Coping Strategies of the Local Farmers in Changing Crop Patterns of Disaster Prone Area of Bangladesh

By

Mohammad Farid Uddin
14272017

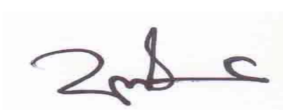
A thesis submitted to the Department of BRAC Institute of Governance and Development
in partial fulfillment of the requirements for the degree of
Master of Arts in Governance and Development

BRAC Institute of Governance and Development
BRAC University
February 2020

Declaration

I do hereby declare that this dissertation entitled "Coping Strategies of the Local Farmers in Changing Crop Patterns of Disaster Prone Area of Bangladesh" is the result of my own study under the supervision of *Dr. Mohammad Hafiz Uddin Bhuiyan, Professor, Institute of Social Welfare & Research, University of Dhaka,* Bangladesh. The total thesis is prepared for academic reason and exclusively aimed for the partial fulfillment of the degree of Master of Arts in Governance and Development (MAGD). I permit only BRAC Institute of Governance and Development (BIGD), BRAC University to copy this dissertation by reproduce or by other means, in total or in partial at request of other institutions or individuals for scholastic and research intention.

I further announce that this dissertation details has not been submitted in part or in full earlier for any degree or diploma either in this university or any other institution of higher education. The report is submitted to BIGD, BRAC University, Bangladesh with due acknowledgement of the cited text and norms of research works.



Mohammad Farid Uddin

Student ID- 14272017,

MA in Governance and Development,

Batch- 06, BIGD

Approval

The thesis titled "Coping Strategies of the Local Farmers in Changing Crop Patterns of Disaster Prone Area of Bangladesh " submitted by Mohammad Farid Uddin ID: 14272017 of Spring 2020 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Arts in Governance and Development.

Examining Committee:

Supervisor:

Dr. Mohammad Hafiz Uddin Bhuiyan
Professor,
Institute of Social welfare & Research
University of Dhaka

Acknowledgement

The researcher is taking this opportunity to express his thankfulness and deepest sense of gratitude to everyone who supported him by providing friendly suggestion and guidance throughout the course of this dissertation groundwork.

Firstly, he would like to express his all thanks to the Almighty Allah for making things and situations congenial and favorable for him to the task undertaken.

He recalls the contribution of his supervisor Dr. Mohammad Hafiz Uddin Bhuiyan, Professor, Institute of Social Welfare & Research, University of Dhaka with most honour and dignity for his untiring efforts, indispensable guidance, constant encouragement and thoughtful suggestions throughout the progress of this research work.

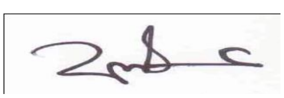
The researcher is grateful to the course coordinators and support staffs, especially to the Assistant Admin Officer of BIGD, Md. Khorshed Alom, for giving him the opportunity of using library and providing books and other amenities of BIGD.

He is also obliged to express his gratitude to all the farmers of coastal area to give him valuable information and BRAC Authority for allowing him to study at the Masters level and also providing valuable information on this topic

The researcher also wishes to record his deep sense of gratefulness to all the authors, researchers and those who has written books and articles, prepared and published different websites related to changing crop patterns of coastal area of Bangladesh and concern issues.

Last but not the least, he is pleased to his wife, Nazma Akhter, and daughters, Fariha Nawreen Ruhana and Fariza Nawsheen Lubaba, who allowed their family time to collect data and prepare the dissertation. He would also extend his cordial thanks to all friends and colleagues for their proper support and healthy cooperation during the time of preparing this dissertation.

Acknowledged by:



Mohmmad Farid Uddin
Student ID- 14272017, MAGD, Batch- 06,
BRAC Institute of Governance and Development
BRAC UNIVERSITY

Abstract

In the Bangladesh economy the agriculture sector plays a crucial role throughout contributing to GDP, creating employment, living conditions and alleviating poverty. However various natural hazards, including the climate change, have put the sector under rising pressure. Extreme events such as storms, droughts, cyclones, storm surges, sea-level rise and salinity intrusion are likely to occur more regularly and worsen in the future. This will have a significant effect on food production, particularly in vulnerable areas, such as the low coastal belts of the country. The research for this thesis discusses how local farmers already adopt mitigation methods at different levels to tackle hazards and disasters caused by climate change. These include: 30 percent farmers use water vessel to conserve fresh water for irrigation, as well as 58 percent are planting saline-resistant rice varieties. However, 86% farmers are using hybrid seeds. Furthermore, the use of modern technologies in agriculture is also common coping strategies in the study area. 97% farmers are using tractor for ploughing, 98% are applying insecticides and 100% are adopted by chemical fertilizers to counter the adverse effect of climate change. A very noteworthy and alarming finding is that during the disaster especially the cyclone, flood, flow tide and so on which were frequently confronted by the farmers of the coastal areas when their farm lands were under water or destroyed 92% of them are willing to switch from agricultural sector to industry.

Moreover, due to their lack of relevant knowledge and insufficient extension facilities, most farmers are not fully aware of the benefits of these adaptation technologies. Farmers are typically prepared to embrace saline-resistant organisms and have also requested them in the region studied. While freshwater conservation can provide an efficient improvement strategy for irrigation by excavating canals, it is often expensive and beyond the budgetary capacity of disadvantaged smallholder farmers. Another argument that farmers stress is the need for training and education. Capacity building for agricultural workers and farmers must be strengthened at the same time in order to meet targets to adjust to the coastal region. In addition, the appropriate stakeholder organizations must be allocated additional funding to ensure that adaptation initiatives can be successfully enforced and further extended.

Table of Contents:

List of Tables

List of Figures

Chapter 1: Introduction

Geometric expansion of global populations and limited land-space are key obstacles to the attainment of food security and poverty reduction. Climate change – increasing temperatures and causing weather extremes – adds to the challenge. The developing world must bear a top-heavy-load of adverse impacts from this disaster. In the sense of diminishing agricultural land and climate change impacts, Bangladesh is now facing a severe challenge in agricultural production to feed its rising population. The population of the present 162 million is projected to grow to 191 million by 2030.

However the discussions on climate change have been separated from the agricultural policy debate, the two have begun to come together. There is now a clear consensus within climate change circles that due importance must be given to agricultural needs, and within agricultural circles that climate change must be incorporated in to future climate change negotiations. Discussions regarding agreements after 2012 on climate change and the Post 2015 Development Agenda include agricultural dimensions with climate change. This study feeds into these debates by considering the ways in which climate change affects agricultural crop patterns in disaster prone area of Bangladesh, how the local farmers respond to this, and how much these responses will meet the coping strategies of that farmers. To do this requires an in-depth understanding of the role agriculture plays in coastal area of Bangladesh, how the farming system had been operated traditionally, and how it is shaping in a new coping mechanism intricately by the influence of climate change are being inquired.

1.1 Background

Bangladesh is one of the world's most vulnerable countries to disasters. The physical hazards which could potentially cause significant loss of life and physical damage and stabilize society and the national economy. Such risks include massive and intense flooding, extreme tropical cyclones and the subsequent coastal storms, drought, tornadoes and riverbank erosion.

Weather and seasonal characteristics, such as temperature, low or heavy rainfall and damp, length of the day, etc. affect agriculture in coastal Bangladesh. Various weather vulnerabilities, such as floods, droughts and the salinity of soils and water, cyclones and surges, are often restricted to crop production. Multiple models of weather forecasting predict different levels of yield reduction impacts in different situations of climate change. The temperature increase is projected to deteriorate by 4 ° C to 17% in rice production and 61% in Bangladesh in wheat production. Other adverse climatic effects are central concerns for agriculture in coastal regions of the country, with a rise in the sea level and salinity intrusion. Due to the large-scale intensity of cultivation of food grains, introductive high yardstick growth, expansion and increased use of chemical fertilizers in irrigated areas; Bangladesh has made tremendous progress for these past three decades towards self-sufficiency in food grains. The contribution of fertilizers to increased production is approximately 50 Percent, among these factors.[1] Nevertheless, the combined effects of various limitations and climatic risks relating to soil organic matter, unbalanced fertilizer use, nutrient harvesting, soil physical and chemical properties degradation, soil rains increase, irregular precipitation, droughts, floods, salinity, water supplies, cyclone, we have recently been observed. Over recent years, there have been significant losses for the quality of soil to the proportion of different nutrients used in agriculture, without soil testing. Alone, nitrogen accounts for some 83 percent of the total country's use of nutrients while only about 7.75 and 9.1 percent are used for phosphorus and potassium. Such factors obviously pose significant risks for optimal crop production systems. The current challenges for plant nutrient management are to preserve sustainable crop productivity in order to meet growing food and raw material demands and improve the quality of land and water supplies.

A recent study on the relative increase in the sea in the Bangladeshi coast was conducted by SAARC Meteorological Research Council (SMRC, 2010). The research used historical tidal statistics of 22 years from the three coastal stations. The study revealed that the sea-level rise rate over the past 22 years is much higher than the average global sea-level rise over 100 years. The 3rd assessment study of IPCC predicted a global sea-level rise of 9-88 cm, from 1990 to 2100. Using various pollution scenarios, the Third Assessment Report also estimated global sea-level rise for 2020, 2050 and 2080. A recent study by the SAARC Meteorological Research Council (SMRC, 2010) revealed that approximately 13 percent more land (469,000 ha) in Bangladesh will be inundated in the monsoon due to an increase of 62 cm in sea level for high emission scenario A2 in addition to the inundated areas. The areas without polders such as Barguna, Patuakhali, Pirojpur, Barisal, Jhalakathi, Bagerhat and Bhola are the most vulnerable areas. The flooded areas will be increased by the increased rainfall and the sea level will rise to 62 cm; and by the year 2080, about sixteen percent more (551,500 ha) will be flooded.

Due to the 62 cm sea level rise in the dry season, however, some 364,200 ha (10%) more area will be flooded with A2 scenarios in the year 2080. However, an increase of 15 cm at sea level has a small impact on flooding in the dry season.[2] Over 30 percent of Bangladesh's cultivable land lies in the coastal area, of which about 1.0 million hectares are severely affected by varying degrees of salinity during the dry season and flooding/submergence each year during the wet season. In the Aman season, farmers traditionally cultivate rice, while several crops are a chance to ensure sufficient food. For the most part, farmers grow low yielding conventional rice varieties only during the July to December monsoon (Aman) season. In the dry (Rabi / Boro) and pre-monsoon (Aus) seasons, most such terrains remain fallow because of high perceived salinity and lack of high-quality water for irrigation. While farmers in Bangladesh in other parts benefit from higher farm productivity and can cover their losses from more or less secure Boro rice production, some 1.6 million farming families in the coastal salt areas of Bangladesh have very limited options for continuing rainfall and over-constraints. In this area, crop yields, crop intensity, production levels and people livelihood quality are much lower than elsewhere in the country (BBS, 2009). Improving rice production, growing crops by either adding an Aus or an acceptable non-rice crop before or Boro Rice or a non-rice crop after Aman Rice, will increase productivity, increase farm incomes and improve the livelihoods of farmers. In most of these coastal areas, Aman rice productivity is particularly low due to the extreme flooding (either partial or complete) and reduced adoption of adequate high return (HYV) rice. The farmers rely on the high, unresponsive inputs and low yields of 2-2.5 t / ha on conventional rice (Mondale al., 2004a). Farmers are unwilling to use HYV due to their short size, quickly submerged and impaired by variations in the tidal waters.

