temperatures, lack of rain in the rainy season, and delayed winter are the main causes of production barriers in coastal districts, especially in Patuakhali.

Table 28: Respondents' View on Climate Change Pattern

Change in Climate Pattern	Impacts
Rise in Temperature **Longer Summer** **Delayed Rainfall** **Rises in temperature throughout the day and night**	Accelerate Crop Maturation Reduction of Yields Hamper Crop Quality Reduction of Fresh Water for Irrigation Reduce Soil Health and Fertility

Advancements in technology and the advent of several crop varieties contribute to increased productivity
Man-made hazards are accelerating the productivity impediments

Changes in precipitation patterns disrupt cropping calendars, contribute to waterlogging, crop damage and loss of soil nutrients. Roughly 79% of the participants mentioned that alterations in precipitation patterns had significant effects on coastal agriculture. A result of changes in rainfall patterns, such as a rise in the frequency of both heavy rainstorms and dry periods, exacerbate waterlogging and erosion during rainfall events and drought stress during dry seasons causing more frequent and severe flooding, particularly in the monsoon season, which leads to agriculture fields' inundation, wash away crops, erodes soil, and generates inconsistent crop yields. These observations are in line with the historical temperature and precipitation trends in the study area. Seasonal temperatures showed the strongest increasing tendency for the corresponding mean temperature, minimum temperature, and maximum temperature, which were 0.18℃ per decade (post-monsoon), 0.18℃ per decade (winter), and 0.23℃ per decade (post-monsoon), respectively. In addition, a noteworthy upward trend was observed in the mean annual rainfall and pre-monsoon rainfall, with corresponding averages of 4.20 mm and 1.35 mm/year, respectively.

According to climate records from 1970 to 2017, the coastal regions experienced an increase in temperature of 0.35 °C and precipitation of 579 mm, respectively, with a wider variance of 0.15 and 8.57% than the mainland. Thus, it became apparent that the coastal region exhibited greater adverse consequences of climate change patterns and variabilities on yield trends and variabilities. Due to climatic trends and variabilities, agricultural yields were lost on average by 2.75 and 2.91%, respectively; this translates to 2.4 million tons (Mt/yr) annually. Temperature and precipitation contribute 12% (=3.06 Mt./yr.) of the disparity in crop production, presuming locations and variety of crops have been considered in account. (Hasan et. al., 2020).

Shifting seasons marked by delayed monsoon, shorter winter, and erratic transition are undermining crop calendars and increasing production hazards. Nearly 51 per cent of the respondents mentioned that the cropping season pattern is changing in the coastal areas, especially in the eastern southern part of

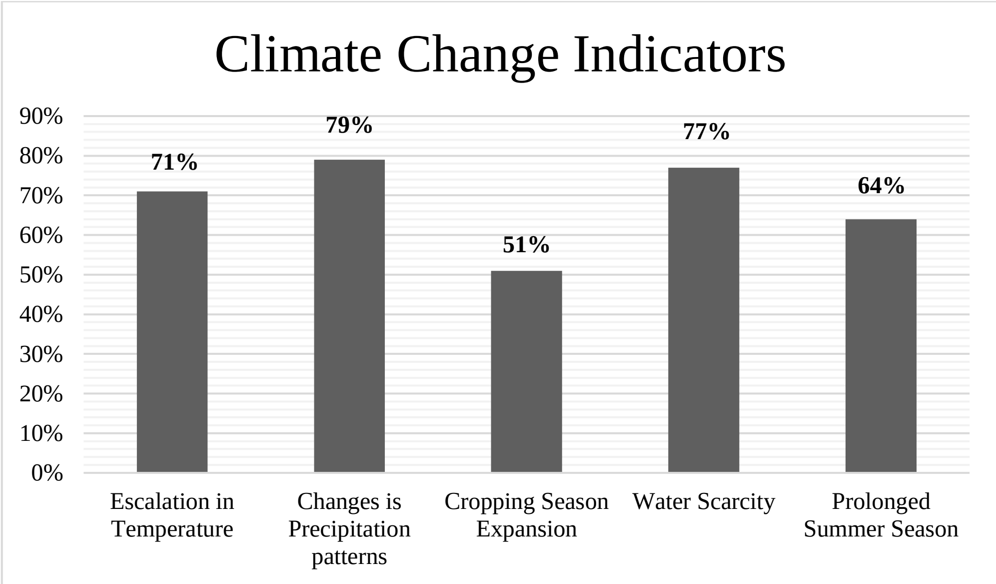
Bangladesh. In Bangladesh, Rabi and Kharif are the two main growing seasons for crops. The Kharif season, which spans from May to October, is known as the Kharif crops and includes rice, jute, maize, lentils, and other crops. The Rabi season, which starts in November and ends in April, is known as the wheat, mustard, chickpea, lentil, etc. In addition to these two main seasons, there is also a transitional season known as pre-kharif. The season ends in May or June, which starts in March and continues through April. Respondents stated that the biggest challenge to Rabi crops is the postponement of Aman rice cultivation due to heavy rains, tidal flooding, and waterlogging.

Table 29: Cropping Patterns in Bangladesh

Cropping Pattern	**Rice**	**Sowing Period**	**Harvesting Period**
Pre Kharif	Aus	Mid-March to Mid-April	Mid July to early August
Kharif	Aman-Broadcast	Mid-March to Mid-April	Mid November to Mid-December
	Aman-Transplanted	End of June to early September	December to early January
Rabi	Boro-Local	Mid-November to mid-January	April to May
	Boro-HYV	December to mid-February	Mid-April to June

Approximately 64 per cent of respondents’ state that an extension of the summer season or prolonged summer is common in coastal areas. A prolonged summer is characterised by higher temperatures and extended dry periods that often coincide with decreased rainfall, exacerbating water shortages, and intense heatwaves impeding photosynthesis, reducing pollen viability, increasing respiration rates in crops, and causing them to mature earlier than usual, which often leads to lower yields and smaller production.

Figure 47: Climate Change Indicators Reported by Respondents



The availability of fresh water becomes increasingly defined by variability, salinity, and dependence on groundwater, presenting significant problems to sustainable irrigation and crop production. Nearly 77 per cent of respondents stated that the scarcity of fresh surface and groundwater hinders crop production. Agriculture is responsible for nearly 70% of that withdrawal volume, and it is, therefore, the most water-intensive sector. Most of the respondents mention that changes in the availability of freshwater for irrigation due to altered precipitation patterns and increased competition for water reduced water supplies for irrigation, necessitating changes in cropping patterns or irrigation practices. River course change, excessive abstraction of groundwater for agriculture by shallow and deep tube wells, seasonal variability, shift of critical rainfall period, intensity of rains, higher water use cropping pattern, and irrigation inefficiency for rice-based farming are among the key factors that govern the water resource utilisation and degradation in Bangladesh.

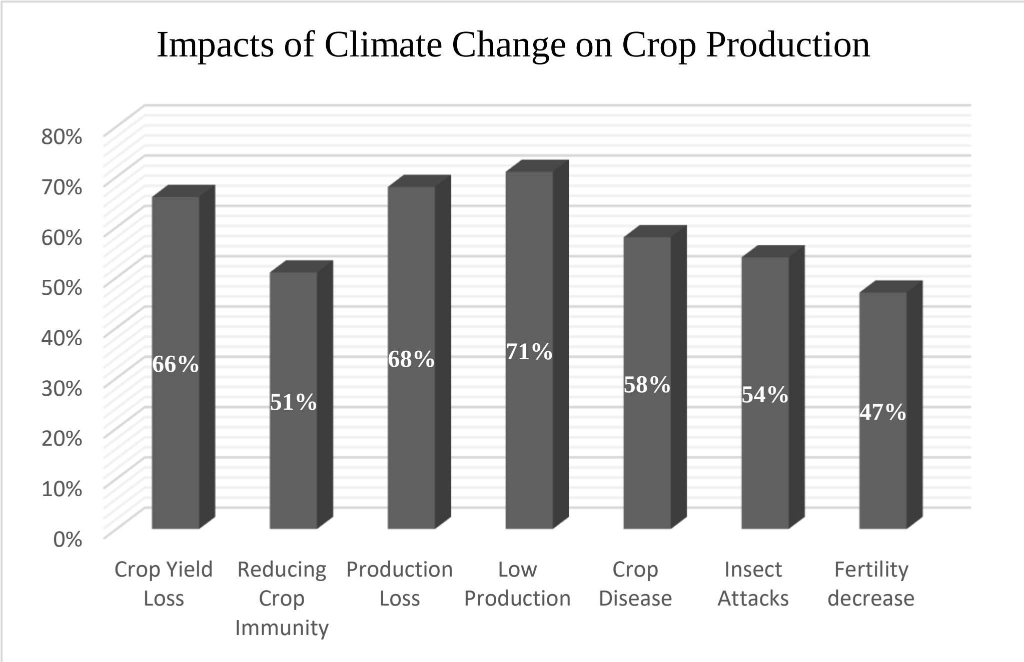
In addition, a possible increase in temperature due to climate change will bring a radical change in the management of both surface and groundwater resources (Mannan & Hossain, 2015). It is said that South Asia might experience a 30 per cent drop in agricultural production by 2050 (Siddique, 2024). Water Limiting

Resource for Sustainable Agriculture in Bangladesh. Despite abundant water in rivers and canals, farmers struggled with irrigation water because of the high salt content in the water.

The results indicate that the majority of climate-induced impacts documented are biophysical (saline intrusion, flood, scarcity of water resources, prolonged summer or drought) and biological (insects, disease, and pest infestation). Approximately 73% of respondents believe that the most significant issue affecting coastal agriculture is salt intrusion. The agricultural pattern has shifted after the two disasters, Cyclone Sidr in 2007 and Cyclone Aila in 2009. Farmers had cultivated paddy and other crops before these calamities, but after the saline intrusion, the cultivation of sesame was severely affected.

The study revealed that salinity levels in the coastal region of Bangladesh varied from 1.7 to 2.3 ppt, although freshwater salinity is below 0.5 parts per thousand. It became apparent that river salinity was lower during the monsoon season and higher during the dry season, which extends from March to April (Uddin et al., 2024). They argue that a mix of human activity and natural forces drives it. The infiltration of saltwater into freshwater systems and agricultural regions due to storm surges and sea level rise causes the salinity of the water and soil to increase, triggering damage to crops that are not resistant to salt. According to one of the DAE respondents, persistent salinity is deteriorating fertility and soil structure, making it difficult to grow crops without significant interventions, which are costly for many farmers and discourage them from making any investments.

Figure 48: Impacts of Climate Change on Crop Production



The contemplations of the participants, as shown in the above table, demonstrate serious concerns regarding numerous facets of agriculture and show how climate change is affecting coastal regions. A substantial 71% reported experiencing low production rates, which is influenced by various factors such as inadequate irrigation facilities, geographical vulnerabilities, salinity intrusion, soil degradation, limited access to resources, flooding, waterlogging, pest infestation, diseases, and so on, indicating a widespread challenge in meeting expected yield levels. This was compounded by a 68% consensus on production losses, underscoring the severity of agricultural setbacks. Crop yield loss was prevalent among 66% of respondents, illustrating a direct impact on harvest quantity and quality.

Additionally, 58% cited increased occurrences of crop diseases, indicating heightened vulnerability and health risks to cultivated plants. Nearly 54% of respondents emphasised the growing threat posed by pests under changing climatic conditions by mentioning that insect infestation is increasing on plants due to several interconnected ecological and environmental shifts, such as warmer temperatures, longer growing seasons, and drought stress. Furthermore, a notable 51% reported a reduction in crop immunity due to drought and excessive water, reflecting the diminished resilience of crops to environmental stressors. A decrease in fertility in soils was noted by 47% of respondents, signalling long-term implications for agricultural sustainability and productivity in coastal regions. Loss of topsoil as a result of catastrophic weather events, saltwater intrusion, and nutrient depletion due to excessive use of chemical fertilisers can all contribute to a decline in fertility by lowering soil pH and affecting nutrient availability. These findings collectively underscore the urgent need for adaptive strategies and resilient farming practices to mitigate the adverse effects of climate change on coastal agriculture in Bangladesh.

Table 30: Indicators and Impacts of Climate Change

Climate Change Indicators	**Impacts of Climate Change**
Saltwater Intrusion (saltwater into the freshwater system and agricultural lands)	Soil and water salinity increase Cultivable Land decreases Damages in rice and vegetables
Changes in precipitation pattern (Altered rainfall patterns, including both increased frequency of heavy rains and periods of drought)	Waterlogging and erosion during heavy rains, drought stress during dry periods, leading to inconsistent crop yields
Temperature variation (Rising average temperatures and more frequent heatwaves)	Heat stress on crops, altered growing seasons, and reduced yields of temperature-sensitive crops
Variation in the cropping calendar	
Shift in Agricultural Zones Climate zones shift, making some regions less suitable for traditional crops	Farmers need to switch to different crops or farming practices, which may not be as profitable or well-understood
Soil degradation (Increased salinity, erosion, and loss of organic matter due to extreme weather events.)	Declining soil fertility and structure, reducing the land's ability to support healthy crops
Water Availability or Water Logging Changes in the availability of freshwater for irrigation due to altered precipitation patterns and increased competition for water	Reduced water supplies for irrigation, necessitating changes in cropping patterns or irrigation practices
Extreme weather events	Direct damage to crops, infrastructure, and loss of livestock, leading to economic losses for farmers

Institutional Capacities Regarding Climate Change Adaptation in Agriculture

Using an Indicators-based Index method grounded on six parameters, this study examined agricultural organizations' capabilities in further detail. The results of the chosen indicators are displayed in the table, which demonstrates the medium level of capacity and preparedness of the chosen institutions. The outcomes of each indicator are explained in the following.