Nevertheless, excess water can be drained during the low tide by maintaining the coastal polders ' sluice gates installed by the Bangladesh Water Development Board (BWDB). Sadly, many of the sluices are not working properly and farmers do not have the experience to operate the sluices correctly. Improving drainage in the monsoon season will help cultivate HYV Aman rice and early establishment of Rabi crops in the country's coastal areas. With technological advances in agriculture in the Bangladeshi coastal region, it is only lagging behind rather than in other parts of the country. Just a few agricultural technologies can be used directly in Bangladesh's coastal disaster-prone areas. Therefore, it is extremely necessary to demonstrate modern agricultural technology by a system approach" rather than a seasonal or cultivable-specific approach to that particular soil and atmospheric conditions. However, some high-value plants can be cultivated through better management practices. It is expected that food security and agricultural incomes in coastal areas could be increased extensively by plant intensification and diversification.

1.2. Rationale of the Study:

People living in Bangladesh's coastal area suffered from a lack of food security. There are many factors behind this such as lower crop production and less crop intensity due to increased salinity, increased incidence of pests and disease, swelling, cyclones, submergence precipitation, higher temperatures, drought, large fallow fields, land losses, bad roads, poor marketing facilities and poverty with long-term soil consequences. Because people do not have enough work throughout the year, their food security situation is precarious. The majorities of coastal people are engaged in crops and often remain unemployed because of tidal floods and other natural disasters resulting in food insecurity in the coastal belt region. Bangladesh's government is committed to reducing the number of undernourished to less than $1 a day by 2030 with the goal of the World Food Summit and the SDG objective of eliminating starvation and poverty by that time. People were involved in evaluating their harm and potential crop plan in the study area. The study was conducted to improve their awareness of demand to make them aware of high yields and varieties of salt tolerance. The present study in the district of Barguna has tried to determine the real amount of land not cultivated and the reasons behind it. Farmers ' opinion was sought for plant variety, seeds, resources and problems they faced to bring back all their arable land under cultivation. This study also identified the huge loss of climate change, in particular, the loss of the agricultural sector and the minimization of the gaps between farmers and development workers.

In the past, numerous studies of climate change issues were carried out by various organizations and potential impact projections were developed. Different adaptation actions, technologies, and strategies to adapt to climate change have already been developed by various organizations and communities. Because agriculture is the main sector of this economy, it is important to identify suitable adaptive technologies or varieties of farm crops through field testing and community sustainability knowledge. This study identified suitable adaptation measures and crop varieties. The findings of the study, I believe, would enable policymakers to build an effective and sustainable roadmap and farmers in the area concerned to be optimistic about their crops responding to climate change.

1.3. Objectives of the Study:

- ✓ *To know the experiences of traditional crop system of the local farmers in the study area;*
- ✓ *To explore the changing pattern of cropping system in the disastrous area;*
- ✓ *To find out the coping mechanism of farmers in disaster prone area; and*
- ✓ *To identify the challenges of local farmers in changing crop pattern.*

1.4. Methodology:

Examining the variables related to the coping strategies of the local farmers in changing crop patterns of disaster prone area of Bangladesh demands a dynamic research approach that is firmly rooted in both qualitative and quantitative etymology. This is necessary to ensure that the respondents (the farmers of the study area) in a study of this magnitude and complexity are not denied of their subjective views on the phenomena being studied, while the objectivity of the entire research enterprise is guaranteed. In line with this thinking, this study is based on a mixed methods research approach which is explained in detail in the following sections.

Research Design and Methodology:

The two concepts research design and research methodology need to be clarified firstly. Each of these concepts is presented as a compound word, with the concepts design and methodology attached to the noun research. The two concepts are discussed below.

Research Design:

The function of a research design is to ensure that the evidence obtained enables us to answer the initial question as unambiguously as possible. Leedy (1997:195) defines research design as a plan for a study, providing the overall framework for collecting data. MacMillan and Schumacher (2001:166) define it as a plan for selecting subjects, research sites, and data collection procedures to answer the research question(s). They further indicate that the goal of a sound research design is to provide results that are judged to be credible. For Derrheim (200: 29), research design is a strategic framework for action that serves as a bridge between research questions and the execution or implementation of the research strategy. The research design refers to the overall strategy that you choose to integrate the different components of the study in a coherent and logical way, thereby, ensuring you will effectively address the research problem; it constitutes the blueprint for the collection, measurement, and analysis of data. Note that your research problem determines the type of design you can use, not the other way around! (De Vaus, D.A, 2008).

Research Methodology:

The method section of a research paper provides the information by which a study's validity is judged. The method section answers two main questions: (1) how the data was collected or generated and (2) how it was analyzed. The writing should be directed and precise and written in the past tense (Bem. Daryl J, 2008). Schwardt (2007:195) defines research methodology as a theory of how an inquiry should proceed. It involves analysis of the assumptions, principles and procedures in a particular approach to inquiry. According to Schwardt (2007), Creswell and Tashakkori (2007), and Teddlie and Tashakkori (2007), methodologies explicate and define the kinds of problems that are worth investing; what constitute a researchable problem; testable hypotheses; how to frame a problem in such a way that it can be investigated using particular design and procedure; and how to select and develop appropriate means of collecting data. The methodology should discuss the problems that were anticipated and the steps you took to prevent them from occurring. For any problems that did arise, you must describe the ways in which their impact was minimized or why these problems do not affect the findings in any way that impacts your interpretation of the data.

Mixed Methods Research Methodology:

Kemper, Springfield and Teddlie (2003) describe mixed method design as a system that includes parallel data collection and analysis in both quality and quantity (concurrent mixed method design where two types of data are collected and sequentially analyzed). Bazely (2003) describes the approach as using the same form of mixed data (numerical and text) and other methods (statistics and analysis). It is a kind of research in which a researcher uses the qualitative research paradigm for a study phase and another study period a quantitative research paradigm.

Burke and Onwügbuzie (2005:1) suggest that the use of either the conventional qualitative or quantitative research methods in isolation is a natural complement to mixed-method analysis. It is considered the research class in which the researcher in a single study combines or combines qualitative and quantitative research methods, methods, approaches, concepts or language. According to Burke et al., mixed methodology research at the philosophical level is a' third wave' or third research movement which moves past paradigm wars through offering a logical and practical alternative.

Creswell, Fetters and Ivankova (2004:7) suggest that research in mixed methods is more than just the gathering of qualitative and quantitative data; data is combined, linked or mixed at some stage in the research process. We also suggest that the logic behind mixing is that neither qualitative nor quantitative approaches themselves are adequate to capture the patterns and specifics of the situation. Once integrated, qualitative and quantitative data provide a more comprehensive analysis and expertise.

Quantitative Research Methodology:

According to Van der Merwe(1996), quantitative research is a research approach designed to test theories and determine facts, show relations between variables and predict the results. Quantitative research uses natural science methods that ensure objective, widespread use and reliability (Weinreich, 2009). Quantitative research techniques include a random selection of research participants from the study population on an unequivocal basis, standardized questionnaires or interventions, and statistical methods for testing predetermined assumptions on the relationship between specific variables. A researcher in quantitative research is assumed to be outside the study, and the findings are supposed to be replicable, irrespective of who performs the research, as opposed to the qualitative parade in which he or she is considered a great tool of analysis because of his / her active involvement in the research process.

Qualitative Research Methodology:

According to Van der Merwe (cited by Garbers, 1996), qualitative research is a research approach designed to develop theories and understanding. Denzin and Lincoln (2005) describe qualitative research as a place of observation in the world. This provides an interpretative, naturalistic approach to the world, i.e. empirical scientists study phenomena in their natural environments, try to understand, or translate phenomenon into meanings. Qualitative research involves emphasizing the qualities of entities and processes and meanings that are not analyzed or measured experimentally (Denzin & Lincoln 2005:10). Weinreich (2009) says that qualitative research aims to give the researcher the viewpoint of target audience members by immersing himself in a community or circumstance and personally engaging with studied individuals. It means that the researcher becomes an instrument of data collection in the qualitative paradigm, and results can differ significantly depending on who carries out the research.

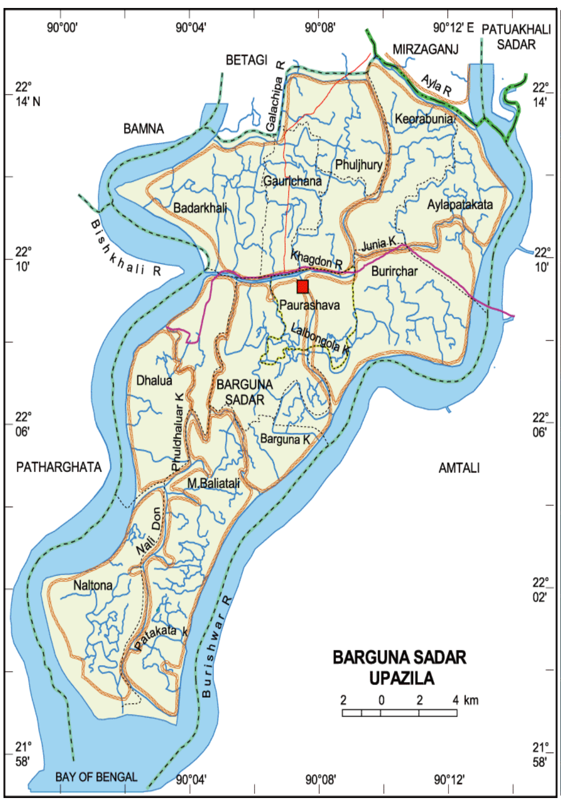
Qualitative research aims to promote a better understanding of one and to increase understanding of the human condition. In comparison to quantitative research aimed at collecting evidence on human actions leading to the validation and extension of theory, qualitative research explores an increased understanding of human action and experience. Qualitative approaches include direct observation, review and description of reports, participant assessment and open-ended unstructured interviewing. This approach was designed to help researchers understand the significance that people attribute to social phenomena and elucidate behavioural mental processes. Qualitative inquiry requires the use of multiple data collection methods, particularly interviews with respondents, and employs an inductive approach for data analysis, extracting the principles from a mass of particular details that shape the database. According to Weinreich (2009) the strength of qualitative approaches is that "they generate rich and detailed data, which leave the participant's perspective unchanged and provide the context of the phenomena being studied." One disadvantage of the qualitative approach is that it can be time-consuming and labor intensified.

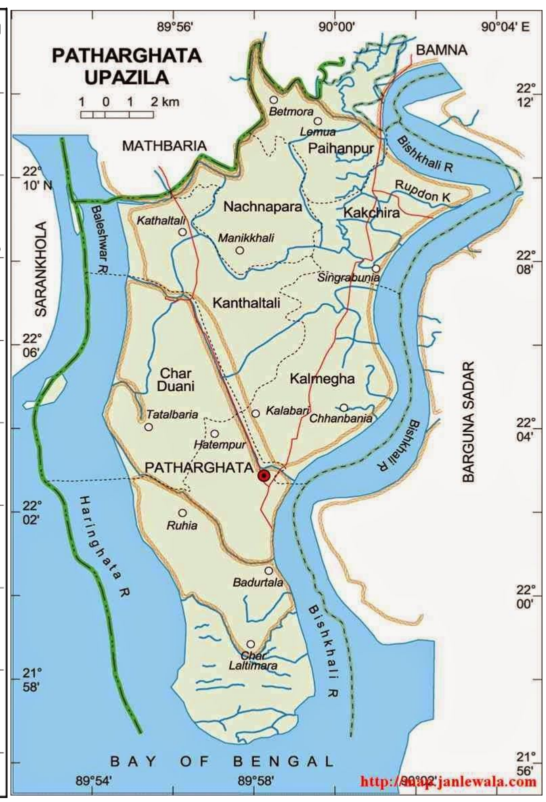
1.4.1. Nature of the Study:

The research process is, for many of us, just the way we do things. This study is both qualitative and quantitative in nature. So, this study adopted a mixed method research approach. A qualitative method is used to explore the objectives and some quantitative procedures were followed to support the qualitative data. It is also descriptive in its literature reviewing strategies. For properly gathering data and information a multiple instrument approach was adopted.

1.4.2. Study Area:

Barguna district, at southern last district of Bangladesh nearing to Bay of Bengal, consists of 6 upazilas. The subject of the study includes all the farmers of two upazilas (barguna sadar and Patharghata) of Barguna district under Barisal division in Bangladesh where serious damage is occurring in agriculture sector due to climate change such as salinity, storm surge, cyclone, sea level rise and flood. In Bangladesh there is a vast costal area consisting of several upazilas (administrative unit). These upazilas are disaster prone. The farmers of these upazilas face the same kinds of disaster over the year. This is why for this study two upazilas of Barguna district (Barguna Sadar and Patharghata) have been selected.





Barguna Sadar is located at 22.1508°N 90.1264°E . It has 41868 households and a total area of 454.39 km². According to the 1991 Bangladesh census, Barguna Sadar had a population of 219,729. And Patharghata is located at 22.0458°N 89.9689°E. It has 25,610 households and a total area of 387.36 km². As of the 1991 Bangladesh census, Patharghata has a population of 134635.

1.4.3. Sample and Sampling Procedure:

In this study by means of purposive sampling technique two upazilas (Barguna sadar and Patharghata) have been selected. From these upazilas 100 (One hundred) respondents (farmers) have been selected. In the selection process random sampling technique has been used here. Simple descriptive statistic has been used for data analysis.

1.4.4. Sources of Data:

The required data of the study have been collected from mainly in primary sources. Primary data has been collected from two upazilas of Barguna district under the division of Barisal through questionnaires and interviews of the farmers. A focus group discussion and some Key Informants Interview (KII) were also used to collect data. In the process of policy recommendation as well as proving hypothesis some data have been presumed from relevant literature reviews as secondary source.

1.4.5. Data Collection Techniques:

Barguna Sadar Upazila consists of ten union councils, and Patharghata Upazila has seven unions. Data were collected from two unions of Barguna Sadar and two unions of Patharghata Upazila. Out of 8 villages of four unions, a total of 100 farmers (minimum farming experience of 20 years) were chosen. 12-13 farmers were sampled randomly for interview from each of a village and data were collected for the study. The Union's most affected list of villages was collected from the Agriculture Extension Officer (AEO), Barguna Sadar and Patharghata. Following the field test, interview schedules were finalized. Observation methods have also been introduced to consider the practical view of farmers ' cropping practices as a result of climate change. Focus Group Discussions were conducted with farmers to learn about past and present crop patterns, traditional farming, changes in the workplace and their future crop plan. This research also discussed their thoughts about the problems they face in agriculture and how they expect to solve their problems. Data were collected using interview schedules from landless and well-off crops growing village farmers. Prior to the interview, the selected farmers were contacted when they were available. All data was properly recorded during the interview. If any data appears to be confused, it was gathered by revisit. The collected data were primarily coded manually according to the study objective. All the data gathered have been carefully compiled and analyzed. The data was then processed using different tables, bar-charts, pie-charts and MS Excel.

Primary Data Collection:

Different techniques such as observation, interview schedules, the transect walk, key informant interviews, and focus-group discussion are used to collect primary data from the field of study.

Key Informant Interviews (KII):

There have been interviews with various professionals in this area to experience the true gradual impact of climate change. In fact, the local farmers observe the changes but have no great idea of the hidden causes of the changes. The expertise of the experts in this particular area, therefore, felt necessary to explore. With traditional knowledge, it was attempted to examine reality by testing and rechecking their ideas. The key informers were selected on the basis of their expertise on the relevant subjects required for a rigorous analysis of the issue. In order to carry out this report, the Deputy Agriculture Director, Upazila Agriculture Extension Officer, the Block Supervisor (Block) and a dealer (seeds and fertilities) respectively took four main informants (KII) interviews.

Focus Group Discussion (FGD):

The FGD was organized on 20 June 2015. Getting there on time, the program started with a greeting and thanksgiving. The FGD was carried out with 10 peasants. They also participated in discussions directed by a facilitator on various types of climate change issues, especially the conference on climate-related hazards, livelihoods, past and present agricultural production, income generation, food security and adaptation techniques applied in the locality. It helps to collect a wide range of information in a relatively short period of time. The data collected from FGD were cross-checked through interviews with farmers.

The following key issues focused on FGD:

- ✓ What types of traditional crops they had but are now going to be lost and why;
- ✓ Typical and current crop markets;
- ✓ What changes do you see in the seasonal trend in your area?
- ✓ What's your idea about the reason for this change?
- ✓ How do seasonal changes impact your farming practice?
- ✓ What kind of problems do you face in irrigation today?
- ✓ The reasons behind the change to the new cropping process.

1.4.6. Secondary Data Collection:

Information on agricultural issues has been collected by cross-referencing between different sources. The information was obtained from various related books, documents, survey reports, maps, journals, research papers, the internet, daily newspapers, the library, the agriculturist office of Barguna and PatharghataUpazila, local NGO reports, field study reports (DMG-605, PPDM) from BRAC University, etc.

1.4.7. Data Editing Process and Analysis:

A mixed form of research was used in this study. The key information collected was manually coded for the purpose of the study. All the data gathered have been carefully compiled and analyzed. Instead, various tables, bar-charts, pie-charts and MS Excel were used to process data. Qualitative analyzes rather than statistics configure observations and interpretations. Conceptualization, therefore, is necessary to bring order of understanding systematically. Three steps have been taken to analyze and interpret narrative data in the following way: 1. Get the data to know, 2. Concentrate on analyzes, 3. Categorize data. The questionnaires were arranged in one place and reviewed if they were done. The insignificant and insufficient answers are screened.

1.5. Limitations of the Study:

Farmers throughout the study area cultivate different crops with different yield potential. The interviewees were asked the common questions to estimate the yield loss and the decrease in crop size. The questions were asked both to farmers and wage workers on the effects of salinity in agriculture, but the answers to these questions were more accurate than others by farmers directly engaged in crop production. In the paper, however, we used the average response that reduces the study robustness. In addition, only three villages used for the creation of a general internal coastal scenario, specifically the District of Barguna, were used for sampling. This small number of samples does not cover the whole of the coastal area or the district, but a new climate change research window can be opened in Bangladesh, which calls for a larger multidisciplinary analysis. The study was conducted in six months. The sample size was limited because of budget constraints. In order to maintain the rigor of the study, the data were nevertheless revised and compared with established literature.

Chapter 2: Literature Review:

Bangladesh has a high sensitivity to agrarian disruption as one of the most climate prone countries in the world. The effects of climate change will most likely affect small farmers in developing countries like Bangladesh since they depend highly on agriculture for the sustainability of their livelihoods. Moreover, the population pressures are high in the country; economic development and urbanization are largely unforeseen and poverty is endemic. The multiple and cumulative consequences of climate and non-climate changes are expressed in the overall poor adaptive ability of SMEs to overcome the impacts of climate change. Planned policies and actions on climate change adaptation are necessary and national adaptation plans such as the 'Bangladesh Climate Change Strategy and Action Plan' (BCCSAP), 2009, were prepared by the Government of Bangladesh (GoB). The basic requirement for the implementation of this action plan is to identify the impact because adaptation depends heavily on the context. Consequently, various communities may need different adaptation strategies on climate change impacts.

In agriculture, Bangladesh's coastal area is highly productive. Nevertheless, due to the high level of threats and high exposure of poor local populations to these dangers, the region is vulnerable to natural hazards than any other part of the country.[3] Coastal flooding occurs annually with varying height and severity. The geographical location of Bangladesh has turned the country into a major hotspot for global tropical cyclones and mare surges. Erratic rainfall patterns and an increasing number of cyclones and heat-waves were observed during the past decade. From 2000 to 2010, two mega cyclones were reported to be causing huge cultural, infrastructural, agriculture and human losses in the coastal area in Bangladesh. In coastal Bangladesh, rising sea level is already noted. It is predicted that 97.1% of coastal areas and over 35 million coastal people are vulnerable to and exposed to many threats from climate change, such as tropical cyclones, storm surges, coastal flooding, global warming and rising sea levels.[4]

The combination of coastal mangrove forests, tidal estuary lands, agricultural production lands, and economic activities such as shrimp production are also ecologically rich. Storm surges and coastal flooding, however, put severe pressure on agricultural production and reduce productivity.[5] In combination with low socio-economic conditions, the impacts of climate events such as cyclone, instability and tidal flooding inevitably have a negative impact on the health, employment prospects, and education and food security of coastal agricultural communities. Climate change contributes significantly to increased salinity intrusion in coastal Bangladesh, which in effect kills biodiversity, loss of agricultural jobs, reduction of agricultural production and growing food and human insecurity in the region in cascading and consequential orders across different time horizons.[6]

Research on climate change and farmers ' coping strategies was enhanced by the advent of anthropogenic climate change. The understanding of the effects of disasters and coping mechanisms over the last three decades has shifted from technological theories to a holistic approach to risk reduction. The vulnerability is defined as the degree to which a system is vulnerable, exposed, and unable to respond to the impacts of climate stressors, according to the Intergovernmental Panel on Climate Change (IPCC).[7] Vulnerability is known according to Birkmann as a nuanced phenomenon covering environment as well as non-climatic stressors, socio-economic and cultural environments, political structures and socio-ecological attributes. The latter interpretation of vulnerability, which is mainly conceived as an internal risk factor that includes physical, social, economic, and environmental factors which cause damage to the system, was embraced by Birkmann and colleagues. The effects of interactions with the human and natural systems 'vulnerability underlying other social, physical and environmental variables in the context of climate change is described. Similar to the vulnerability concept, impact evaluation has been extended from one single to multidimensional aspects, including non-climate incentive as major determinants of impacts such as socio-economic indicators.[8]

A significant determinant of vulnerability and impacts is "adaptive capacity which is defined as a system's ability and capacity to adapt to climate change by reducing vulnerabilities and alleviating consequences. Adaptation capacity relates to the development of a range of adaptation options and the Community's ability to anticipate, mitigate and recover from climate impacts.[9] The idea of adaptive capacity is commonly used to assess the power of the socio-ecological system, often interpreted as an opposite weakness phenomenon. Therefore, the existence of adaptive capacity decreases the vulnerability by mitigating exposure and device sensitivity, therefore reducing impacts and increasing system overall climate resilience. Coastal threats often become disasters due to reduced resilience, combined with low community adaptability and environmental change. [10] The "sustainable livelihood" literature emphasizes the existence of social, cultural, environmental, physical, human and capital assets as an adaptive capacity to resist catastrophic effects and to reduce livelihood vulnerabilities. Natural capital availability (for example, fertile soil and groundwater) is necessary to adapt agricultural populations to extreme climate events while human and social capital improves their economic capacity to cope with the effects of extreme climate change.[11]