Climate Perception and Knowledge (PKI):

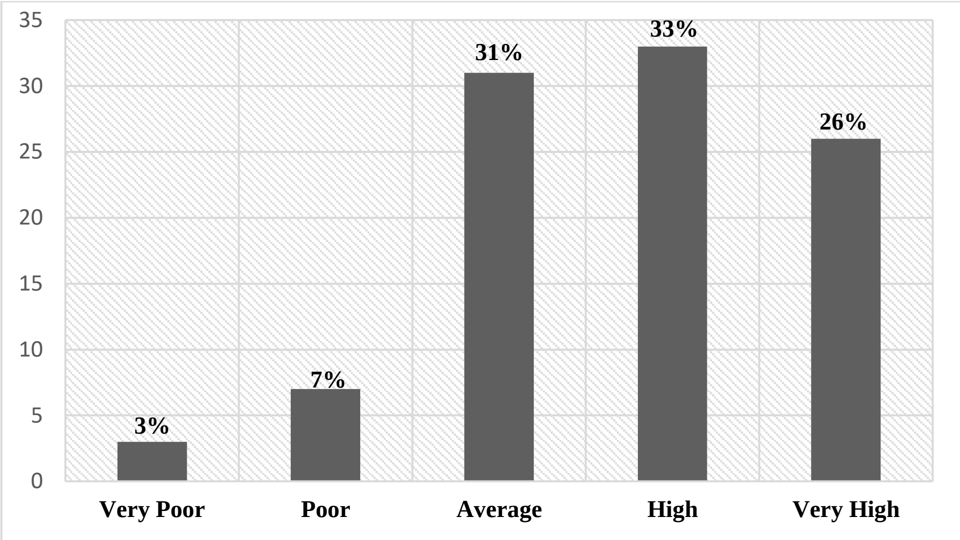
The first indicator evaluated to assess institutional capacities is officials' perception and knowledge of climate change and its impact on agricultural production in the selected coastal districts in Bangladesh under four sub indicators firstly, Climate Change Perception (CCP); secondly, Perceived Impacts of Climate Change; thirdly, Knowledge of CCA/CRM; and fourthly, Beliefs or Acknowledgement of CCA/CRM. Numerous empirical studies show that perception and understanding of climate change risks and/or chances are significant determinants of adaptation at household, organisational, and community levels.

The literature identified the main determining factor of the adaptation incentive is the perception of risks or risk appraisal and/or chances of climate change and its possible impacts (Grothmann and Patt, 2005; Weber, 1997, Berkhout, 2012; Jones and Boyd, 2011). They argue that knowledge about the hazard and the risk, knowledge about how to prepare for, cope with, and recover from their negative effects, knowledge about other organizations involved in handling hazards and emergencies and their level of preparedness, insights about formal institutions consisting of legal frameworks along with particular laws, and knowledge about the underlying informal values, norms, and beliefs of various actors are all crucial for accelerating the development of individuals and organizational capacities.

According to Ghahremanin et. al. (2019), the knowledge and perception of the stakeholders on climate change and its impacts indicate their intention to make efforts regarding CCA. Hackmann (2016) claims that individuals may attain knowledge about environmental disquiets and acquire the obligatory stances, behaviours, and skills to resolve environmental challenges successfully. While Folke et al. (2005) and Reed et al. (2009) asserted that actors might acquire knowledge about the environmental setting and apply it to address environmental issues. It is believed that when the actors emphasise the importance of addressing the challenges of climate change, they are better able to use their knowledge and beliefs to develop the strategies and action plan to provide sufficient support for adaptation. To evaluate the perception and beliefs, the interviews started with a question regarding the field of activity of the organisation the respondent is working for, including the region of the organisation, and regarding the fields of activity of the interviewee themselves. Then they were asked to describe the recent climate issues they perceive for their respective sectors (Agricultural production, water management, coastal protection, regional planning, etc.) and their induced impacts at the farm level in two coastal districts in Bangladesh. It is evident from the results that a majority of the individuals had a significant perspective on climate change and the detrimental impact it has on farms.

Here, the climate change perception and knowledge in terms of adaptation motivation is decided to be assessed by the questions asking for the perceived relevance of adaptation in the organisations. Almost 94.7 per cent (27.9 per cent moderate, 37.2 percent high, and 32.6 per cent very high) stated that the coastal climate is changing rapidly and the risk of changing temperature, precipitation patterns, shifting of cropping season, and extreme natural events are presumably the biggest concerns for coastal agriculture. In addition, a total of 33 per cent of respondents stated that there is a very high impact of climate change on agricultural output, while 31 per cent and 26 percent remarks the impact at moderate and very high levels respectively.

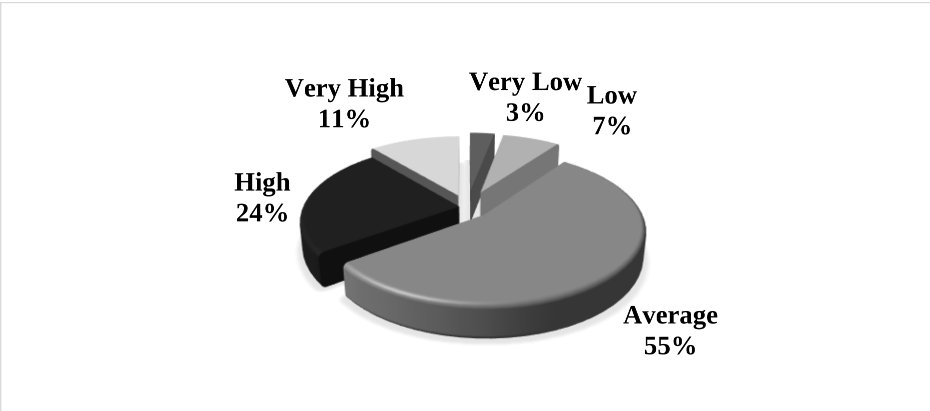
Figure 49: Percentage of Respondents' Perceptions of Climate Change Impact on Crop Production



Based on participants' responses, it is inferred that out of the 28 sub-indicators, Climate Change Perception (CCP) had the highest value at 78.2, which indicates that the respondents are concerned enough about specific ways that crop yields, agricultural practices, risks associated with climate change, and total farm productivity are being impacted by climate change in the coastal area. Their comprehensive description most likely includes information on how weather patterns have changed, how frequently extreme weather events have occurred, how growing seasons have changed, and other climate-related aspects that have an immediate influence on farming operations.

The result shows that in terms of climate change perception and understanding, the research organisation is rated as having a high level of perception, the field organisation is moderate, but the credit and marketing department scored low. In interpreting the levels of climate change perception, it is important to mention that all the respondents from different institutions emphasised that there is an urgent need for effective adaptation to climate change in coastal districts because the protection level in their sectors is not adequate. Furthermore, two officials from BADC stated that a distinct cell or unit for effective agricultural adaptation in coastal areas needs to be established. In Addition, the interviewees were asked to rate the perceived impacts of climate change on agricultural production to understand their perspicuity on the impacts of climate change on the following scale (no impact, small impact, average impact, high impact, and very high impact), and they gave a high score of 73.1 to the impact of climate change among the sub-indicators. It indicates that their clear descriptions likely include details about extreme temperature, excessive evaporation, decreasing crop immunity, drought, inundations, wind storms, degradation in soil fertility and irrigation water quality, crop diseases, shrinking of water resources, yield losses, and decreasing of farmland and food security. Nonetheless, their comprehension of adaptation processes and their efficacy is constrained. To measure the knowledge and beliefs of officials from different institutions, the officials were asked to answer how their organisation has action plans to lessen the effects of climate change at the farm level and the effectiveness with which the sector is putting these plans into practice.

Figure 50: Respondents' opinion on Institutions coping with the impacts of Climate Change



After the participants answered the initiatives descriptively, they were asked to rate the realizability of their practices and behaviour to cope with the effects of climate change. Following their assessment of the adaptation within their respective institutions, the participants were asked to identify the barriers and potential synergies concerning these adaptation measures. We know from previous studies that institutional representatives do not want to make straightforward statements about risks, the feasibility of practices, and behaviour regarding institutional adaptation, especially when there is a lack of formalised organisational assessment and organisational discourse on climate change has just started (Zebisch et al., 2005).

A significant proportion of the participants (54.8 per cent) believed their institution's coping mechanisms for the negative impacts of climate change adaptation are inadequate, whereas 23.8 per cent indicated that the rate of adequacy is high. 40 per cent of the respondents argue that the institutions have action plans to mitigate farm-level impacts of climate change, whereas 20 per cent of the respondents stated that there is no action plan or a very low action plan regarding climate change adaptation at the farm level. It indicates that the majority of the respondents believe that there is a lack of adequate strategies and techniques available for mitigating the impacts of climate change, such as adopting resilient crop varieties, implementing irrigation practices, or converting to organic soil.

Better understanding of climate change Impacts

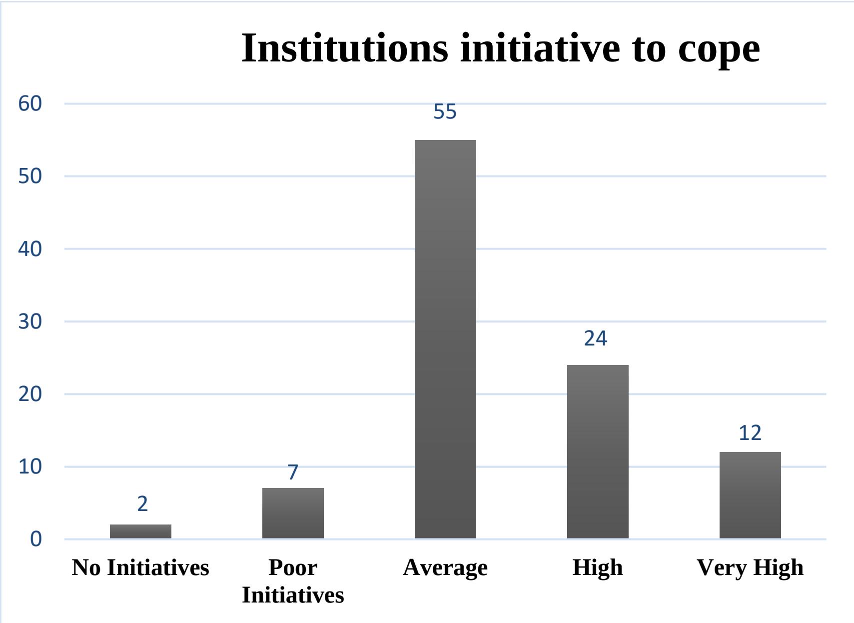
Emphasises the urgent need for adaptation

Lack of integrated and effective strategies and coping Mechanism

No clear action plans to adjust practices and behaviour

This means they don’t have strong convictions about how to adjust their practices and behaviours. Most respondents who expressed an undesirable view of climate change adaptation were mainly from the field, credit and marketing departments. A wide range of literature demonstrates that implementing risk management mechanisms necessitates an extensive understanding of climate change. Numerous studies demonstrate that understanding the socio-cognitive processes influencing people’s perception of environmental change can help us better understand the subjective boundaries of adaptation and make it easier to develop strategies that support the dissemination of fact-based knowledge and enhance adaptive capacity (Clayton et al., 2015; Grothmann and Patt, 2005; Helgeson et al., 2012; Kunda, 1990; Shome et al., 2009; Spence et al., 2012; Wiest et al., 2015).

Figure 51: Institutions' Initiative to Cope



In addition, Adger et al. (2009, p. 339) argue that "adaptation action is limited by social and individual factors such as perception of risk, habit, social status, and age that influence individual decision-making, also limit collective action. More comprehensively, Kuhlicke et al. (2011, p. 806) describe this psychological element as "Motivation to prepare for, cope with and recover from the negative impact of a hazard" while many guidelines for adapting to climate change (UNDP, 2010) and some scientific writings (Moser & Ekstrom, 2010) refer to "awareness" of climate change and its effects rather than risk perception, basically means the same thing. Though agricultural institutions are linked together, these findings insinuate that the agenda for climate change should be mainstreamed across all of them. As a result, institutions may be more inclined to develop and put into place local risk management strategies. This might result in a more widespread understanding of climate-smart activities.