The effect of saline water intrusion into estuaries and surface waters, the rise in sea levels and subsidence, would be increased according to the IPCC report (2007). The adverse impact of saline water intrusion on coastal agriculture will be significant, and the availability of freshwater for public and industrial water supplies will decline. Agriculture is an important economic sector of Bangladesh and is very fruitful for growing rice in the coastal area of Bangladesh. Increases in salinity and salinity will seriously adversely affect agriculture. The rice varieties currently practiced cannot withstand elevated salinity. In the event of climate change, food production doesn't seem to have a better future. Rice production in Bangladesh may fall by 10% and wheat by 30% by 2050 (The Asian "too disturbing to contemplate" report, IPCC 2007).[12]

Agricultural production system in the south Asian region is the most vulnerable and affected by the recent climatic change. Bangladesh's climate is changing. Every year it is more volatile, and its instability is more common than ever before. Climate change is likely to intensify threats such as floods, droughts, cyclones and many other weather events. The intrusion of salinity in the coastal region would be a more acute problem. It will have an additional effect on farming and drinking water in that area. The salinity problems in Bangladesh's coastal area may further intensify as freshwater supplies from upstream sources declined in the dry season due both to climate change and to rising salt water levels.[13]

The study found that harvest yields were adversely affected by temperature increases, erratic rainfall, floods, droughts, salinity, etc. and that water-logging and drainage congestion were among the most significant issues. The environmental conditions are more fragile but are most likely to be alerted to climate change and the increase in the sea level gradually but inevitably. Dependence on fertilizer and irrigation is on the rise, resulting in permanent land fertility loss, biodiversity loss, local truth-extinction, groundwater scarcity and loss of production sustainability. Adaptations to climate change may minimize risks, delay processing and increase food safety, for example by adapting agriculture, sustainable climate-sensitive agriculture, changing dates of plantings, using shorter crop growers.

According to S. S. J. M and Huque. Ayers, seasonal high salt levels within the soil root zone are the significant barrier to the increased crop production in the coastal areas. Salts enter inland through rivers and channels, especially during the later dry (winter) season when the downstream freshwater flow becomes very minimal. The salinity of the water in the river rises during this period. The salts enter the soil by flooding with saline river water or flowing from the rivers, and by evaporation, the salts become concentrated in the surface layers. The saline water can also increase groundwater salinity and make it unfit for irrigation.[14]

Climate change is believed to increase differences among developed and developing countries in cereal production. Climate change would benefit production in the developed world while developing nations would decline (Walker and Steffen, 1997). Farm-level coping mechanisms would be inadequate to reduce disparities. Though the comprehensive change in the farming sector would not eliminate these adverse effects entirely. Generally, tropical and subtropical countries would be more vulnerable to the potential impacts of global warming by impacting crops, soils, insects, weeds and diseases. However, elevated concentrations of carbon-dioxide (CO) will have beneficial effects on crop production. Climate change impacts would increase vulnerability to Bangladesh's crop production systems.

According to the Briefing Report-2008 (Climate Change and Agriculture in Bangladesh Information), sea-level rise affects agriculture in three ways, i.e. by salinity infiltration, flooding, and rising cyclone frequency and damage depth. Cumulative effects of these three factors decrease coastal agricultural production. Invasion of salinity due to sea-level rise will decrease agricultural production due to non-fresh water and soil degradation. Salinity also reduces some plants ' terminative energy and germination rate. The reduction of rice production in a village in Bagerhat (at the same belt of the district of Barguna) was studied, showing that in 2003 rice production was 1,151 metric tons lower than in 1985, equivalent to 69 per cent. Due to the conversion of office field into a shrimp pond, 77 percent of total production decreased and 23 percent was due to yield loss.

The World Watch Institute, an International Research Organization, published a report on 22 October 2007 (Prothom Alo, 2007), in which it was reported that 21 countries of the world, including Bangladesh, are at serious risk due to rising seawater levels for climate change. Over the past 100 years, the sea-water level has risen to 9-20 cm. This can grow to about 88 cm by 2100. The key reasons cited in the article were climate change, and regular small or large disasters became evident. These contribute to suffering and loss of money for people.

The rise in sea level causes further area flooding, potential damage to agricultural crops would increase. Around 1/3 Bangladesh, 49,000 square Km. Km. Zone affected by Bengal Bay tides. Obviously, the coastal flood area will increase in future with an adverse effect on crop production. When sea level rises to 1 meter, regular flood waves are expected to rise from 7.4 meters to 9.1 meters. Approximately 15-17 million people will be displaced by sea-level rise in Bangladesh, which will cost 12-16 percent of total land area. In its Research Report on Climate Change Adaptation for Sustainable Development of Bangladesh Agriculture (2007), BARI (2007) reported that tidal flooding during the wet season (June-October), direct flooding by saline water and rising or cross movement of saline groundwater during the dry season (November-January). The FAO (2010) estimated that about 1.5 million ha of land had moderate salinity in 1973, slowly increasing to 2.5 million ha in 1997, and may reach over 3.0 million ha in 2007. The extent of Bangladesh's salinity problem increases due to rainfall shortages. Bangladesh's coastal area is 2.5 million ha. Around 1.0 million ha, along the coastal belt, are under various magnitude salinities. Bangladesh is predicted to lose a large portion of coastal areas to sea.[15]

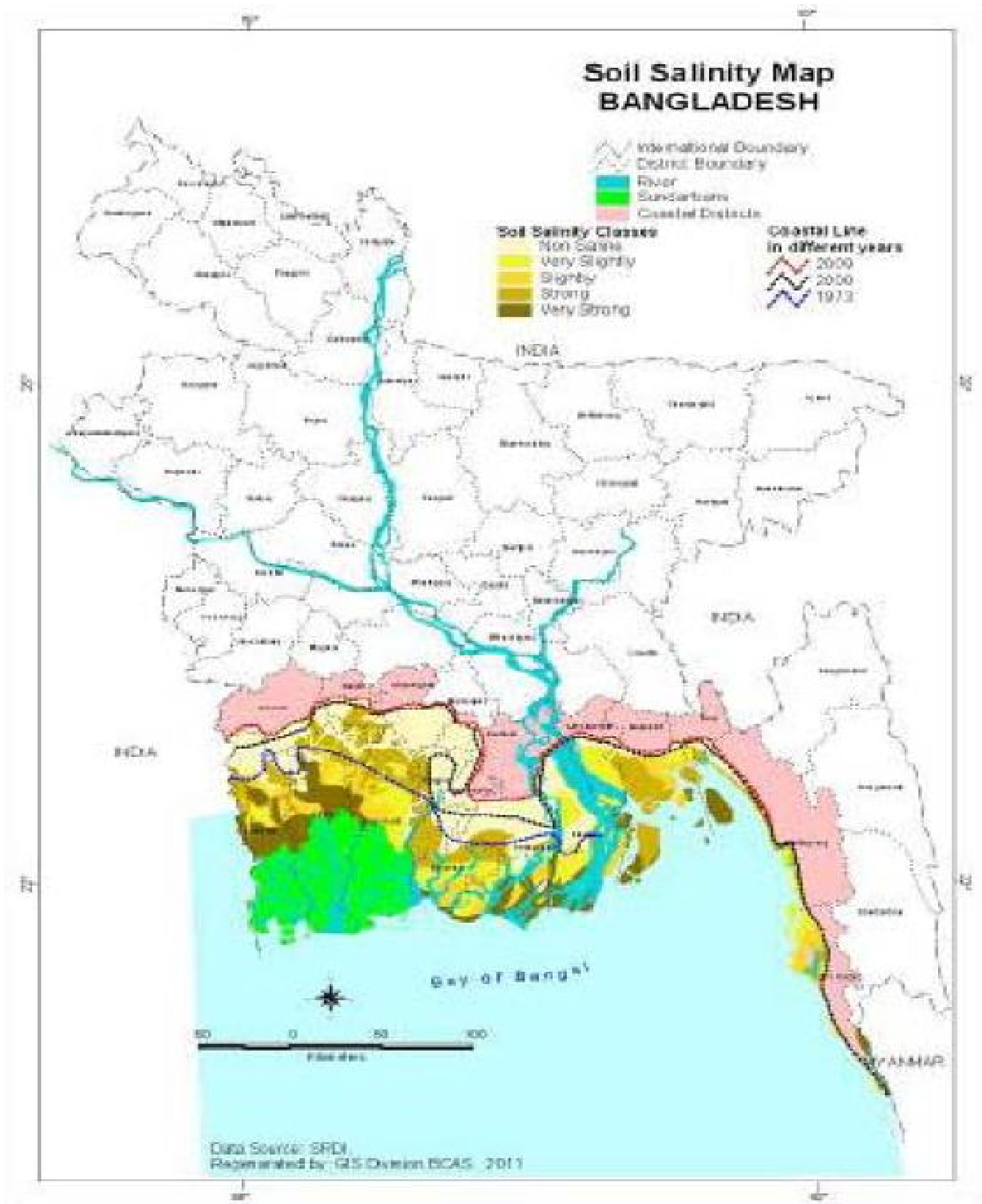


Figure: *Increasing trend of salinity coverage area in different years, and present salinity level in those areas; Source: Soil Resources Development Institute (SRDI) of Bangladesh.*

As a result of saltwater intrusion, the Bangladeshi coastline already suffers from high salinity thresholds. This is growing in the statistic. Under different climate change scenarios, salt levels are expected to increase further as sea levels rise and saltwater intrudes evermore. The loss of crop due to the intrusion of salinity (due to rising sea levels) may lead to approximately 0.2 million metric tons under a moderate climate change scenario. In contrast to that resulting from floods, production loss due to these effects can be relatively high. The damage in other industries could, however, be significantly greater in the event of flooding than as a result of direct climate change. Low flows have a much less severe impact on agricultural vulnerability compared with other effects.[16]

Time series data/information on changes in river water salinity of some coastal rivers of Barguna district were collected from local offices of SRDI, DAE ,BWDB and BIWTA. The data have been compiled in the following Tables. The data showed that river water salinity has remarkably increased (12.9-24.5 % ds/m:3.1-25.3) during last 8-10 years.[17]

Name of River	River water salinity (Ec:ds/m) Year: 2005	River water salinity (Ec:ds/m) Year: 2015	% increase of salinity level
Bishkhali river, Patharghata	April/2005: 3.10	April /2015: 3.98	24.35
Payra river, Taltali, Barguna	March/2005: 8.58	April/ 2015: 9.88	13.33
Andhermanik river, kalapara	April/2005: 22.65	April/2015: 26.11	14.05

Table A**:** Changes in River water salinity in the Coastal Regions

The data showed that there is an increasing trend of river water salinity (12.9-24.5 % increase) in Bishkhali river at Patharghata point, Andharmanik river at Kalapara point and Payra river at Taltali point during 2001 to 2009.