While acknowledging the immediate impacts of climate change, respondents suspected that alterations in crop production would occur over the long term. They argued that climate change would impact crop production in the coastal zone, potentially resulting in alterations to the distribution of certain varieties and their eventual extinction. Over time, these would have a negative impact on the local communities' ability to achieve food security and livelihood. One respondent from DAE commented that

> "…. *The primary impact of climate change is, of course, on crop production. You know that due to climate change, sea level rise, salinity intrusion, temperature rise, irregular rainfall and waterlogging have become common phenomenon in the coast, which leads to the least crop production, yield losses, white head disease in rice plants, lower nutritional quality and slower growth of plants."*

Many respondents expressed concern that changes, possibly due to climate change, were already being observed in terms of variation in the arrival of rains, which affect the agricultural calendar and production operations. The concern was expressed that the timing of wet and dry seasons was not as distinct as in the past and that this was having an impact on agricultural production in the short term. Several respondents from different institutions felt that a smaller winter span, differences in day and night temperature, the unpredictability of the rains, as well as the quantity of rain, were beginning to affect crop breeding, seedbed damages, changes in crop calendars and pest infestation.

Coordination and Collaboration (CCI)

A wide range of literature shows that coordination between different stakeholders is among the critical determinants of the institution's adaptive and risk management capacities and often supports collective action and decision-making regarding climate change adaptation. Brown et. al. (2010) highlighted effective inter-sectoral coordination as a significant indicator for adaptation, as policies and plans related to other sectors like water development, environmental management, and resource development will influence agricultural development. Smit and Wandel (2006) argue that the limited coordination or lack of collaboration among the different agencies of government at different levels and local communities regarding climate change restricts adaptive capacity and may increase the vulnerability of local communities.

> *'...we don't have any collaboration with educational institutions.'*
>
> *—Respondent (BADC)*

Carlsson and Sandstrom (2008) stated that well-connected institutions, collaboration and coordination among the stakeholders, and a resilient network build social capital and foster innovations, are essential to tackle the problems as complex as climate change. Collaborative procedures, systematic learnings and multi-level interactions among the institutions are the prerequisites for an effective governance system to adapt to changes (Armitage et. al., 2008). Gupta, with associates, introduced the Adaptive Capacity Wheel (ACW) in which they proposed six dimensions that enable governance institutions to empower stakeholders to adapt and respond flexibly to environmental challenges. The dimensions define adaptive capacity as the combination of institutions' learning capacity, responsiveness to changing society, resource availability, accountability and collaborative ability to work with diverse actors in governance settings (Gupta et al., 2021). For instance, Lockwood et al. (2015) emphasise legitimacy, accountability, inclusiveness, justice, leadership, coordination, and cooperation for actors to develop adaptive capacity. The coordination and collaboration capabilities of stakeholders, including private entities, public institutions, and NGOs, are important components of adaptive capacity, as stated by Gunderson et al. (2005). Sharing of information, hands-on involvement, or effective collaboration between governmental and non-governmental organisations are considered examples of participation and coordination. Indeed, Olsson et al. (2005) and Armitage et al. 2008 stated a new way to measure adaptive capacity. According to them, the learning dimension of adaptive management and the linkage dimension of co-management work together to focus on the rights, responsibilities, and power between different levels and sectors of government and civil society.

Collaboration comprises the cooperation of various government bodies to address issues that exceed jurisdictional boundaries and multiple policy sectors, along with the involvement of non-governmental organisations, such as individual citizens and interest groups (Lee 1993, 1999). Most of the literature acknowledges that effective collaboration among impacted stakeholders is essential for successful adaptation efforts (Bodin and Crona 2009; Cassidy and Barnes 2012; Folke et al. 2005; Newman and Dale 2005).

To evaluate the coordination and collaboration among the stakeholders, the respondents were asked to answer whether their institutions have the mandates for institutional collaboration and coordination for adaptation planning and implementation. After the interviewees had answered the mandates for institutional cooperation, they were asked to mark the level of coordination between different levels and sectors of government institutions, private organisations, non-government organisations, and the community. They were asked to rate the level of coordination on the following scale: No coordination, Poor level of Coordination, Average level of Coordination, High level of coordination, Very High level of coordination.

A respondent from BADC stated that

> *'.... in comparison to the cooperation with BWDB, the cooperation with the community and the research institution is remarkable. Some private organisations moderately collaborate about pesticides, micronutrient supplies, and seed, while BADC mostly coordinates regarding seed availability.'*

Institutional mandates for coordination and collaboration are an important determinant for adaptation. Almost 79 per cent of respondents mentioned that they have mandates for coordination and collaboration, whereas almost 8 per cent of respondents mentioned that they have few mandates for coordination with other institutions. Although the CCI value of 0.60 showed that institutions have an intensified level of coordination with other stakeholders, which is quite satisfactory, most of the officials stated that this coordination is predominantly happening within the field institutions solely. For instance, out of thirteen institutions, only officials from DAE reported direct cooperation with farmers in terms of community coordination, which indicates minimal interaction or no connection between the majority of the institutions and farmers. Among the respondents from DAE, the credit and marketing department, 39 per cent of interviewees mentioned that their institutions and farmers are collaborating well, whereas 24 per cent assessed the cooperation as average because of institutional shortages of employees. The personnel who indicated the coordination with farmers were mainly from field institutions. However, there is minimal coordination between farmers and research institutions; the officials explicitly acknowledged the importance of institution-community coordination.

In terms of intra-institutional collaboration, 39 per cent of the respondents indicated that their institutions have coordination mechanisms with other institutions functioning under the Ministry of Agriculture directives. They weighed the level of coordination and collaboration within the same institutions at 67, which is quite a decent value for interacting satisfactorily. The result shows that intra-institutional coordination is comparatively higher than the coordination mechanism with other public sector institutions and private institutions. In comparison, 40 per cent of the respondents indicated that the coordination with other public sector institutions is average, and they evaluated the level of inter-institutional (Public) coordination at 62, which shows moderate coordination between different government bodies and agencies functioning for coastal adaptation and resilience.

Table 31: Values of Sub-Indicators (CCI)

Sub Indicators	Value
Intra-Institutional Coordination	66.9
Community Coordination	65.5
Inter-Institutional Collaboration (Public)	62.6
Inter-Institutional Collaboration (Private)	57.5

Nonetheless, 25 per cent of the participants claimed that the amount of collaboration with private sector institutions remained below average. The interaction between public institutions and non-government bodies is worrisome, though they gave a score of 58, which is not too low to interact, but it seems they overrated it. Two respondents from two different NGOs working in the Patuakhali district mentioned that the coordination and collaboration rate is very poor in terms of agricultural adaptation in their area, and they were unable to get any support from the public institution in need. Literature shows that collaboration between governmental and non-governmental stakeholders is an important theme in the governance literature on common-pool resource management, network management, and process management (Ostrom 1990, Keohane and Ostrom 1995, Klijn and Koppenjan 2000, De Bruijn and Ten Heuvelhof 2003). Cooperative governance systems are supposed to be more resilient and better able to cope with change and uncertainty (Granovetter 1981, Perrow 1999). Furthermore, strong networks among diverse institutions across scales enhance the adaptive capacity of the system to respond to the challenges of changing circumstances. However, weak links among institutions that fail to plan for changing environmental and policy conditions and risks constrain adaptive capacity and increase vulnerability (Adger and Vincent 2005). Conversely, Brown stated that a well-coordinated network between the actors of the same institution chain is critical for an active response to a challenge like climate change (Brown et. al. 2010). Consequently, these results indicate that different institutions and communities collaborating within a well-coordinated institutional framework may be better suited to address environmental concerns.

> *'…it's very difficult and time-consuming to coordinate with the officials to organise any meeting with farmers and stakeholders for the project implementation'*
>
> *-A respondent from Patuakhali Districts*

Resource Availability

Numerous studies show that resource availability is one of the significant determinants of capacity assessment. Jessani et al. (2014) refer to a shared understanding of objectives, sufficient resources, data accessibility, and leadership support are some of the elements that impact institutional capability. Adaptive capacity is the collection of resources and the aptitude to use them that are necessary for adaptation (Nelson et. al., 2009). Gain et al. (2012), in their study, determined the adaptive capacity index by combining the elements of natural capacity, physical capacity, human resource capacity, and economic capacity. Furthermore, multiple research studies demonstrate that several factors, including organizational competence, access to financial, technological, and information resources, infrastructure, the institutional environment in which adaptations take place, power in politics, kinship networks, etc., can affect an organization's capacity to implement adaptations at the local level (Watts and Bohle, 1993; Hamdy et al., 1998; Adger, 1999; Handmer et al., 1999; Kelly and Adger, 2000; Toth, 1999; Smit and Pilifosova, 2001; Wisner et al., 2004; Adger et al, 2001; Blaikie and Brookfield, 1987). Key criteria for assessing adaptive capacity include variety, learning capacity, space for autonomous action, leadership, resource availability, and fair governance (Gupta et al., 2008). In an organisation, resource availability means the total number of employees, equipment, and materials that are readily available and may be applied to address a variety of issues. In terms of human resources, resource availability refers to the quantity of workers who possess the necessary training and experience. It also comprises deliberating issues such as employee readiness due to vacations, leaves, or other commitments. Similarly, evaluating the accessibility of tools and supplies is another aspect of resource availability assessment. This area may include evaluating the availability of tools, equipment, or technology required for task execution. Increased responsibility for fund consumption and the long-term effects of capacity-building methods on society has become necessary due to resource restrictions and budget availability (Hailey and James, 2003). Often, an institution's capacity to generate resources determines how effective it is. (Yohe et al. 1996, Mendelsohn & Nordhaus 1999, Nelson et al. 2010). According to Biermann (2009), it is the responsibility of institutions to provide actors with enough resources and incentives to adapt, implement, and comply with rules and norms. These resources can be technological, personal, financial, political, and legal. The question of whether institutions support authority (political and legal mandates), intellectual property (knowledge, skills, and labour), and financial resources (including access to technology) is among the criteria. An institution's ability to acquire funds will also be greatly impacted by the environment in which it operates.

Table 32: Respondents' Opinion on Resource Availability

Institutions	Lack of Resources
DAE	Logistics, vehicles, Emergency budget
BADC	Machineries, Cold Storage, Infrastructure
SCA	Laboratory, Policy
NARS	Lack of field research equipment
Credit	Human Resources, Computer Shortage
Marketing	Human resources, Infrastructure, Vehicle

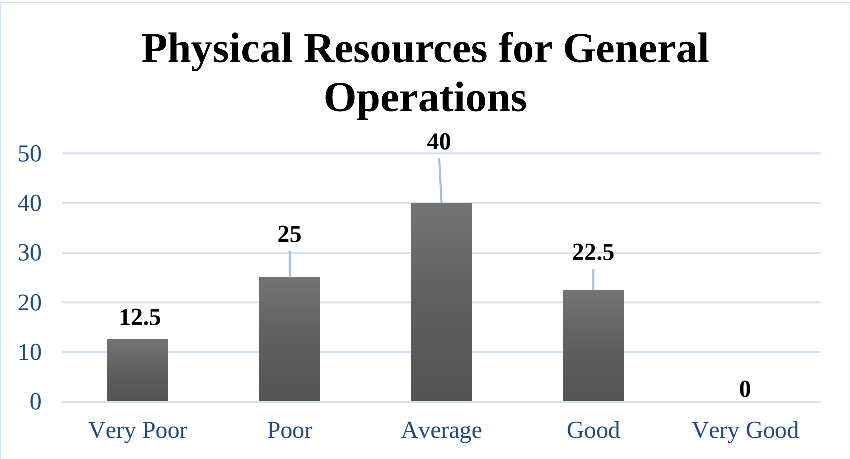
Physical Resources

Several studies emphasise the importance of adaptive, well-resourced institutions in effectively managing climate change adaptation efforts (Molden et al., 2001). It is believed that having access to sufficient physical resources is another essential element in defining the role of institutions in assisting farmers in managing climate risks at the community level. When evaluating the physical resources of field and market institutions, the availability of hardware, vehicles, machinery (such as harvesters, bulldozers, and cranes), communication devices, infrastructure, and other resources is taken into consideration. On the other hand, research institutions are cogitated instruments, apparatuses, and laboratory equipment.

A member in BKB said that *'…it is very undesirable that many branches have five to eight officials and staff, but the entire branch has only one or two computers.'*

To evaluate the adequacy of physical resources, the respondents were asked whether the institution has adequate physical resources such as vehicles, machinery, harvesters, bulldozers, communication equipment, hardware, and research equipment for the general operation of the institution. Almost 40 per cent of the respondents stated that the adequacy and availability of physical resources are average. The result shows that the critical index value is 0.39, indicating inadequate availability of infrastructure and physical resources in public institutions. Nearly 37.5 per cent of the respondents mentioned that the availability of physical resources is below average to very poor.

Figure 52: Physical Resources for General Operations



Almost all the institutions have indicated the shortage of these resources. The credit department has a critical shortage of infrastructure at the coast. According to marketing department officials, it is challenging to assist farmers in managing climatic risks because coastal districts need cold storage facilities and office equipment. The results of the sub-indicators indicated that the requirement of physical resource value is very high, which is more than 74.6, whereas the availability rate of the resources is 49.5, which shows an enormous gap between the resources' actual requirements and availability.