Climate change is nowadays posing a serious threat, particularly in the agricultural and food security sectors among all other sectors affected. Crop yields are expected to decline by as much as 30 percent, creating a very high risk of malnutrition, and sustainable climate-resilient agriculture is the key to adapting and increasing food security for farmers (ICEAB 2010).[18]

A research paper - Assessing Long-term Impacts and Vulnerabilities on Crop Production Due to Climate Change in Bangladesh's Coastal Areas (BCAS, 2010) reported that Bangladesh is one of the worst-affected countries fronting the primary influences of climate change, particularly in agriculture. Over 30 per cent of Bangladesh's net farmland in the coastal zone comprises approximately 0.828 million hectares of coastal and off-shore lands, comprising around 52.5 percent of Bangladesh's total cultivable territory, in 64 upazilas, in 13 districts. But the uncertainties of climate change threaten these vast cultivable fields, and crop production declines rapidly. The coastal region of Bangladesh is naturally catastrophically susceptible, while climate change affirms a new depressing impact on life and agronomy. The coastal livelihoods depend largely on agricultural crops, mainly on rice. Flooding, physiography, soil salinity, and drainage pollution and irrigation infrastructure are important factors influencing land use in agriculture. Food production in the coastal region is limited to wet season cultivation as soil salinity in the dry season is high. The coastal zone is covered by medium-high vegetation, followed by highlands, medium, lowlands and lowlands. Currently, coastal regions account for approximately 16 percent of the country's total rice production. Rain-fed mountain paddy is the dominant crop in coastal districts, covering about 70 percent of the total paddy crop area. Almost 60 per cent of the paddy cultivated area is planted with local varieties adapted to poor water management and water recovery and salinity. The rate of cultivation is 170%. The coastal region yields a relatively high percentage of pulses, olive oil, betel nuts and leaves, potatoes and winter vegetables.[19]

BCAS (2010) also reports that coastal agriculture is seriously affected by various climatic risk levels due to integrated effects of the following factors: soil salinity, salinity of water, sea level increase, mare surges, cyclones, heavy soils, soil wetness/water stagnation, fallow/seasonal fallow terrain, incidence of pests and diseases, a lack of marketing infrastructure and agro-based problems As a result of climate change, the coastal belt is extremely vulnerable. Disasters such as sea-level rise, mare growth, salinity and cyclone are increasing in the coastal belt. The intrusion of salinity is a major factor preventing the development of crops in the coastal belt. In many areas of the coastal region, water and soil salinity are a serious threat. As a result, the crop area is decreasing, and the cultivation of boron and rice, boron and other rabbits is limited. Cumulative impacts of soil and water restrictions, climate threats and socioeconomic issues are seriously affected by coastal agriculture.

Changing Crop Patterns:

In its 2012 study, Gunasena stated that shifting crop patterns refers to the addition of new crops or crop systems to agricultural production on a specific farm, in view of varying returns on value-added crops with additional marketing opportunities. Changing crop pattern can be a useful means to increase crop output under different situations. It can be approached in two ways. The main form and the commonly understood concept is the addition of more crops to the existing cropping system, which could be referred to as horizontal diversification. For example, farming in rice fields or cultivating different types of other crops on the highlands is defined as changing crop patterns. This type of change in crop design also means extending the base of the system simply by adding more crops to the current cultivation system using techniques such as multiple crops along with other effective management practices. Different cultivation systems have increased the food production capacity to more than 30 t / ha with a 400-500 percent increase in crop intensity. The other type of change in crop pattern is a vertical diversification of crops in which various other downstream operations are carried out. The use of any plant species that can be refined to produce products, such as fruit that can be canned or made into juices or syrups can illustrate this. Vertical crop diversification is mentioned to reflect the extent and stage of crop industrialization. It must be remembered that evolving crop trends take economic returns from different crops into account. There will also be different levels of transition in trends or diversification in different countries. Diversification at the agricultural level would require the cultivation of several species, but this can be a totally different strategy at the national level. Changing crop patterns at the national level needs more energy and involves the selection and management of a specific crop or group of crops sold fresh or added value to make better profits.[20]

The advantages of crop diversification were found in Gunasena (2012), which are (1) relative net crop return, (2) greater net labor returns, (3) resource use optimization, (4) higher ground use efficiencies, and (5) higher employment opportunities. The Honorable Minister of Agriculture stressed that the government would focus the most attention in the next fiscal year's Budget on food production in southern areas including the coastline (Daily Star, 2010). She said that coastal areas are untapped and the government will take different steps such as digging canals and introducing salt-tolerant hybrid crops to increase the land productivity of Bangladesh's coastal areas. It stressed that coastal lands should be used through livestock and fishing, cereal crops produced by wisely applying surface water and seed quality and agricultural mechanisms to make the Barisal region the Bangladesh rice basket once more.

Resilient livelihoods Research Report FAO (2011) shows that support for policy support, capacity building, agricultural transitions, livestock and fisheries/aquaculture, and better management of natural resources, such as land, forest, water or other resources, are required for the promotion of more competitive and resilient rural livelihoods, disaster risk reduction (DRR) for food security and nutrition This FAO study (2011) highlighted the importance of more innovation, through the mainstreaming of DRR into sustainable, long-term growth and environmental protection such as the agricultural or food chain (food storage, processing and transport) infrastructures, in prevention and/or mitigation of potential disasters. Sustainable models of food products that use local technology and practices to increase yields and reduce the risk of production failure need to be invested.[21] The report cites a number of examples, including better crop species management; adopting crops and species that are more resilient and climate-resilient and more adaptable to flood or seed; plant breeding for developing new adaptive and productive varieties. Sustainable water management was also mentioned in the report, which enhances the efficiency of water use, and productivity, such as precipitation of rainwater, river water storage techniques and irrigation techniques; agro-forestry systems which make use of trees and shrubs to reduce the effects of severe weather events, windbreaks and live clutches.

FAO (2011) stressed that preparedness preparation at the national level for agriculture-related sectors must be implemented more consistently. The DRR / M (Management) national system shall include the preparatory action it deals with. In order to ensure that appropriate action measures are in place, technical assistance shall be granted to ministries and departments. Preparatory preparation also calls for corporate initiatives to improve FAO's capacity to help member countries to respond effectively to crises, in particular in view of the multiple and increasingly increasing emergencies in the years ahead.

A research study by FAO on the Asia-Pacific diversification of crops (2001) indicated that a particular ecological zone with specific problems and possibilities constitutes coastal areas of the Southern part of Bangladesh. Often these areas are visited by cyclones, mare boring, salinity etc., which have an impact on agricultural production. For example, a salinity-resistant rice variety for these areas needs to be developed. The major cash crops in these fields are cocoa, betel nut, palm and mangrove. In order to use the potential, location research, extension and other programs will be developed and implemented.[22]

A 2011 World Bank report emphasized that climate-smart agriculture aims to increase productivity, enhance farmers ' climate change-resilience, and reduce the contribution agriculture can make to climate change by reducing greenhouse gas emissions and increasing carbon storage on agricultural land. Agriculture aims to increase environmental and socially sustainable growth. The report highlighted that sustainable agriculture includes proven practical techniques in several fields, in particular water management and innovative practices such as better weather predictions, early warning systems and risk insurance. It was all about bringing existing technologies into farmers' hands and developing new technologies, like drought or flood-tolerant crops, to meet climate change demands.[23]

Lin (2010) said that, as the climate fluctuations have increased, diversified agro-ecosystems are becoming more important for agriculture. The crop yields are very susceptible to temperature and precipitation changes, especially during the development of flora and fruit. Major effects on crop growth and production may be maximum and minimum temperatures as well as seasonal shifts. In many parts of the world, increased precipitation variability, including flooding, drought, and extreme rainfall have affected food safety. These observations indicate the need for developing resilient systems to prevent climatic variability and extreme climate events, particularly in highly relevant periods of development, for agricultural vulnerability to changes in temperature and precipitation. Lin also stressed that a variety of ways are demonstrated by diverse agricultural systems to mitigate the effects of climate change on agricultural production is structurally more complex systems. A more rational strategy for the development and protection of sustainable agricultural systems in the future under climate change can be developed to encourage a diversification of agricultural plants and landscapes.[24]

Lin stated that the resilience of production systems increased with agricultural diversity. An example explains that Sweden had cold tolerance problems while Tanzania had heat tolerance problems. The sites experienced further seasonal drought. In these situations, research showed that effective management practices, which were typically more ecologically complex and capable of tamping systems against climate change and preserving productivity, were integrating wild species in the farming system and growing the variety of crops both temporally and spatially.

Future temperature and precipitation changes will have a negative overall impact in Bangladesh, particularly on crop production. In their report "Appraisals of food grain production losses due to soil salinity caused by climate change," Habibullah and others noted that the effect of climate change on agriculture production and food security in Bangladesh predicted high temperatures will lower the HYV yields of' Aus," Aman' and' Boro' rice all seasons, and that it was especially obvious at 4 ° C development. The loss of crops from salinity intrusion could lead to approximately 0.2 Mt under a moderate scenario of climate change. Agriculture is the most vulnerable sector since its production is totally conditional on climate factors.

In an Asia-Pacific research report (FAO 2001) on crop diversification, a shortage of water supply for agricultural activities was identified as a major concern for Thai farmers. The effect on agricultural areas that rely heavily on rainwater is significant. Sadly, these precipitation areas are a predominant part of the country, where rice and farming are mainly carried out. Such a condition limits farmers from cultivating in the rainy season only once a year. Furthermore, farmers are exposed to high risks and damages due to harmful soil, climate and inconsistent rainfall conditions. Although efforts have been made to combat problems of water shortage, such as digging water pools to store water, appropriate sizes or systems have never been established. Certain factors also increase the shortage of water, such as unsystematically organized farming or monoculture systems.[25]

FAO (2001) also cited in an Indian crop diversification report that the crop shift (diversification) also takes place as a result of government policy and has been a driving force on some cultures over a certain time, such as the creation of a Technology Mission on Oilseed (TMO) to focus oilseed production as the national need to reduce the country's import dependency. Growth of market infrastructure and certain other price supports also lead to crop shifts. High quality crops such as spices often contribute to crop diversification. Greater profitability and production resilience/stability also lead to crop diversification, such as sugar cane substituting for rice and wheat. Crop diversification and growing large numbers of crops are practiced in rain-fed lands to reduce the risk factor of crop failure due to drought or lower rainfall. Crop replacement and shift in areas with distinct soil problems are also taking place. In areas where the high water tables replace oleo seed, pulses and cotton, rice grows; in vertical (medium and deep black soils), promotion of soybean instead of sorghum etc.. FAO (2001) also noted that over the last 50 years India has made huge progress in the agriculture sector. In the early 1960s, we not only became self-reliant in the food grain but we also gained adequate resilience to tidal conditions. During this period, wheat production increased approximately ten times and rice production increased four times. These accomplishments are the result of a rural infrastructure policy framework including irrigation, research, extension, provision of agricultural inputs at reasonable prices and marketing support through a minimum price mechanism.