Table 33: Values of Sub-Indicators (RAI)

Sub Indicators	Value
Machine/Equipment Availability	49.5
Machine/Equipment availability for CCA/CRM	44.7
Machine/Equipment Requirement	74.6

More than 42% of the respondents from different institutions scored the requirement for machinery and equipment 4 to 5, which indicates a high level of necessity, whereas 25% scored 5, which was the highest value for evaluating the sub-criteria. In addition, only 19% of the respondents from different institutions indicated that they have machinery and hardware for extreme climate conditions and emergencies, though they also mentioned that they require more to improve the overall functioning of the institution. Nonetheless, 44% of them claimed that the machinery and equipment are not enough for general functioning and in extreme climate conditions. Several studies identify these characteristics as physical resources that are crucial components in offering support during emergencies. The research, credit and marketing departments have highlighted a significant scarcity of physical resources.

'...logistic support for the field officials is inadequate. In most of the cases, the UAO or SAO don't have any vehicles, though they have to visit at the block level regularly. There are some projects on agricultural machinery, but they are not adequate for both regular operations and emergencies. There is a lack of modern technology-based machinery.'

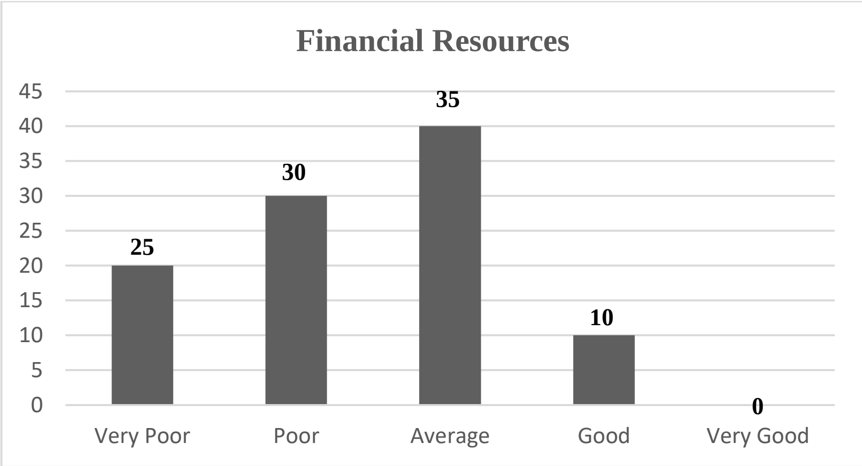
--Respondent (DAE)

The officials from SCA, BRRI, BARI, DAM, and BKB have stated that the primary obstacle limiting their effectiveness in conducting field operations is the lack of vehicles, infrastructure, and laboratory equipment in the field area. The BRRI respondents said that because their field office lacks a well-equipped laboratory, they are forced to rely on the head office for all types of research endeavours. The field office is not equipped to conduct research on regional adaptation. Previous studies have also reported similar findings of a lack of logistic and communication resources and advocated that these resources should be made available to institutions working toward adaptation to strengthen their capacity. In a nutshell, the physical resources of agricultural institutions are inadequate to address catastrophic concerns, and they should be given careful consideration by relevant authorities.

Financial Resources

The availability of financial resources to support policy initiatives and financial incentives is an important indicator of institutional adaptive capacity (Gupta et. al. 2010). Smit and Pilifosova (2001) list economic resources as one of the highly significant factors of capacity assessment, while Kuhlicke et al. (2011) defined this classification as economic capacities. It is embodied in the collection of accessible resources, which comprise financial capital, infrastructure and technology, information, knowledge, institutions, learning potential, and social capital (Nelson, 2010). The institution's financial resources support the actors' readiness and capacity for emergency response in the event. However, the FRI in the current study is 0.34, indicating that the agricultural institutions' financial resources were woefully inadequate. Only 10% of the institutions reported that financial resources were available for activities associated with climate change adaptation and/or climate risk management. However, the respondents who mentioned the availability of finances, in particular, were involved in the GoB-donor-funded development projects at various institutions. The overwhelming majority of officials (55%) stated that the financial resources allocated to combating climate change were inadequate. And, only 35% of the respondents mentioned that the availability of funds for CCA and CRM is mediocre.

Figure 53: Respondents' Opinion on Financial Resources



The sub-indicators yielded a very low score of 42.6 for financial availability for general operations and a close score of 42.2 for financial availability to risk management (CRM) and/or climate change adaptation (CCA). On the other hand, their score for the funding requirements was 77.1, indicating a high level of concern. However, the majority of participants consistently claimed that there was a significant lack of required financial resources. Credit institutions have expressed similar concerns alongside field institutions.

Table 34: Values of Sub-Indicators (Financial Resources)

Sub Indicators	Value
Funds Availability	42.6
Funds availability for CCA/CRM	42.2
Funds Requirement	77.1

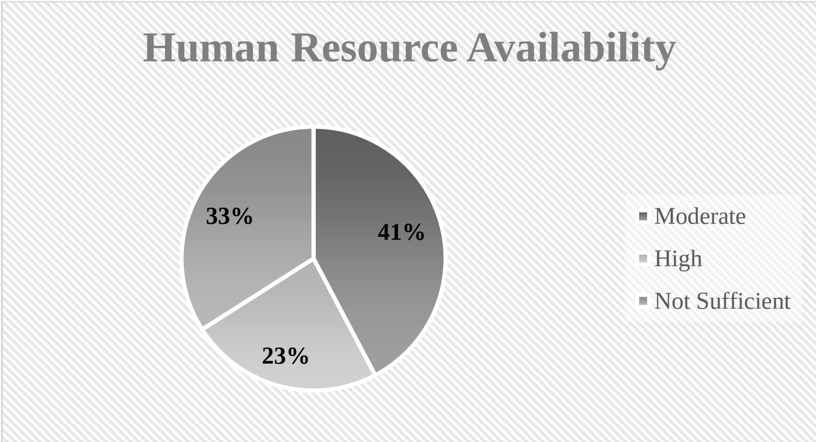
Our findings are consistent with research from Cameroon, Cambodia, and Pakistan. Similar difficulties were identified by the institution when putting climate response plans into practice. These results suggest that we need to put a great deal of resources into strengthening the institutions that serve as farmers' primary means of defense in instances of emergency.

One of the respondents stated that '…*in the past, there was an example of using helicopters to spray pesticides when insects attacked crops to quickly control such infestations. However, since disaster management is no longer under the purview of the Ministry of Agriculture (MoA), it becomes difficult to resolve such problems through inter-ministerial coordination.'*

Human Resources

Human resources are frequently mentioned as crucial factors influencing institutional adaptive capacity. Gupta et. al. (2010) acknowledge human resources as an essential element in evaluating the capacity of an institution to address risks associated with climate change. They argued that the availability of expertise, knowledge and human labour is the prerequisite for capacity development, whereas Kuhlicke et. al. (2011) emphasise knowledge capacities. Brown et. al. (2013) noted the inadequacy of human resources as a key obstacle to addressing climate change by both governmental and non-governmental organisations. Smit and Pilifosova (2001) claim that a country's or community's susceptibility to the different difficulties posed by climate change increases when important drivers of adaptive capabilities, such as economic wealth, technology, information, skills, and infrastructure, are insufficient. In line with the factors found in the research, human resources were also selected as a metric to evaluate the institutional capacities. The respondents were asked whether the institution possessed an acceptable number of personnel for general operations and CCA/CRM emergencies in order to assess the availability and demand of human resources.

Figure 54: Human Resource Availability



Four sub-criteria, including staff requirements for both regular operations and emergency events, employee availability for regular operations and CCA/CRM, and human resource accessibility and their capacity to handle problems, were used to evaluate the human resources. Based on the findings, 41% of the participants stated that the accessibility of human resources for regular operations is mediocre, while 23% rated it highly. It is closely comparable to the findings on the sub-criteria of personnel availability for emergency response. More than 33% of respondents said there is not sufficient staff available for coastal adaptation and risk management. Around 30% of respondents stated that their employees' capacity for adaptation is strong, while 44% felt that, because of their workload and lack of training, their employees' capacity is average.

Table 35: Values of Sub-Indicators (Human Resources)

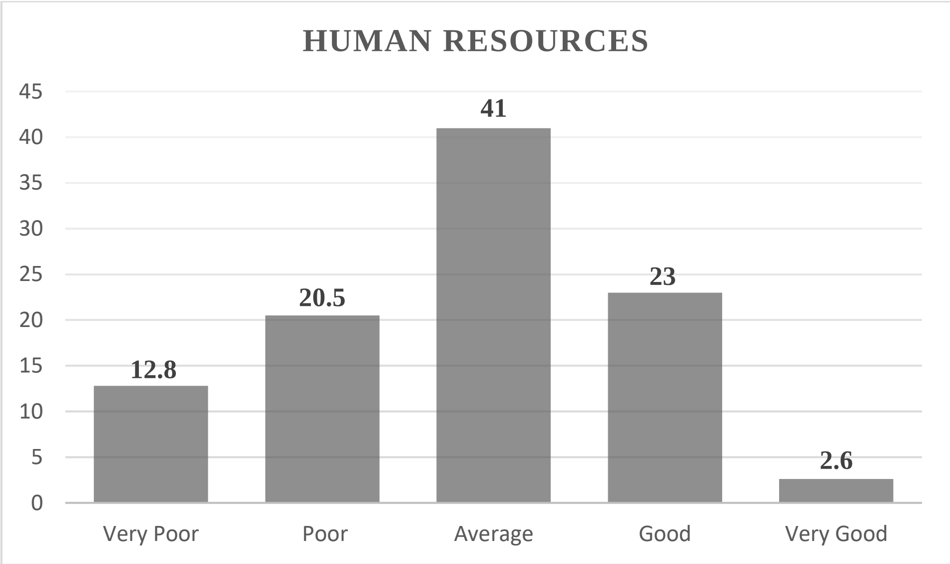
Sub Indicators	Value
Human Resource Availability	50.6
Human Resource availability for CCA/CRM	47.6
HR Training Needs	76
Human Resource Requirement	53.4

Human resources obtained the second-lowest value (0.37) out of the 28 sub-indicators, demonstrating that most institutions are lacking in this particular domain. Sub-indices also showed that the value of staff adequacy was 50, and in particular, the value of human resources available to meet operational requirements related to risk management was 47.

> *'... there is a shortage of skilled and efficient manpower for general operations. Moreover, officials appointed for regular operations perform duties on different projects, which increases the workload.'*
>
> --*Respondent (DAE)*

It is closely comparable to the results obtained from the sub-indicators of personnel availability for CCA/CRM. The vast majority of interviewers (72%) think that half of their potential staffing needs are met, and their institutions are significantly understaffed. The shortage of capable employees represents a significant obstacle to capacity development in public institutions, as demonstrated by their assessment of the requirement for human resources, which they assessed with a score of 53. The results indicate that understaffing leads to increased workload for existing employees, potential burnout, and decreased productivity and morale. Following these evaluations, the training needs were assessed by asking to rate the training needs for human resources in your organisation by the following scale: No need, minimal, medium, high, and very high. The majority of interviewees believe that the lack of qualified personnel is a major barrier to capacity development in public institutions, as evidenced by their evaluation of HR training needs, which they assessed with a score of 76, a very high range among the sub-indicators.

Figure 55: Percentage of Respondents' Opinion on Human Resources



In order to address the problems caused by climate change in the field of operations, officials from all the institutions, particularly BADC, SAC, BKB, and DAM, highlighted an acute scarcity of proficient manpower.

These results demonstrated that a shortage of human resources in public institutions might result in a lack of support for risk management, which would further raise farming communities' susceptibility to climate change. Research carried out in the Democratic Republic of the Congo, where forest institutions lacked human resources for responding to climate change, supports these findings. Gupta believed that institutions with sufficient human resources are better equipped to deploy risk management and climate change adaptation strategies in agriculture. Research conducted in the Netherlands, Germany, Cambodia, and Pakistan demonstrated that a lack of funding and inadequate stakeholder cooperation are typical obstacles to institutional adaptability. These results indicate that adequate human resources in public institutions are necessary for proactive risk management assistance. (Dany et al., 2015; Khan et al., 2020).

Training Obtainability

Another imperative indicator evaluated to assess the institutional capacity is professional training and expertise, which will help the officials to be well-prepared and responsive to hazards. Several studies have demonstrated that institutional technical resources, such as professional training and expertise, should be taken into consideration while coping with climate challenges. Professional training and expertise in climate change adaptation for agricultural institutions are considered crucial for building adaptive capacity in the face of climate-related risks. Research highlights the need for education and capacity building for built environment professionals and agricultural extension workers to address climate change impacts (Ogunbameru, 2013). Professional frontline extension officers are therefore required to improve their knowledge of climate change issues, including causes, consequences, and adaptation plans (Ozor, 2011). In order to improve performance, the micro perspective of capacity building focuses on the recruitment, training, and retention of skilled personnel for strategically placed organisations (Straussman, 2007). Diehl et. al. (2015) claimed that to comprehend adaptation techniques, interact with stakeholders, and take part in knowledge co-production, extension personnel need to receive conveniently accessible and tailored climate training. They state that it is imperative to create suitable educational modules and curricula for agricultural extension workers in order to efficiently distribute climate change adaptation strategies to farmers. To assist farmers in optimising success under uncertain situations, key areas for training include management methods, technology-related changes, and decision-making tools (Diehl et al., 2015).