In the coastal regions of Bangladesh, BRAC (2011) monitored the crop intensification project. The Monitoring Report of 405 sample farmers from 12 blocks showed that 242 (60%) of the beneficiary farmers used one crop per year and 163 (40%), in one year before the crop intensification project, cultivated double crops. Following project implementation, 298 (74 percent) farmers adopted three crops and 107 (26 percent) farmers took two crops annually. Many sampled farmers have shown interest in growing various robust crops for higher income. The cost of production per acre was BDT 6697 before action, but after project implementation, the costs of production were increased to BDT 10230 due to improved cultivation practices. Following the project intervention, the farmers produced 22 kg of rice per decimal whereas the farms only produced 12 kg per decimal before the procedure. They were pleased about the activities of the approach to intensification of crops, especially with the new knowledge and higher production they gained during the project. The farmers obtained BDT 26,477,891 because of cultivation of two or three crops a year; the farmers had only obtained BDT 6,350,195 and cultivated one crop a year before the intervention. Almost every farmer showed an interest in cultivating hybrid / HYV rice even after the project was completed. All sampled farmers have been informed that their household income has increased significantly and they are purchasing different agricultural equipment such as power tillers, sprayers etc. with increased incomes, apart from the investment in their children's and other families ' health and training.[26]

BRAC's completion report entitled' Intensification of crops to achieve food independence for Bangladesh coastal regions' stated that 15 crop patterns have been identified for coastal areas of Bangladesh, with the participation of agricultural communities and the local agricultural extension providers of the Bangladesh government. Six crop patterns were shown in the districts of Khulna and Satkhira, of which 15 crop patterns were shown. Nine patterns were shown in Bagerhat, Barguna, Jhalohathi, Patuakhali and Pirojpur. Because of (a) Rice-Rice-Maize, (b) Rice Rice-Sunflower, (c) Rice-Rice Kheshari, (d) Rice-Rice-Mungbean and (e) Rice-Rice-Rice, the farmers in the Barisal district of Bagerhat district could produce about 12-19 t / ha per year. By investing BDT 85,000-117,000 per ha, farmers earned BDT 218,000-315,000 per ha annually in gross income.

The findings of Europe Aid on BRAC's (2011) crop intensification program were as follows: the financial and technical help they needed to grow 2 to 3 crops a year in their historically single-cropping region was given 28,000 beneficiaries. A hands-on training in cultivation was provided to 73,021 farmers (both husband and wife) and 3,121 government extension officials. Intensification of crops created new agricultural jobs for landless people. Additional stakeholders (seed and fertilizer suppliers, power tiller owners, etc.) also benefited from increased earnings.

A further 34,687 tons of paddy were produced by the beneficiary farmers in the seven coastal districts of Bangladesh. An IRRI (2010) rice intensification study has shown that plant intensification can also be a primary culprit for stagnating yields, particularly for rice. Farmers, today, have been usually grown two to three rice plants a year, only one or two of them have been grown in the past. It is possible because some modern rice varieties grow faster than traditional varieties, and produce more grain per crop. The rice is known as IR8, for instance, one of the early' miracle ' rice species introduced in the Philippines by plant breeders in 1966, is 20 to 30 days ahead of improved rice species in the International Rice Research Institute. However, the additional crops that new varieties allow can put heavy pressure on soils, especially for rice paddy products, where the medium of cultivation is submerged for long periods of time (IRRI, 2010).

An IAEA (2010) research report from the coastal area of Bangladesh stated that about 90 percent of arable land remains unused for 6 to 7 months after harvesting rice due to freshwater shortages and high soil salinity. Soil salinization is primarily due to marine water moving inland along tidal rivers, spilling to soil and salinizing the soil and the hidden soil. However, some other food crops like mouthwatering, mung bean and sesame, which require relatively less water after the early harvest of Aman, a rain-fed rice, may also be produced. To improve farmers' livelihoods, better management of water and soil and further crop varieties are needed in order to reduce the long fallow time and to improve food security.

Due to the growing salinity of certain areas and the growth of the salt area due to the additional intrusion of salt water, normal crop production becomes more limited. Soil salinity is generally thought to be the main cause of low land use as well as the intensity of cultivation within the region. The growing population pressure demands more food. Thus it is becoming more and more important to explore the potential for the increasing production of plants of these (saline) lands.[27] It can be concluded from the above literature that agriculture is Bangladesh's most vulnerable sector because productivity depends totally on climatic factors. Erratic rainfall, extreme temperatures, an increase of sea level and increased salinity, floods, river erosion, cyclones and storms and drought are a negative effect on crop production. These are all likely to increase as a result of climatic change. Frequency of extreme weather events and the rise of the sea level have the potential to raise demand for farming while limiting the number of farmland. Salinity creates unfavorable conditions and hydrology that hinder normal cultivation all year round. The effects of the tides occur in regular variations in the rise and fall of the sea level and the estuarine/tidal channels and streams. Saline river water may also increase groundwater salinity and make it unsuitable for irrigation. The shortage of freshwater irrigation would be a problem especially during the winter, and again the production of Boro would have a negative impact. It affects crops at critical growth stages depending on the level of salinity, reducing yield and losing total yields in severe cases.

However, the happiest thing is that agro-meteorologists have developed short-term and stress-tolerant high yield and hybrid crop varieties which can be taken from the coasts of Bangladesh. Smart use of these crops can improve the coping capacities of coastal communities around the year, which can help satisfy the growing population of Bangladesh's food demand.

Chapter 3: Presentation of study findings:

The location of Bangladesh makes it one of the world's most vulnerable to environmental disastrous. Its huge network of rivers and huge low-lying flood plains make it fertile and exposed to flood, drought and storm erosion. In the form of natural vegetation, protective coastal greenbelts can thus affect life and death during harsh weather and increasingly frequent and deadly cyclones. Climate change in Bangladesh is causing a natural disaster almost every year. Southwest part of Bangladesh (Barisal) is one of the worst-affecting regions, particularly in the agricultural and socio-economic sector, that face the early impacts of climate change. In Barguna Sadar and Patharghata Upazila, it causes significant damage to agriculture every year and daily changes of crop pattern. The farmers of Barguna are having a lot of difficulties getting all their arable land into cultivation, especially because during the winter seasons of Boro crops, a lion portion of the land is only kept up because of salinity problems and lack of quality seeds and agricultural equipment. In coastal areas, the crop patterns followed are primarily Fallow-Fallow-transplanted rice from Aman season. The crop yield is negatively impacted by the rise in temperature, erratic rainfall, flooding, salinity, etc. and among which water-logging and drainage congestion are the major problems. Environmental conditions are more vulnerable, which are likely to be alerted, albeit slowly but surely, by climate change and rising sea levels. Salinity causes unfavorable conditions and hydrology, which restrict normal crop production all year long. Fertilizer dependence and irrigation are on the rise, causing permanent land fertility loss, biodiversity loss, extinction of local truths, shortages in soil-water and a loss of production sustainability. However, adaptations to change climate can reduce vulnerability, retard processes and increase food safety, such as agronomic manipulation, sustainable climate resilient agriculture, changing plant dates, using crop crops that last for a short period. In this chapter, the findings of the study and their logical interpretation have been presented according to the objectives of the study.

3.1. Presentation of Quantitative Data:

Traditional Crop System

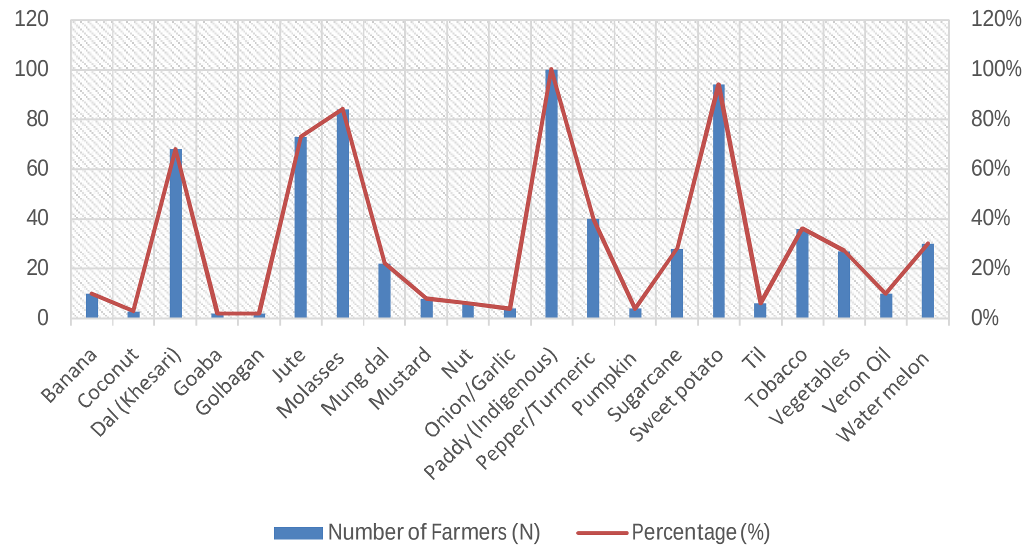
The study was aimed at exploring the experiences of the traditional cropping system of the farmers of the study area. The survey results revealed that hundred percent of the farmers of the study area were involved in producing indigenous variety of paddy (Table 1).

Table 1: Types of traditional practice in case of crop cultivation

Type of crops	Number of Farmers (*N*)	Percentage (%)
Banana	10	10%
Coconut	03	03%
Dal (Khesari)	68	68%
Guava	02	02%
Golbagan	02	02%
Jute	73	73%
Molasses	84	84%
Mung dal	22	22%
Mustard	08	08%
Nut	06	06%
Onion/Garlic	04	04%
Paddy (Indigenous)	100	100%
Pepper/Turmeric	40	40%
Pumpkin	04	04%
Sugarcane	28	28%
Sweet potato	94	94%
Til	06	06%
Tobacco	36	36%
Vegetables	27	27%
Veron Oil	10	10%
Water melon	30	30%

The second highest number of farmers (94%) was involved in the production of sweet potato whereas molasses was produced by third highest number (84%) of farmers (Table 1). Jute which was once called the golden fiber of Bangladesh was produced by fourth highest number (73%) of farmers (Table 1). The other crops which were seen to be produced more commonly were Dal (Khesari), Water melon, Tobacco, Pepper/Turmeric, Onion/Garlic, Veron Oil, Vegetables, Sugarcane, Pumpkin, Golbagan, Nut, Mustard, Til, Coconut, Banana and Goaba (Tabel 1).

Fig. 01:Traditional practices of crop cultivation



The second highest number of farmers (94%) was involved in the production of sweet potato whereas molasses was produced by third highest number (84%) of farmers (Table 1). Jute which was once called the golden fiber of Bangladesh was produced by fourth highest number (73%) of farmers (Table 1). The other crops which were seen to be produced more commonly were Dal (Khesari), Water melon, Tobacco, Pepper/Turmeric, Onion/Garlic, Veron Oil, Vegetables, Sugarcane, Pumpkin, Golbagan, Nut, Mustard, Til, Coconut, Banana and Goaba (Tabel 1).

The study also revealed that almost all the farmers were habituated to the production of indigenous variety of crops. The causes behind this practice might be that at that time the hybrid varieties were not introduced. Besides, the farmers of the study area were not conscious to the expected extent of the hybrid varieties and their merits. On the other hand, their cropping was confined to their own family food need; most of them did not think of commercial production.

It was also divulged that at the very beginning of their cultivation they were accustomed with traditional instruments like plow, cows and buffalos. It was seen that all the farmers were used to the usage of plow and cows (Table 2).

Table 2: Instruments used in traditional cropping system

Name of the instrument	Number of farmers	Percentage
Plow (Pulled by cows)	100	100%
Cows	100	100%
Buffalo	34	34%
Modern Instruments	0	0

It might result from the ignorance of the modern agricultural technologies and the benefit of using those technologies. Most of the farmers of Bangladesh are illiterate. They lack the proper farm knowledge essential for better farming.[28]Consequently, almost all the farmers (80%) of the study area were confined to a single crop in a year (Table 3).