To evaluate the professional training and expertise of the officials, the respondents were asked to answer questions about their educational background and experience compared to climate science, environmental policy, sustainable agriculture, and other related subjects from national and international institutions. Then, the interviewee was questioned to answer whether they have participated in any formal training programs, workshops, or seminars conducted by national and international institutions focusing on agricultural adaptation. As a sub-indicator of the training and expertise index, we then asked whether they have practical experience with agricultural practices and climate adaptation strategies in Bangladesh, and/or have practical experience in managing agricultural projects focused on climate adaptation. Finally, they were asked to provide information on any previous climate change adaptation activities they accomplished at the farm level. Following these evaluations, the training needs were assessed by the following questions: ‘Which skills development opportunity would they like to access now?’ This question is asked to describe their specific training interest in the relevant area. Then they were asked to score the adequacy of training programs and briefly depict a summary of the primary difficulties they had encountered.

Table 36: Values of Sub-Indicators (Training Obtainability)

Sub Indicators	Value
Expertise regarding CCA/CRM	47
Working Experience	43.6
Professional Training	35.3
Trained Staff	38.6
Training Obtainability Index (TEI)	**0.50**

The respondents valued the training obtainability at 0.50, indicating that public institutions have only attained a medium degree of training and competency. Results show that only 47% of the respondents possessed some knowledge regarding CCA/CRM even in the absence of training. The majority of them work as project directors in different agricultural adaptation projects and for research organisations. Similarly, more than half of the respondents (57%) reported no prior experience in climate risk management, whereas only 43% mentioned having previous work experience in coastal districts. Similarly, results show that only 38% of the officials received appropriate training through different projects which are not directly related to CCA and CRM. More than 45% of respondents mentioned that they had never attended any training program regarding CCA yet.

> One of the respondents claimed that, '…*training is primarily essential for the SAOs directly engaged in field implementation. Although the institutions provide various project-based training modules, there is an absence of comprehensive training on climate change for officials.'*

Numerous studies emphasised the significance of personnel competencies in terms of incorporating and using knowledge and deploying available resources in opposition to environmental uncertainties (Razali et al., 2011; Fidelman, 2017). According to Wojcik et al. (2014), it's crucial to involve extension employees in long-term professional development programs that will enhance their knowledge of the climate issue and enable them with the skills necessary to properly inform farmers who may be particularly vulnerable to climate change. Ozor and Nnaji (2011) proposed that the focus of extension services should be on retraining extension employees to acquire new professional skills and competencies in crisis management units within extension agencies, building resilience capacities of vulnerable individuals, and setting up emergency management units.

According to the respondents, the efficacy of training programs is hampered by both insufficient and inadequate well-structured systems. Apart from these, the respondents stated that the most frequent obstacles to training efficacy include limited training scope and confined training at the local level. The majority of DAE representatives remarked that there aren't enough training opportunities for both general operations and CCA. They acknowledged that one-day seminars are not very effective at enhancing operational efficiency; instead, longer, more rigorous, and methodical training sessions are needed to yield better results. The fact that remote officials have very limited access to training opportunities was also noted by these officials. Furthermore, the lack of budget and the absence of resource persons were noted as substantial constraints for effective and efficient training. Additionally, as some respondents pointed out, informal relationships and a lack of employee interaction frequently prejudice the training participant selection process. Moreover, the officials identified several areas of need for training, including project procurement, financial management, responding to CCA/CRM, and ICT development training. Respondents from research and field institutions were most likely to perceive these as significant challenges and restricting factors, with nearly 64% expressing these opinions.

Plan and Priorities

It has been discovered in climate change studies that the state's institutions, the market, and civil groups are crucial in deciding how to respond to changing environmental and policy conditions and hazards (Adger 2000; Adger and Brooks 2005; Smit and Wandel 2006). Tompkins and Adger (2004) refer that the presence of organisations and robust networks that plan for shifting risks, environmental, and policy circumstances improves the ability to adapt. Numerous reports highlight the importance of institutions' planning, emergency response systems, and strategic priorities in addressing environmental risks (Huq 2016; Brown et. al. 2013; Hilton et. al. 2015). To evaluate the plans and priorities index of capacity, the interviewees were asked to answer whether or not their institutions considered climate change in the coastal area to be a significant concern. According to 87% of all respondents, CC is regarded as a major concern for coastal agricultural development in their institutions. A considerable majority of the respondents (63%) perceived that climate change is the priority of their institutions, indicating that the institution's efforts in addressing climate change are noticeable and likely impactful. They mentioned that the institutions have strategies and initiatives to mitigate the impact of climate change. Whereas a small section of respondents (8%) feel that their institutions are not sufficiently prioritising climate change.

However, the remaining 29% of respondents mention the institutional priority at an average level. According to them, different institutions have experienced and perceived priorities differently. Those institutions directly involved in CCA projects are only emphasising CC more compared to others. Most of the respondents from BADC and DAE mentioned that they don't have any comprehensive climate action plan or outline specific goals, timelines, and measures to combat climate change. One of the officers wishes for an amalgamated climate change cell to collaborate with other institutions, industries, and communities on climate-related projects for agricultural resilience. To evaluate the capability in terms of institutional plans and priorities, the respondents were asked to score the sub-indicators. Compared to the other sub-indicators, the institutional priorities have a higher score (71.3). However, out of these five sub-indices, the inclusion of climate change adaptation programs in the past possessed the lowest score (40). According to the findings, the plan priorities of public institutions indicated a low rating of 0.41. Most of the respondents indicated that the future program related to CCA is not adequate by necessity. The respondents gave a score of 50, which indicates that they have a moderate level of satisfaction regarding the future initiatives. Nonetheless, the majority of them felt that more regular and varied activities should be implemented. Many respondents from various institutions stated that the emergency response mechanism appears to be rather inadequate. With a score of 55, most of the respondents from different institutions claimed that they had nothing to do with any climatic emergency. According to a DAE officer, there is neither an evaluation of damage caused by the catastrophe nor immediate measures undertaken to assist farmers with financial aid or replanting and restocking.

Table 37: Values of Sub-Indicators (PPI)

Sub Indicators	Values
Institutional Priorities	71.3
Past Programs	40
Present Programs	47.3
Future Programs	50
Emergency Planning	55
Plan and Priorities Index (PPI)	**0.41**

> *'…it has been specified in the Detailed Project Proposal (DPP) which climate change implications are going to be addressed. Moreover, regarding emergency response, there is an oversight.'*
>
> --*Respondent (BADC)*

The development of adaptive capacity and resilience at different levels can be facilitated by climate-resilient agriculture, and institutional capacity for risk reduction and catastrophe management must be strengthened through effective response (Babu et al., 2019). According to Costanza et al. (2001:243), the most appropriate governmental scales will possess the most pertinent information and can respond rapidly and effectively. Numerous researchers mentioned that having clearly defined objectives and a plan in place is one of the most important factors in effectively responding to flood disasters through adaptation and risk management. Institutional emergency planning is closely related to effective risk management (Wenger, Huq, Pakistan). In order to enhance the institution's capacity to handle environmental disasters, the research suggests filling the current gaps in the planning framework.

Room for Autonomous Change

The ability of an institution to allow social actors to modify their behaviour in response to environmental change independently is another aspect of adaptive capacity. According to Polsky et. al. (2007), institutions should give social actors the tools and information they need to anticipate potential outcomes and take proactive steps to prevent significant hazards. Additionally, institutions ought to support people's and groups' independent ability to improvise. (Folke et al. 2005, Pelling & High 2005). Tierney et. al. (2006) mentioned that institutions must establish a mechanism to acknowledge the social actors to seize opportunities because studies show that during emergencies, immediate relief efforts are undertaken by 'victims' and not by the government or aid organisations. Numerous studies show that in order to deal with data efficiently, an organisation has to balance these three components. Access to information ensures data is available, acting according to plan guarantees that operations are consistent with organisational goals, and improvisation allows for agility in the face of unexpected challenges. Together, they form a comprehensive framework for robust data management.

Farmers rely on agricultural and climatic data, which is derived from a variety of sources, including conventional wisdom, information and communication technologies, and institutional frameworks (Jha & Gupta, 2021). Moreover, A number of organisations, however, experience difficulties in acquiring nationally generated data and lack the capacity for information management and website maintenance (Gumbs, 2005). Jha and Gupta (2021) demonstrated that farmers will more effectively adapt to climate change if they have better access to timely and accurate climate information and agricultural extension services. This will enable them to make better choices about the future while executing comprehensive adaptation strategies.

Criteria to assess the room for autonomous change include understanding whether institutions ensure that actors (a) have continuous access to information, (b) are capable of acting according to plan and (c) have the capability to improvise. The following questions were asked of the respondents to gauge the institutional capacity for data management and information congregating: Do the institutions commit to managing and disseminating information on climate vulnerability, hazards, and impacts to support agricultural decisions regarding adaptation, as well as the victims' ability to act proactively and improvise? In addition, the respondents were asked to indicate whether or not the information was sufficient and whether or not the organisation's goals and objectives aligned with the efforts being made to give priority to data.

The respondents were also asked if the employees were capable of analysing and providing data to support decision-making and to enhance farmers' ability to adapt. Based on the assessment, 83.3% of the respondents stated that their institutions have the mandate to manage and provide information on climate change vulnerability, hazards, and impacts to support adaptation. On the other hand, 5.6% stated that the information provided is connected to tolerant varieties only, while 11.1% of respondents believed there is no explicit mandate for climatic information for adaptation. Approximately 55% of them believe that the organisation can obtain and provide information quickly, which is fairly good, while 28% believe that the data management system is mediocre, and 9.6% think the information management system is very poor. The overall score of access to information is 66.9, which indicates that there is a moderate level of accessibility to relevant data and information that could help farmers, policymakers, and other stakeholders adapt to changes in agriculture, such as those driven by climate change. Most respondents mentioned that considerable gaps and challenges still need to be addressed to improve the accessibility and utility of the information.

Table 38: Values of Sub-Indicators (AII)

Sub-indicators	**Values**
Access to Information	66.9
Act according to plan	50.2
Capability to Improvise	38.7
Room for Autonomous Changes	**0.50**

Through the sharing of information, extension agents can significantly contribute to the strengthening and support of sustainable agriculture practices. Value-added climate information and advisories minimise this uncertainty and enable farmers to better manage risk, take advantage of favourable climate conditions, and adapt to change with the help of supportive institutional assistance and policies (Rupan et. al. 2018). According to P. Dorward et al. (2020), there is a notable deficiency in the utilisation of past climate data for project design and planning, even if institutions have a strong understanding of climate change. The majority of respondents, 89% (54% high, 28% moderate, and 7% very high), state that institutional staff members are competent, skilled, and well-informed when it comes to providing information on hazards and consequences, analysing climate scenarios, and assessing climate vulnerability, which will assist in determining adaptation strategies.

A roadblock to adaptation has been identified as the inadequate accessibility and availability of pertinent climate information (Adger et. al. 2007). At the same time, careful and adaptable planning that is realistic, sound and meets the actors' varied interests is difficult because the majority of adaptation measures are typically developed and carried out by public actors inside of nationally structured systems that are inflexibly bureaucratic, gradual, and frequently minimize the contributions of numerous other actors (Chaudhury et al. 2017; Adger et al. 2005; Scott 1998). According to the study, the majority of respondents, 58%, state that the institutions' ability to produce climate records and evaluate information and data to meet the demand for adaptation to climate change is limited. The officials who indicated the ability of the institution to generate climatic data were mainly from the extension department (DAE).

> *'...there has a very strong information mobilisation in the DAE, BADC, BWDB. The emergency messages regarding agricultural information are transmitted quickly to the field level at the right time. Moreover, the flow of information becomes much easier through SMS. In addition, webpage-based information, a forecasting system developed by SPARSO, the BAMIS portal, and GIS are introduced to develop the agricultural information management systems.'*
>
> *--Respondent from AIS*

In addition, a majority of the respondents from DAE, 44% (8% very low, 36% moderate) stated that the extension department with BARC develops the information and data management systems, including the regulations, facilities and tools needed to compile, monitor, and analyse relevant climatic data. Yet 56% of the respondents think that their institutions have limited capacity to access and collect historical data on climate change adaptation, which will affect the institutions' capacity to learn from the previous activities and impacts of climate change. A score of 50.2 for the ability to act according to plan denotes an average but uneven alignment between planned strategies and their actual implementation in terms of available resources, lack of coordination, and/or unanticipated implementation obstacles. However, 41% of the respondents contend that institutions need to be proficient in quickly pivoting and adjusting their data management practices without compromising data security or quality to handle unexpected challenges. Among the sub-indicators, their capacity to improvise had a lower score of 38.7.

Table 39: Institutional Capacity Index (ICI)

Indicators	**Sub Indicators**	**Value Of 55 respondents (215*100/275)**	**Institutional Capacity Index (ICI)**
Climate Perception and Knowledge (PKI)	Climate Change Perception	78.2	.52
	Perceived Impacts of Climate Change	73.1	
	Knowledge of CCA Practices	65.5	
	Acknowledgement of CCA Practices	64.7	
Coordination and Collaboration (CCI)	Intra-Institutional Coordination	66.9	.60
	Community Coordination	65.5	
	Inter-Institutional Collaboration (Public)	62.6	
	Inter-Institutional Collaboration (Private)	57.5	

Resource Availability (RAI)	Physical Resources	Machine/Equipment Availability	49.5	.39
		Machine/Equipment Requirement	74.6	
		Machine/Equipment Availability for CCA	44.7	
	Financial Resources	Funds Availability	42.6	.34
		Funds Sufficiency	42.2	
		Funds Requirement	77.1	
	Human Resources	Staff Availability	50.6	.37
		Training Needs	76	
		Staff for CCA	47.6	
Training Obtainability (TEI)		Expertise in Climate Change Adaptation	47	.50
		Working Experience	43.6	
		Professional Training	35.3	
		Trained Staff	38.6	
Plans and Priorities (PPI)		Institutional Priorities	71.3	.41
		Past Programs	50	
		Present Programs	47.3	
		Future Programs	40	
		Emergency Planning	55	

Room for autonomous (IAI)	Access to Information	66.9	.50
	Act according to plan	50.2	
	Capability to Improvise	38.7	
Institutional Capacity Index (ICI)			**0.48**

Equation 1: Institutional Capacity Index Calculation

$$\textbf{Institutional Capacity Index (ICI)} = \frac{(PKI) + (CCI) + (RAI) + (TEI) + (PPI) + (IAI)}{6}$$

or, ICI= (.52+.60+.37+.50+.41+.50)/6

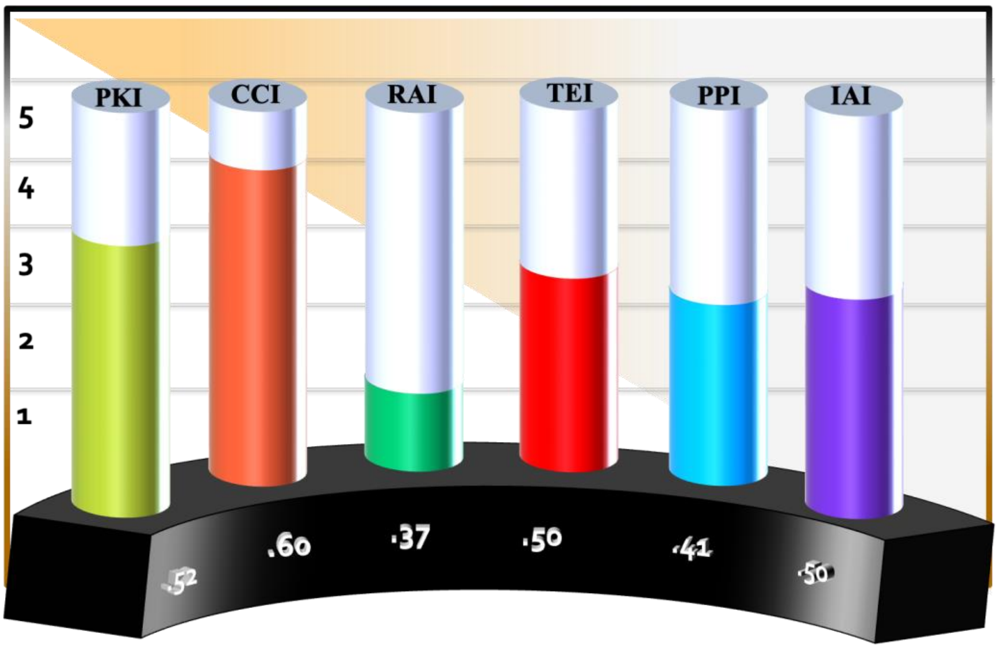
Institutional Capacity Index (ICI) = 0.48

The UNDP index aggregation approach was used for assembling the capacity of the institutions into a set of specifically chosen indicators and sub-indicators. The index calculation method applied a normalisation technique to generate an index-based value, converting the variable values into a uniform unit. In the study, an Institutional Capacity Index (ICI) score of 0.48 was calculated, reflecting a medium degree of institutional capacity for addressing climate change and agricultural adaptation in coastal regions.

The outcome of the study indicates that institutions possess the lowest financial capacity (0.34), followed by deficiencies in physical (0.39) and human (0.37) resources, while the institutions have a high index value for climate change perception (78.2), signifying an extensive knowledge and understanding of climate change at the institutional level. The study indicates that intra-institutional collaboration (66.9) and community coordination (65.5) exceed inter-institutional collaboration (62.6) among public institutions, while collaboration with private entities (57.5), which is overstated, is notably unsatisfactory. Respondents from relevant non-governmental organisations (NGOs) and private organisations (POs) working in coastal districts reported lower cooperation from public institution employees, while some respondents considered private collaboration as not particularly significant for adaptation.

The study found that out of all the indicators, the overall Coordination and Collaboration Index had the highest value of 0.60. Adaptation to climate change received the lowest value for trained personnel (24.6) and professional training (27.3). The majority of respondents advocated for enhanced professional training. Aside from this, the majority of the indicators exhibited a moderate value.

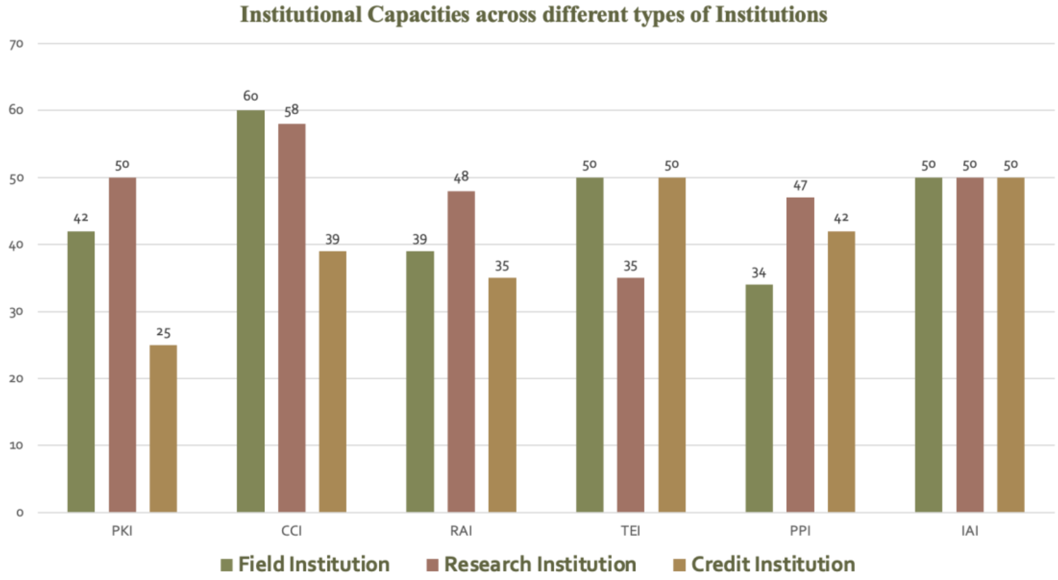
Figure 56: Findings of ICI for Six Indicators



Institutional Capacities Across Different Types of Institutions

The institutional capacity of agriculture in various locations to respond to climate change is examined through comparative analysis. By providing farmers access to knowledge and technological assistance, public institutions are vital for the development of agricultural resilience. However, financial, physical, and human resource constraints often limit their effectiveness (Khan et al., 2020; Keshavarz & Karami, 2013). The agricultural institutions were divided into three groups, such as research, field, along with market and credit institutions, in order to compare ICI and have a comprehensive understanding of institutional capacities across various types of institutions. Study shows that the cumulative ICI values (Fig.58) for research institutions have achieved a higher index value, whereas credit, market and field institutions are among the institutions with the lowest capacities. Furthermore, the ICI values indicate that the field institutions had high values for perception and knowledge regarding the impacts of climate change. This may be attributed to their extensive practical expertise in the field and consistent interaction with local farmers. Through the exchange of information, they can develop a more comprehensive understanding of the climate-related risks and CCA practices implemented on farms. Furthermore, financial resources exhibited the lowest value among all categories of institutions. Research institutes exhibited a superior index value for plans and priorities related to CCA.

Figure 57: Institutional Capacities Across Different Types of Institutions



In contrast, field, credit and market institutions lacked in this indicator, highlighting the need for planning and prioritising the climate change agenda among these institutions. In terms of physical resources, which are regarded among the most critical resources, they revealed alarming indications as both research and field institutions had a deficient amount of machinery and hardware resources. These findings imply that focus should be given to these institutions as they play a more crucial role (in terms of community support) when compared to credit and market institutions. Field institutions were also found lacking in terms of human resources, which could constrain the efficiency of these institutions in managing farm-level activities.

Table 40: Summary of Findings

Dimension	Capacity Level	Major Findings
Perception and Knowledge **Coordination and Collaboration** **Resource Availability** **Training Obtainability** **Plans and Priorities** **Access to Information**	**Poor to Average**	**Shortage of logistics and physical Resources**
		Shortage of Skilled Manpower
		Limited Coordination among the institutions
		No climate-specific training opportunity
		Inadequate Financial Resources regarding the need
		Inadequate accessibility and availability of pertinent climate information
		Research Institutions are moderately capacitated in each dimension, rather than the field, credit and marketing institutions

Conclusion

This chapter delineated the empirical findings of the study in a structured and systematic way, precisely corresponding with the research objectives and questions. The chapter systematically presented the findings of institutional capacities related to climate change adaptation in terms of knowledge and perceptions, coordination and collaboration, resource and training availability, plan and priorities and information access for effective adaptation in Bangladesh. The results demonstrated that in the public institutions, the perception and knowledge of the officials is very satisfactory regarding climate change impacts and adaptation strategies. The intra-institutional coordination is good enough, but the coordination among different agencies and the private sector is average in nature. Although the policies and governance practices formally emphasises on inter institutional coordination and public-private collaboration, a coordination gap exists because of superiority complexities of intergovernmental institutions, mutual distrust, and poor negotiation skills still constrain effective adaptation, particularly in the coastal areas. The findings further reveal that the effective adaptation remains constrained by limited physical and human resources, inadequate technical expertise, inadequate financial resources and training gaps. Furthermore, responses from participants indicate weaknesses in data management and information accessibility of the institutions. Key findings of the study demonstrate that insufficient accessibility and availability of relevant climate information restrict the institutions' ability to respond effectively. Overall, the findings highlight a significant gap in policy commitments and institutional performance that both require improvement.

Chapter Seven

Conclusion

"Adaptation is not a cost – it is a lifeline."

António Guterres
UN Secretary-General

Chapter Summary

This chapter presents the concluding remarks of the study, revisiting the objectives and research questions in light of the findings. It synthesises the key insights derived from the analysis, identifies the prospective areas for future research, reflecting on the limitations.

- *Introduction*
- *Revisiting the Research Objectives and Questions*
- *Principal Contribution of the Research*
- *Prospective Areas of the Research*
- *Conclusion*

Introduction

One of the most severely affected nations by the catastrophic consequences of global warming and climate change is Bangladesh. As a result of its geographical and topological characteristics, Bangladesh is confronted with substantial obstacles in adjusting to the effects of climate change simultaneously. Bangladesh assumed responsibility for the establishment, development, and implementation of the legal framework and was held accountable for the enhancement of the adaptive capacity of government institutions, agencies, civil society, and the private sector to address environmental issues by signing the bottom-up treaty of the Paris Agreement. Climate change has been incorporated into the poverty reduction strategy by the government of Bangladesh. The country is particularly susceptible to extreme weather events, such as cyclones, floods, and storm surges, due to its vulnerability to climate change. Its vulnerability is caused not only by its biophysical factors, like being a flat, low delta country exposed to flooding and cyclones, but also by its socio-economic factors, such as high dependence on agriculture, population density, and poverty. The central and western coastal area, the north-western highlands, and along the main rivers are the hotspots of climate change vulnerability, where both biophysical and socio-economic vulnerability are high (MOEF, 2018). Climate change will severely challenge the country's ability to achieve the high rates of economic growth needed to sustain these reductions in poverty. In the coming years, it is predicted that there will be increasingly frequent and severe floods, tropical cyclones, storm surges, and droughts, which will disrupt the life of the nation and the economy. Therefore, the international community and the government of Bangladesh prioritise the enhancement of human, institutional, and organisational capabilities. Implementing the techniques will enhance the precision of the concerns.