Table 3: Number of yields in a year (in traditional period)

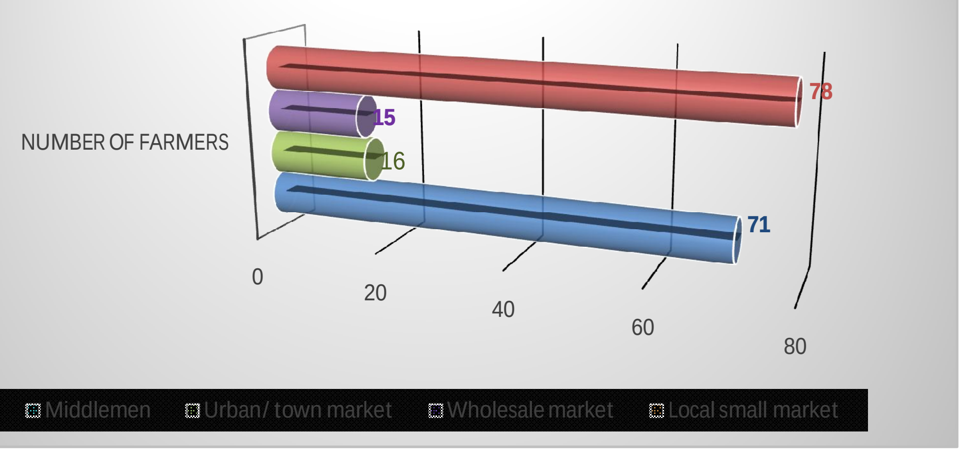
Number of yields	Number of farmers	Percentage
One	80	80%
Two	20	20%
Three	0	0
Four	0	0

A very few farmers (20%) cultivated two crops in a year (Table 3). That means a major portion of the land remained fallow over the year. But according to the modern cropping system year round a farmer can produce three crops in a single piece of land. In this study none was found who cultivates a piece of land thrice a year (Table 3). An effort was made in this research work to know how the farmers market their products in traditional period.

Table 4: Types of markets used by the farmers in traditional period

Types of market	Number of farmers	Percentage
Local small market	71	71%
Middlemen	78	78%
Wholesale market	16	16%
Urban/ town market	15	15%

Fig. 02: Market access in traditional period



It was found that they were not well trained in marketing their produces. Most of the farmers (78%) sold their products to the middlemen (Table 4 & figure 2). And that is why most of them did not get rational prices for their products. A very few of them (15%) were used to get their produces to the urban market (Table 4 & fig. 2) where they had the opportunity to have the fair price for their produces.

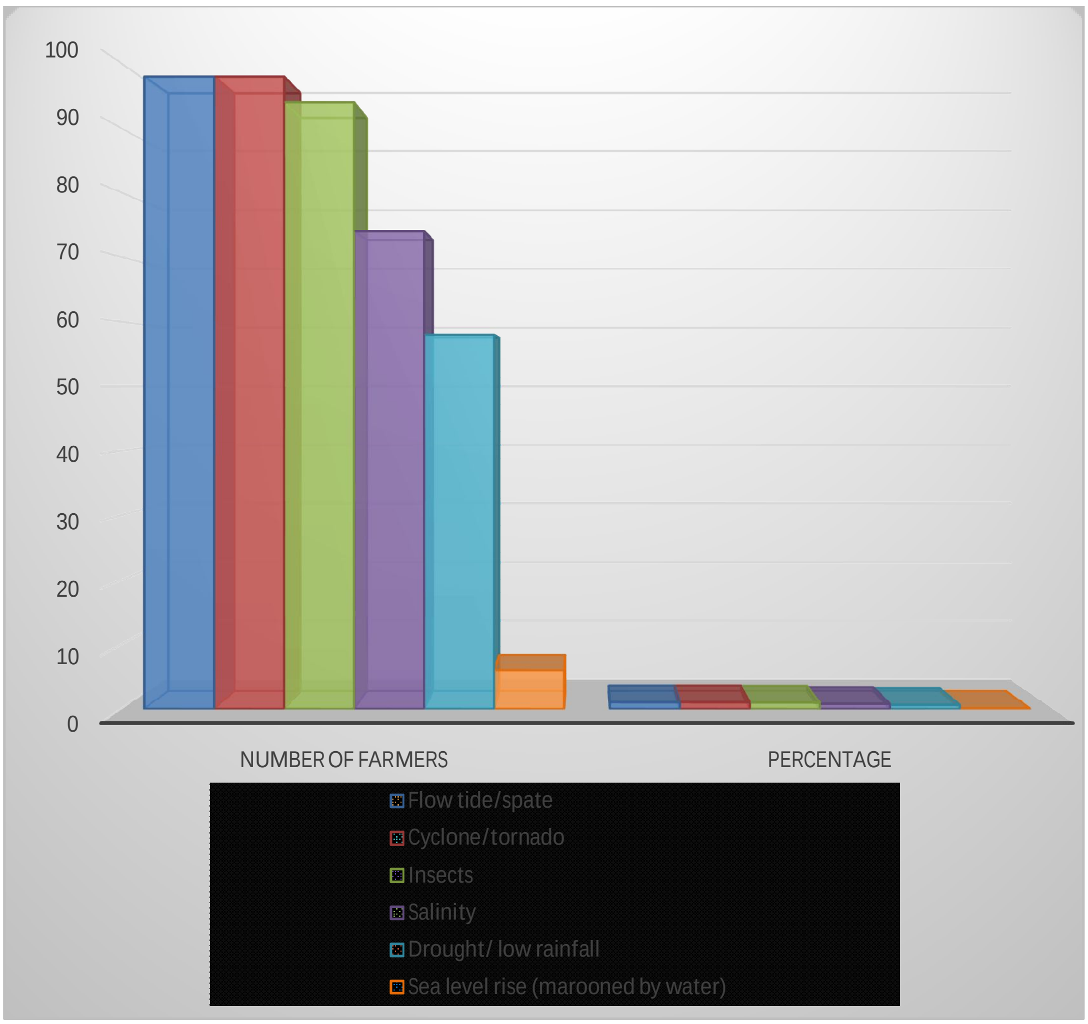
Exploring the changing pattern of cropping system in the disastrous area:

Exhaustion with the natural disasters namely flow tide, cyclone, salinity of land, insects and drought or low rainfall is very common phenomenon of the coastal area of Bangladesh and no exception was the study area sampled for this research work. Being castigated by the respondents flow tide and cyclone stood 1st (98% of the respondents claimed) whereas insects secured the 2nd position (94% of the respondents blamed) based on their frequency of attack (Table 5 & fig. 3).

Table 5: Main Disasters in the study area

Types of disasters	Number of farmers	Percentage
Flow tide/spate	98	98%
Cyclone/tornado	98	98%
Sea level rise (marooned by water)	6	6%
Salinity	74	74%
Insects	94	94%
Drought/ low rainfall	58	58%

Fig. 03: Main Disasters in the study area

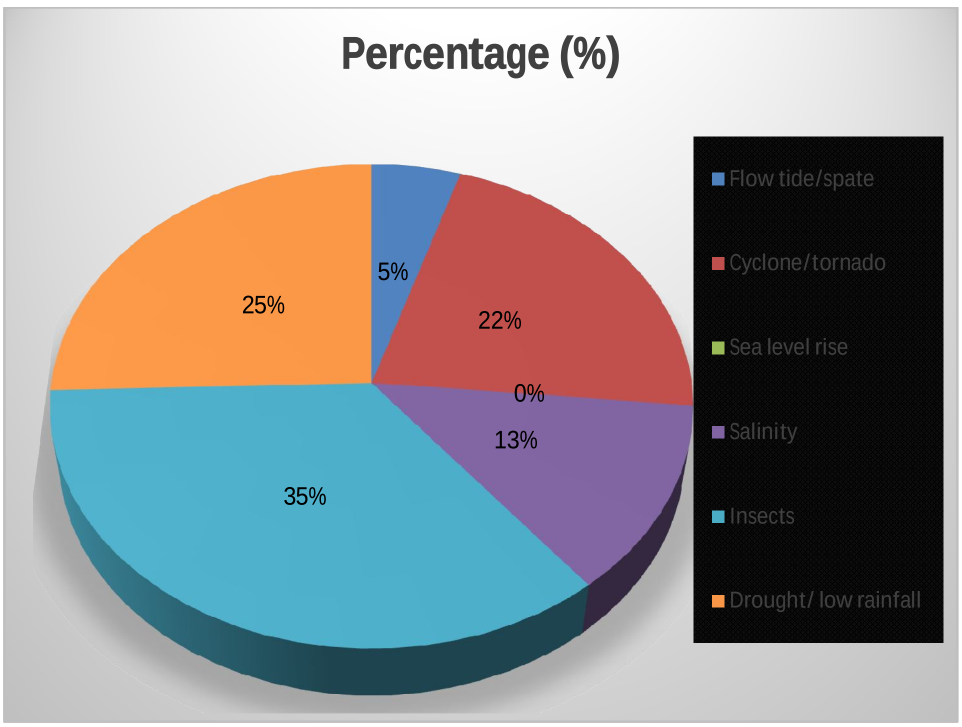


Whatever the disaster is, it is clear that farmers of the study area that means the coastal area of Bangladesh are affected significantly by the natural calamities.

Table 6: Disaster that harms the crops most according to the farmers

Disasters	Number of farmers	Percentage (%)
Flow tide/spate	5	5%
Cyclone/tornado	22	22%
Sea level rise	0	0%
Salinity	13	13%
Insects	35	35%
Drought/ low rainfall	25	25%

Fig. 04: Most harmful disasters in crop cultivation according to the farmer



The largest share of the respondents (35%) attributed blame to insects for low yield that means, insects were the most harmful for crops followed by drought (25%) and cyclone (22%) respectively (Table 6). This result resembles the research findings where it is estimated that 4.14% of rice yield in Bangladesh is lost every year by different pests.[29]

Table 7: Full and partially extinct crops in the study area

Crops	Frequency	Percentage (%)
Paddy (Indigenous)	98	98%
Jute (Indigenous)	95	95%
Sugarcane	20	20%
Sweet potato	82	82%
Tobacco	42	42%
Onion/Garlic	2	2%
Pumpkin	1	1%

In consequence of these natural and man-made disasters according to almost all the farmers (98%) indigenous variety of paddy is extinct and 95% of the farmers thought that the indigenous variety of jute is almost non-existent in the study area whereas according to 82% of the farmers sweet potato is now an extinct species (Table 7). Almost all the farmers (98%) get accustomed to producing hybrid variety of paddy (Table 8). Second highest number of farmers (80%) is now used to producing hybrid potato. The study has also revealed that the farmers of some crops have decreased. For example once most of the farmers (84%) were used to produce molasses, but now only 42% of the farmers produce molasses. At the primitive stage, 06% of the farmers produced nut whereas the number of the nut producer decreased to 02% and the number of sugarcane producer decreased by more than half (Table 8).