Considering the vulnerability of the agricultural sector of coastal areas, the study assessed the capacities of public institutions in two coastal districts in

Bangladesh. An index technique based on six core indicators and twenty-eight sub-indicators is used to conduct the evaluation. This research shows the significance of climate change adaptation and assessment of institutional capacity as fundamental issues for developing nations. It has examined the challenges and opportunities of the public institutions' agricultural adaptation in coastal areas. The study illustrates the significant policy frameworks, such as the National Adaptation Program of Action (NAPA, 2005, updated 2009), BCCSAP (2009), and Coastal Zone Policy (2005), as well as the adaptation initiatives implemented by public institutions that are directly involved in agricultural development, credit, and marketing systems. In coastal regions, public institutions are making substantial contributions, despite the numerous obstacles associated with agricultural adaptation.

The research was guided by the predominant approaches for assessing institutional adaptation capability. The study was conducted using a mixed-methods approach, which included a combination of quantitative and qualitative methods. The secondary data was collected by document analysis, literature review and policy papers. The primary data for assessing the institutional capacity were derived from the semi-structured interviews with officials and stakeholders who know about agricultural adaptation and the impacts of climate change on food production. Using a grounded theory methodology, the qualitative study collected data from in-depth interviews on participants' opinions, evaluations, and ideas regarding the institution's ability and effectiveness in carrying out adaptation programmes. On the other hand, the quantitative study employed a questionnaire survey to gather input on the agricultural adaptation programmes' implementation process from field officials and employees. The primary goal of this research was to investigate the perceptions and knowledge of the participants regarding the effects of climate change, coordination among the stakeholders, information access, plan priorities and actions, as well as each institution's resource availability for the implementation of agricultural adaptation programs in two coastal districts. The degree of adaptability of the public institutions promoting agricultural growth at various levels of governance has been examined in the thesis.

Revisiting the Research Questions

In order to address the effects of climate change on agriculture, particularly concerning agricultural adaptation, the study sought to evaluate the adaptive ability of the public institutions operating in coastal areas. The study mainly focused on the institutional adaptive capacity assessment theories and their consistency with the public institutions in Bangladesh, and thus assessed the institutions' adaptive capacity under selected dimensions of capacity assessment. Five particular and general research questions were posed by the study in light of the situation. In an attempt to address the research questions, this section summarises the main conclusions of the study.

Research Question 1: What are the major impacts of climate change on the coastal agricultural sector in Bangladesh?

A wide variety of literature describing the effects of climate change on agriculture has been examined to address the impacts of climate change. There is a lot of evidence from research and interviews showing coastal farmers are dealing with problems such as saline intrusion, high temperatures, excessive evaporation, changes in the pattern of precipitation, variation in cropping patterns, a lack of water for irrigation, disease outbreaks, and a decline in crop immunity. Decrease in production, crop yield loss, insect infestation, a decrease in soil fertility, drought and excessive water logging, loss of topsoil are identified by the respondents as significant impacts of the coastal region, directly affecting the harvest quality and production quantity.

This research illustrates the policy initiatives and action plans of the institutions that are directly working on the agricultural production, credit and marketing systems in the coastal areas. In this context, the study first focused on the agricultural activities and production process to understand the present state and impact of climate change on coastal agriculture. The research identifies that temperature rise, salinity intrusion, waterlogging due to heavy rainfall and changing precipitation patterns are the main impacts of climate change on crops in coastal areas. The main effects of the shifting climatic patterns on crop growth, productivity, and quality, as well as the dynamics of pests and diseases, were elicited from the respondents. Temperature increases, longer summers, and delayed rainfall were the three most prominent changes in coastal climate patterns mentioned by almost all respondents. The increase in temperature and frequent heatwaves accelerates crop maturation and affects crop quality. Higher temperatures are degrading soil health by increasing the rate of decomposition of organic matter, making it harder to sustain crops. Moreover, the main characteristics of the agricultural sector, as well as institutional arrangements for agricultural governance in coastal Bangladesh, were also studied thoroughly with the purpose of providing background information and insights on the opportunities for and limitations on wider adaptation initiatives in the country.

Research Question 2: What is the existing institutional and policy framework for supporting agricultural adaptation in coastal areas?

The study illustrates the policy process of the implementation of climate change adaptation in coastal districts in Bangladesh to answer the first question. The adaptation action plans in Bangladesh are carried out based on BCCSAP and NAPA, which are the policy guidelines for climate change adaptation in Bangladesh. There were certain government agencies, ministries and departments for agricultural production, marketing and credit distribution working at the grassroots level to achieve the targeted level of crop production set by the government to achieve. Among them, the thirteen (13) institutions under the Ministry of Agriculture (MOA), the Ministry of Finance (MOF) and the Ministry of Environment, Forest and Climate Change (MOEFCC) were selected to assess the adaptive capacity for agricultural adaptation in the coast.

Research Question 03: Do the institutions have any adaptive measures to increase their capacity for climate change adaptation?

The institutions' primary goals are food security and general agricultural growth. Adaptation efforts are being carried out concurrently with the rise of climate-related problems and natural disasters. Several adaptation projects have already been completed by DAE, BADC, BARC, and wide-tolerant varieties like BRRI Dhan (51, 52, 56, 57, 79, 66, 67, 97, 99), BINA Dhan 17, and BINA Dhan 10 have been developed by the NARS (BRRI, BARI, BINA). BRRI is now working with 12,610 pollinators from 12 crossings, focusing on the rising salinity along the nation's coast, to develop more resilient and sustainable rice varieties. BRRI is currently working with 12,610 pollinators from 12 crossings, focusing on the rising salinity along the coast, to develop more resilient and sustainable rice varieties.

Research Question 04: How far are the institutions capable of addressing the climate change issues?

The study attempted to understand the adaptive capacity of public institutions within the framework of indicator-based capacity assessment. Considering the existing empirical studies and institutional capacity assessment approaches, six indicators were selected to assess the institutional capacities dealing with climate change adaptation in agriculture. A total of 29 sub-indicators were created by breaking down each of the chosen indicators into three to five smaller indicators that were related to the study's primary goals. The dependent variables of the study were the adaptive capacity of the institutions. The independent variables were the perception and knowledge of climate change, the level of coordination and collaboration, the degree of resource availability, the availability of training and expertise, plans and priorities and the level of access to information. Compared to the credit and marketing authorities, it was discovered that the research organisation's officials had a higher degree of perception and knowledge about how climate change affects agricultural output. Field office respondents express a moderate opinion on climate change issues. The degree of coordination and collaboration among the institutions, community and stakeholders was measured at different tiers. Under the BARC guidelines, the research institutions exhibit the highest degree of cooperation. However, intra-institutional coordination is at a high degree, in contrast to inter-institutional cooperation.

Nearly all the institutions suffer from a lack of financial, human, and physical resources to deal with the impacts of climate change. Most of the research organisations have limitations in well-equipped laboratories in the field areas. Credit institutions have a critical shortage of infrastructure and office equipment to conduct general operations. The marketing institutions reported the shortage of infrastructure and cold storage as a primary obstacle limiting their effectiveness in conducting field operations. The research indicates that most institutions are under-resourced in terms of human capital. Most of the institutions have limited scope and opportunities for general operations and for emergencies. The majority of the training does not explicitly address professional skills and competencies associated with adapting to climate change. The majority of the employees working on climate change adaptation projects did not have prior experience in climate risk management or had not obtained the necessary training related to it.

Though coastal agricultural development is considered a major concern of the institutions, only the institutions directly involved in climate change adaptation projects are emphasising climate change more compared to others. Furthermore, there is no comprehensive climate action plan or outline of specific goals for agricultural adaptation. The institutions themselves lack an action plan to evaluate the effects of the catastrophes, and they are not mandated to take prompt action to support farmers in the event of a climate emergency. According to the study, the sixth indicator- access to information to meet the demand for adaptation to climate change is limited. The information and data management system, which includes regulations, facilities and tools needed to compile, monitor, and analyse pertinent climate data, was created by BARC in collaboration with the extension department.

Research Question 05: What are the barriers to Climate Change Adaptation (CCA) in coastal districts in Bangladesh?

The study aims to identify the factors that influence the implementation of adaptation projects in coastal areas. It finds that inadequate knowledge, poor coordination, limited resources, and weak governance are the main institutional barriers to effective agricultural adaptation. There is also a lack of suitable strategies and techniques to address the impacts of climate change. A significant obstacle is the insufficient understanding of stakeholders, which hampers the implementation of risk management strategies. While national adaptation programmes often focus on mainstreaming climate change into action plans, specific policy measures are necessary for agricultural adaptation. Effective agricultural adaptation demands strong inter-institutional coordination and cross-sector collaboration to ensure efficient planning and outcomes. However, poor coordination among ministries such as agriculture, fisheries, water resources, environment, and disaster management, along with unclear institutional roles, results in inefficiencies and duplicated efforts. The findings reveal limited cooperation between the private sector and NGOs, with public institutions primarily handling agricultural adaptation. There is no direct coordination between the farmers and any of the institutions other than DAE in terms of community cooperation.

Furthermore, both qualitative and quantitative data found that another significant institutional impediment is the lack of available resources. Most of the institutions have inadequate financial capacity, technical expertise, and insufficient human resources that limit their ability to provide extension services, region-based introduction to tolerant varieties and dissemination of adaptation technologies. In all kinds of institutions, the shortage of vehicles, infrastructure, machinery, laboratory equipment, and cold storage facilities is found. The data findings also show that bureaucratic procedures are causing issues with access to climate money, particularly during emergencies. The local agriculture officials do not have the authority or resources to carry out their duties. The institution's agricultural adaptation experienced numerous obstacles, including inadequate advanced training programs and technologies, limited access to information, and a lack of monitoring and evaluation.

Principal Contribution of the Research

This study examines how officials perceive their experiences conducting general operations and crises, as well as the adaptive capabilities of governmental institutions working on agricultural adaptation in coastal areas. The study shows that there is a significant impact of climate change on agricultural production, irrigation, crop health, and nutrition. The institution faced challenges in implementing the adaptation process, including policy procedures, collaboration, funding circulation, project distribution, and accessibility to advanced research and training. The study assesses the institutional adaptive capacity for agricultural adaptation in two coastal districts based on an indicator-based approach. None of the prior studies adopted any index assessment method to assess these public institutions' adaptive capacity to understand the coastal agricultural adaptation under the remaining circumstances. A detailed analysis offers a comprehensive understanding of the adaptive capacity of the selected institutions from different dimensions, compared to several previous studies so far.

Firstly, it acknowledges the importance of developing an integrated indicator-based capacity index assessment approach as a means to assess the adaptive capacity of institutions dealing with environmental challenges. Due to the absence of a comprehensive study on institutional assessment in Bangladesh, mostly the institutions dealing with environmental contests, this research could be particularly useful as it developed an index approach based on six indicators by using the renowned institutional adaptive capacity assessment theories. Rather than applying the established theories of the capacity assessment approaches, the study develops a context-specific, knowledge-based index approach that is more relevant for studying the institutions in developing countries like Bangladesh. These indicators may be used to evaluate the structure of any kind of public institution in Bangladesh, which will help towards an inclusive evaluation of its capacities.

Secondly, the research primarily focuses on the specific indicators that are prerequisite for the effective operation of the institutions, as well as necessary to conduct climate risk management. The impact of climate change on agricultural productivity and food security must be better understood in order to implement effective adaptation measures, particularly for the authorities who have direct involvement in farm operations. Some theories emphasise the economic indicators, some on social capacities, and some others on adaptive capacities to assess the institutional capacity. This study integrates the coordination, knowledge about hazards and impacts, knowledge about formal and informal institutions, resource availability, and continuous access to information to evaluate the adaptive capacity for adaptation. With the action plans of the government of Bangladesh, the Ministry of Environment, Forest and Climate Change (MoEFCC), and the Ministry of Agriculture (MoA) administer the overall planning and implementation of adaptation in coastal areas. Lack of coordination among the inter-ministerial and inter-departmental agencies severely challenges the quality and quick response of adaptation governance.

Thirdly, the research examines how the limited ability of public institutions to respond to climate consequences is caused by their lack of coordination, financial, physical, and human resources. Resource availability is considered one of the most important factors in responding to climate change and a significant determinant of capacity assessment (Jessani et al., 2014). The study emphasises institutional resource availability and resource requirements for successful operation in two coastal districts. And the result shows that the limited logistic facilities restrict the field operations of the institutions working at the farm level, especially in the Patuakhali district. Additionally, the research organisation complained about having limited laboratory facilities at regional offices. Most organisations reported that they do not have specific financial support for climate risk management, and there is a gap between fund availability and requirements.

Finally, to be more precise in identifying obstacles for coastal agricultural adaptation, the study developed an inclusive mixed-method approach to address the limitations of the previous research. The idea of a mixed method approach is not unique, but the studies from institutional capacity assessment rarely employ the mixed method approach to assess adaptive capacity. The study employs a mixed-method approach with four stages, which is a methodological step towards research completeness: selecting pertinent studies, developing and applying context-specific indicators, and assessing the contextually derived indicators. This research has created a new prospect for evaluating the adaptive potentials of public institutions in Bangladesh. Mostly, studies on public institutions' capacity assessment used a quantitative approach utilising structured interviews and document analysis as the main data collection techniques. The majority of the research focuses on how farmers see the provision of services. Very little research addresses the use of mixed approaches to evaluate the institution from the perspective of the officials who work there or directly provide the services. Although the main focus of the study was on the institutions' capacity for adaptation and agricultural production in coastal areas, the entire research approach may be applied to assess the adaptive capacity of all public institutions.

The study's particular results should be considered while attempting to hypothesise agricultural adaptation and adaptive capacity.

Prospective Areas of Research

Although the current study has provided a comprehensive evaluation of the adaptive capacity of the public institutions in two coastal districts in Bangladesh, future research should focus on the processes and potential integration of the findings into institutional capacity building. The perspective and contentment of farmers with the services provided by public institutions in the chosen coastal regions have not been included in this study. Although the most important indicators for institutional operations were examined, certain components remained unexplained, possibly requiring further research to investigate the monitoring and evaluation, project assessment, and psychological aspects of adaptation belief and adaptation motivation. The study has identified the challenges and limitations of implementing adaptation on the coast until 2023; it will be worth examining the newly adapted projects and techniques in information access management and smart agricultural technology in future research. Simultaneously, future research can try to take into account the surveys of farmers, including beneficiaries and smallholder farmers. The capacity of the institutions will help to understand the strengths, weaknesses and resource gaps of the institution, such as extension services, research organisations and local government bodies that are responsible for the policy implementation, technology dissemination, and community-level support.

To assess the adaptive capacity more comprehensively, future research might concentrate on developing a more integrated framework that includes inter-institutional, technological, social, and environmental aspects to evaluate the institution's adaptive capacity more holistically. The use of digital tools, data analytics and GIS-based monitoring of adaptive responses will get more attention from researchers in future studies. Assessment of multi-level governance in terms of coordination between the national, local and regional levels and the degree of horizontal coordination among the institutions can also be investigated more thoroughly by the researcher. Furthermore, the researcher may also investigate the influence of gender equity, social inclusion, and local community knowledge on enhancing institutional capacity for climate adaptation. Future researchers may conduct comparative studies across regions or districts, examine public-private partnerships, explore financing mechanisms for institutional capacity building, and analyse capacity building models, which could provide valuable insights and strengthen institutional resilience and sustainability. Finally, future research may facilitate evidence-based policy reforms that match institutional capacity with national and international climate change adaptation objectives, including the Sustainable Development Goals (SDGs).

Conclusion

Bangladesh is the worst victim of the impacts of climate change and environmental challenges due to its geographical location. Salinity intrusion, flood, rising temperature, and delayed monsoon are the major climatic issues that have an impact on agricultural production and the livelihoods of the community. Effective adaptation is badly needed for sustainable development to make communities more resilient. The institutional capacity assessment provides comprehensive perceptions on the strengths, weaknesses, and ambiguities of the existing institutional arrangement and action plans, as well as emphasising the importance of strong coordination among agencies, resource accessibility, knowledge sharing and policy implementation mechanisms for improved adaptation.

The research findings indicated that with the existing challenges regarding agricultural adaptation, the adaptation efforts by the public institutions along the coast are relatively satisfactory, and to some extent, there has been a notable increase in production compared to previous levels. The institutional capacity index 0.48 specifies that institutions have a moderate level of preparedness and capacities in climate change adaptation and climate risk management. The result identified the lack of effective administrative coordination, inadequate financial, physical and skilled human resources, and a lack of professional and advanced training as the major obstacles towards effective adaptation of the institutions. The research further provides a comprehensive understanding of climate change and its impacts on agricultural production. Findings show that the majority of the respondents mentioned that an increase in average temperature, a decrease in rainfall, an increase in heatwaves, a variation in the temperature between day and night, and a shift in cropping calendars in their particular zones. Climate-induced germination process, pest attacks, and incidents of disease are also reported by the respondents. Understanding these negative impacts of climate change is important for effective institutional action plans. A well-capacitated institutional support for the farming community in Bangladesh by addressing the climate-induced challenges effectively requires an effective administrative structure, a significant increase in resources and the concerns of the policymakers, higher authorities and international agencies are desirable.

From the above analysis, the following broad conclusion can be drawn:

> Agriculture is essential for socio-economic sustainable development in Bangladesh. The agricultural sector significantly improves national food security and serves as a primary source of employment, providing livelihoods to a significant portion of the population; consequently, it plays a crucial role in poverty alleviation. However, climate change poses major challenges to agricultural systems throughout the world, especially in climate-vulnerable countries like Bangladesh, where agricultural adaptation becomes more critical due to significant exposure to climate change effects, including elevated temperatures, erratic rainfall, flooding, drought, saltwater intrusion, and cyclones. Nowadays, the key priority of government initiatives is adaptation, particularly regarding agriculture. Effective adaptation enhanced institutional adaptive capacity that

combines strengthened governance, adequate resource allocation, capacity building initiatives, improved information and knowledge management. The study primarily investigated the adaptive capacity of public institutions in addressing the implications of climate change. The findings indicated that public institutions have significantly advanced in incorporating climate change factors into policies, plans, and programs, with a reasonable level of intra-institutional coordination. Still, their overall adaptive capacities remain inconsistent and are hindered by structural, financial, and technical constraints. The study highlights the limited financial resources, inadequate machinery and technical expertise, and fragmented coordination as the major challenges for effective coordination. Furthermore, international agencies such as IPCC and UNFCCC also emphasise the adaptive capacity building of public institutions for effective agricultural adaptation. Consequently, the findings of the study will contribute to a better understanding of knowledge on institutional adaptive capacity and agricultural adaptation, and can provide practical insights for policymakers, planners and development practitioners aiming to improve institutional preparedness and resilient climate change adaptation.

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Appendix

Questionnaire

Capacity Assessment of Public Institutions for Climate Change Adaptation: Evidence from Coastal Districts in Bangladesh

Background Information

1.1.Respondent's name

____

1.2.Email address:

____

1.3.Gender of respondent:

Female__________ Male __________Other__________

1.4.Age: (26-35) ___ (36-45) ___ (46-55) ___Over 55______

1.5.Educational Qualification:

____

____

1.6.Name of the organisation:

____

____

1.7. Position held in the organization:

____

____

1.8. Type of organisation:

Government __ Academic ___ Private ___ NGO ___ Civil Society Group ___ Donor/international organization ___

1.9. Nature of work of the organisation:

Research __ Project Implementation __ Advocacy __ Policy__ Project M&E __

1.10. Disciplinary training or field of specialization of respondent:

____

____

____

____

____

____

1.11. How is your organization or how are you related to climate change adaptation?

What is the name/title of a specific climate change adaptation activity in agriculture/fisheries/livestock for which you can provide additional information? Write none if there is no specific project.

1.12. Kindly provide some description or information on the type of activity mentioned in Q1.11 above. If you prefer, kindly send some project documents/reports to the email provided above.

Dimension 1: Climate Perception and Knowledge

Climate Perception and Knowledge	**Score** (use a scale from 1 to 5 where 1= lowest and 5 = highest; NA if not applicable)					**Opinion**
1.1 Climate Change Perception	**1**	**2**	**3**	**4**	**5**	
a. To what extent is the climate pattern changing in the coastal zone?						
b. What are the major changes that occur in the local climate?						
1.2 Perceived Impacts of Climate Change	**1**	**2**	**3**	**4**	**5**	
c. To what extent, impacts of climate change (floods/droughts/salinity/sea level rise/heat intensity/rainfall/biological hazards) affect the production?						

1.3 Knowledge of CCA Practices	**1**	**2**	**3**	**4**	**5**	
d. To what extent is the institution coping with the negative impacts of CC?						
e. What are the major adaptation initiatives the institution is working on?						
1.4 Acknowledgement of CCA Practices	**1**	**2**	**3**	**4**	**5**	
f. To what extent do institutions have an action plan to avoid farm-level impacts of climate change?						

Dimension 2: Coordination and Collaboration

Coordination and Cooperation	Score					Opinion
2.1 Intra-Institutional Coordination	**1**	**2**	**3**	**4**	**5**	
g. On a scale of 1 to 5, how much do the ministry/department/units coordinate and collaborate within the same institutions at the national and subnational level for adaptation planning and implementation?						
2.2 Community Coordination	**1**	**2**	**3**	**4**	**5**	
h. On a scale of 1 to 5, how much do the ministry/department/units coordinate and interact with the farming communities at the national and subnational levels for adaptation planning and implementation?						
2.3 Inter-Institutional Collaboration (Public)	**1**	**2**	**3**	**4**	**5**	

i. On a scale of 1 to 5, how much do the ministry/department/units coordinate and collaborate with other public sector institutions at the national and subnational level for adaptation planning and implementation?						
2.4 Inter-Institutional Collaboration (private)	**1**	**2**	**3**	**4**	**5**	
j. On a scale of 1 to 5, how much do the ministry/department/units coordinate and collaborate with the private sector's institutions at the national and subnational levels for adaptation planning and implementation?						
k. Is the institutional engagement and partnership building a priority for the ministry/department/ unit in supporting the implementation of the national adaptation priorities?						

l. Do the climate policies and existing institutional arrangements support the ministry/department/unit role in engagement within the research/public/private institutions on climate change adaptation?						
m. What are the coordination and collaboration strengths and gaps?						
n. What additional initiatives will be needed to improve Coordination and collaboration?						

Dimension 3: Resource Availability

Resource Availability	**Score**					**Opinion**
3.1 Physical Resources	**1**	**2**	**3**	**4**	**5**	
o. On a scale of 1 to 5, how much do the ministry/department/units have **physical resources, e.g. machines and equipment** availability for general operations at the national and subnational level for adaptation planning and implementation?						
3.2 Financial Resources	**1**	**2**	**3**	**4**	**5**	
p. Any financial support being provided for CCA in your organisation? If yes, how much and the procedure?						

q. On a scale of 1 to 5, how much does the ministry/department/units **have sufficiency of available finance** in terms of meeting challenges at the national and subnational level for adaptation planning and implementation?						
3.3 Human Resources	**1**	**2**	**3**	**4**	**5**	
r. On a scale of 1 to 5, how much does the ministry/department/units have **the staff availability** for general operations at the national and subnational level for adaptation planning and implementation?						
s. On a scale of 1 to 5, to what extent **are the staff capable of meeting** the challenges of CC and operational procedure?						

t. On a scale of 1 to 5, how much does the ministry/department/units have **the staff availability for CCA emergencies** at the national and subnational levels for adaptation planning and implementation?						
u. How far is the educational background of the staff relevant to the sectors working on?						
v. Whether staff need training on CCA or not?						

w. What additional skill will be needed to increase the staff capacity?						
x. Is the staff capacity development being a priority for the ministry/department/ unit in supporting implementation of the national adaptation priorities?						

Dimension 4: Training obtainability

Training obtainability	**Score**					**Opinion**
4.1 Expertise regarding Climate Change Adaptation (CCA)	**1**	**2**	**3**	**4**	**5**	
y. On a scale of 1 to 5, how much does the staff have **practical skills regarding farm-level CCA** at the national and subnational levels for adaptation planning and implementation?						
4.2 Working experience	**1**	**2**	**3**	**4**	**5**	
z. On a scale of 1 to 5, how much does the staff have **previous working experience regarding CCA** at the national and subnational level for adaptation planning and implementation?						
4.3 Professional Training	**1**	**2**	**3**	**4**	**5**	
aa. On a scale of 1 to 5, how much has the staff **attended the formal training courses regarding CCA?**						

4.4 Trained Staff	**1**	**2**	**3**	**4**	**5**	
bb. The percentage of trained staff in the institutions to meet the CC challenges						
cc. What are the major gaps/problems regarding training programs?						

Dimension 5: Plans and Priorities

Plans and Priorities	**Score**					**Opinion**
5.1 Institutional Priorities	**1**	**2**	**3**	**4**	**5**	
dd. On a scale of 1 to 5, how much CC is considered an important concern for the institution at the national and subnational level for adaptation planning and implementation?						

5.2 Past Programs	**1**	**2**	**3**	**4**	**5**	
ee. How many CCA programs are carried out by the institution?						
5.3 Present/Current Programs	**1**	**2**	**3**	**4**	**5**	
ff. How many programs/projects/initiatives are going on?						
5.4 Future Programs	**1**	**2**	**3**	**4**	**5**	
gg. How many projects are in the pipeline regarding CCA?						
5.5 Emergency Planning	**1**	**2**	**3**	**4**	**5**	
hh. On a scale of 1 to 5, percentage of emergency response planning for extreme events?						

Dimension 6: Access to Information

6.1 Access to Information	**1**	**2**	**3**	**4**	**5**	
ii. Does the institution have a mandate to manage and provide information on climate						

change vulnerability, hazard, and impacts to support adaptation?						
jj. To what extent can institutions access, manage and provide information?						
kk. On a scale of 1 to 5, how much do you think the institution is capable of accessing and providing information on time?						

Miscellaneous	**1**	**2**	**3**	**4**	**5**	
7. What are the major challenges of such institutions for coastal adaptation?						
8. In which sector/wing does the institution progress a lot?						

9. What is the scope for the future adaptation practices?						
10. How far do the adaptation measures vary from district to district? What are the parameters of differences?						