Table 8: A comparative analysis between traditional and modern practices

Traditional Practices			Present/modern practices		
Type of crops	Number of Farmers (*N*)		Type of crops	Number of Farmers (*N*)	
Banana	10	10%	Banana	0	0%
Coconut	02	02%	Coconut	02	02%
Dal (Khesari)	68	68%	Dal (Khesari)	42	42%
Guava	02	02%	Guava	0	0%
Golbagan	02	02%	Golbagan	0	0%
Jute	95	95%	Jute	0	0%
Molasses	84	84%	Molasses	42	42%
Mug dal	22	22%	Mug dal	60	60%
Mustard	08	08%	Mustard	08	08%
Nut	06	06%	Nut	02	02%
Onion/Garlic	04	04%	Mango	40	40%
Paddy (Indigenous)	100	100%	Paddy (Hybrid)	98	98%
Pepper/Turmeric	40	40%	Pepper/Turmeric	0	0%
Pumpkin	04	04%	Pumpkin	0	0%
Sugarcane	28	28%	Sugarcane	10	10%
Sweet potato	94	94%	Sweet potato	0	0%
Til	06	06%	Til	02	02%
Tobacco	42	42%	Tobacco	0	0%
Vegetables	26	26%	Vegetables	56	56%
Veron Oil	10	10%	Veron Oil	0	0%
Watermelon	23	23%	Watermelon	56	56%
			Potato (Hybrid)	80	80%
			Lemon	04	04%
			Maize	06	06%
			Sunflower	52	52%
			Wheat	06	06%

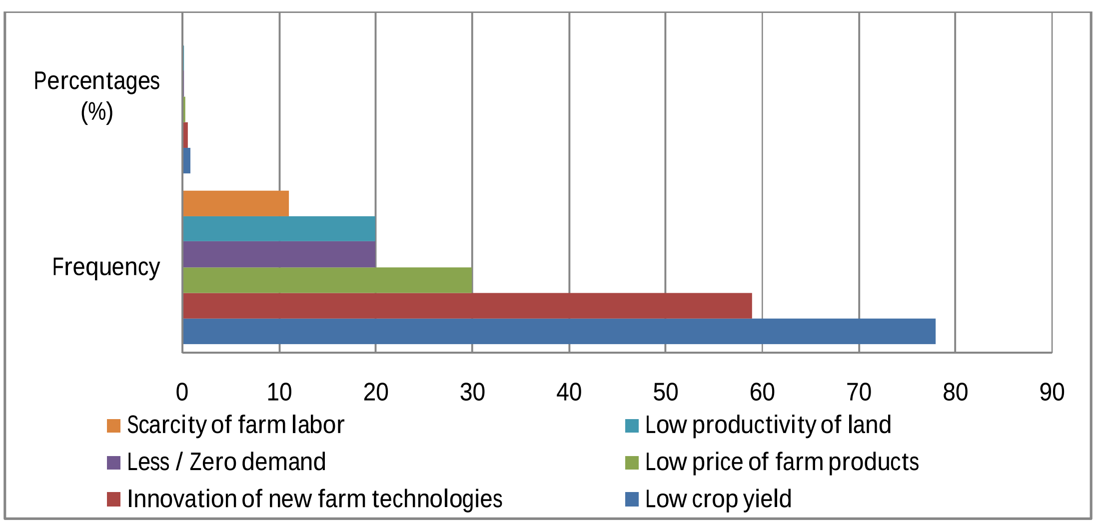
In case of pulses it was seen that the production of Khesari Dal decreased from 68% to 42% and on the other hand the production of Mug Dal increased from 22% to 60%. There are some crops which were not produced by the farmers at the early stage of their cultivation but they are now producing. For example more than half of the farmers (52%) now produce sunflower and 06% of them are producing wheat (Table 8). The study has also revealed that almost one fourth of the farmers were used to produce vegetables (26%)

and watermelon (23%) but now more than half (56%) of the farmers are producing vegetables and watermelon. It is also divulged that some crops like jute, banana, guava, Golbagan, pepper/turmeric, pumpkin, sweet potato, tobacco, Veron oil which were once produced by the farmers of the study area now totally out of cultivation. There is none who produces these types of crops. But among the farmers now 40% produces mango, 74% produces hybrid potato, 52% produces sunflower and 6% produces maize and wheat which were not produced earlier. The results might be because the farmers are very much responsive to the natural and situational changes took place in the field of agriculture. Though they are not educated enough but the environmental changes have molded them up in such a way to cope with the changes through proper selection of crop types. Though more or less the causes of these changes could be assumed, yet there raises the question about the shifts to the modern crop choices have taken place.

Table 9: Causes behind the shift to the modern cropping system:

Variables	Frequency	Percentages (%)
Low crop yield	78	78%
Low productivity of land	20	20%
Innovation of new farm technologies	59	59%
Scarcity of farm labor	11	11%
Low price of farm products	30	30%
Less / Zero demand	20	20%

Fig. 5: Causes behind the shift to the modern cropping system



Low crop yield, according to most of the farmers (78%), stood as the causes behind the shift to the modern cropping types for cultivation as per the research findings proclaim. Besides, more than half of the farmers (59%) told that they had shifted from the old cropping system to the modern cropping system because of the availability of the new farm technologies (Table 9 & fig. 5). According to most of the farmers of the study area the low yield of indigenous varieties of crops and the availability of modern farm technologies inspired them to produce hybrid varieties of crops. But they could not avail the modern marketing technologies. Still almost all the farmers (84%) used the local markets for marketing their produces. A very few of them (22%) used the urban markets (Table 10).

Table 10: Where farmers sell the products

Type of Market	Frequency	Percentage (%)
Local small market	84	84%
Middlemen	40	40%
Wholesale market	17	17%
Urban market	22	22%

This is why; a large number of farmers did not get the rational prices for their products. So, still cultivation was not that much profitable to them. Modern transport mechanism is also a part of good marketing system. But, in this study it was also found that almost all of the farmers (92%) used non-conventional transport mechanism that was rickshaw/van (transport pulled by human) (Table 11).

Table 11: Transport system of marketing the crop products at present

Transports	Frequency	Percentage (%)
Boat/trawler	20	20%
Rickshaw/van	92	92%
Track/pickup	06	06%
Votvoti/ Nosimon (nonconventional transport)	42	42%
Self-carrying on solder	40	40%
Buyer comes at home	04	04%

Utility creation is the way of generating demand of anything for which the existing and potential buyers are not ready to pay. If the producer can create any sort of utility, he or she will be able to convince the buyer to pay for his/her product. But, in the study area it was seen that all the farmers (Table 12) used traditional storage system.

Table 12: Storage system

Type of storage	Frequency	Percentage (%)
Traditional system	100	100
Modern (cold storage)	0	0

So, they would not be able to create time utility properly to get rational price for their product and thereby make profit. The result might be because of the absence of proper initiatives from the concerned authority. The farmers are ready to cope with the modern technologies. But technology like cold storage cannot be established by individual farmers of coastal area as their economic background is not that much strong. Here the responsibility lies with the concerned authority to facilitate the farmers with the modern farming facilities.

Coping mechanism of farmers in disaster prone area:

In search of the real life situation of the adoption process of the farmers in their agriculture in the study area it was seen that a very few of the respondents (16%) accustomed with the use of power pump which is essential for irrigation during the dry season. It was also revealed that most of the farmers (78%) were dependent on the rain water (Table 13). In that case, cultivation fate would have conditional on nature in the study area.

Table 13: Irrigation system used in cultivation

Irrigation system	Frequency	Percentage (%)
Deep tube well	0	0%
Power pump	16	16%
Tidal water storage	25	25%
Water vessel	30	30%
Depend on rain water	78	78%

In the coastal belt, a very few farmers were used to irrigate their farmlands with deep tube well (ranked least in the table 13/A) which are needed for the best cultivation. Nature-depended rainy water secured 1st rank for cultivation. Water vessel and the storage of tidal water placed 2nd and 3rd positions for irrigation (Table 13/A).

Table 13/A: Extent of practice of coping strategies related to Irrigation system:

Coping strategies of Irrigation system	Extent of practices					CI	Rank
	Re	Fre	Oc	Ra	N		
1. Depend on rain water	21	35	19	20	5	17.03	1st
2. Water vessel	16	33	31	11	9	16.27	2nd
3. Tidal water storage	20	26	14	23	17	14.41	3rd
4. Power pump	5	14	51	13	17	12.21	4th
5. Deep tube well	0	0	0	12	88	0.83	5th

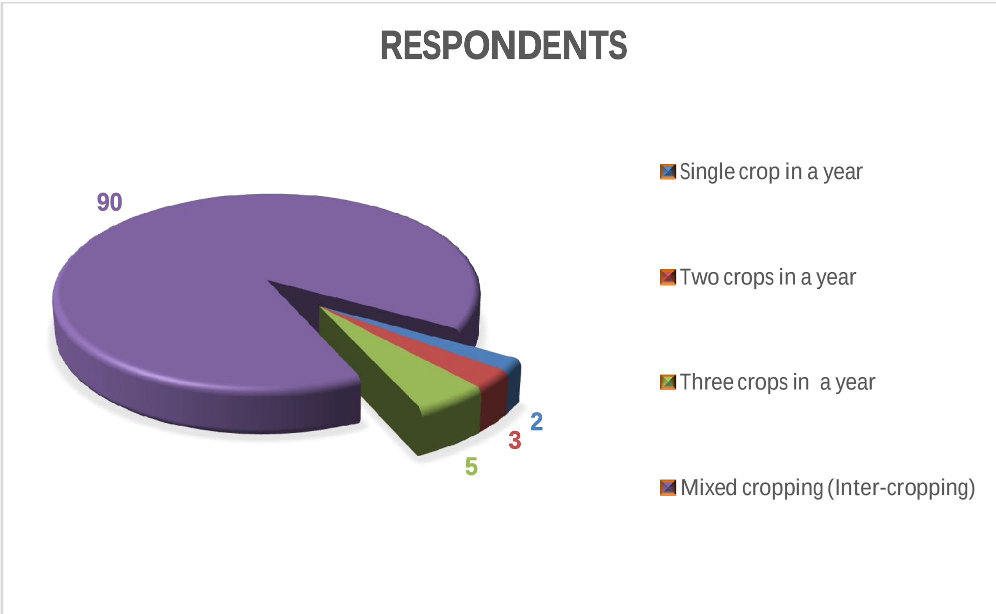
Re=Regularly=4, Fre=Frequently=3, Oc=Occasionally=2, Ra=Rarely=1 and N=Never=0, CI= Composite Index.

Almost all the farmers (90%) had shifted from single cropping to mixed cropping, that is, intercropping (Table 14) which bears a very positive sign because in case of managing the risk of disaster intercropping is a good solution.

Table 14: Changes in cultivation

Cropping pattern	Respondents	Percentage (%)
Single crop in a year	2	2%
Two crops in a year	3	3%
Three crops in a year	5	5%
Mixed cropping (Inter-cropping)	90	90%

Fig. 6: Changes in cultivation:



In the coastal disastrous area most of the farmers used to cultivate different types of pulses in the paddy-fields simultaneously. Fishing is also introduced recently in the paddy farms at rainy season. Furthermore, vegetables are farmed at the surroundings of farmlands in most cases. That's why, mixed cropping system took place top (1st rank) in the practice of coping mechanism related to cultivation (table 14/A).

Table 14/A: Extent of practice of coping strategies related to cultivation:

Coping strategies of cultivation	Extent of practices					CI	Rank
	Re	Fre	Oc	Ra	N		
Single crop in a year	2	1	22	35	40	6.21	4th
Two crops in a year	3	24	28	16	29	10.76	3rd
Three crops in a year	5	26	19	23	27	10.96	2nd
Mixed cropping (Inter-cropping)	90	1	5	4	0	26.00	1st

Re=Regularly=4, Fre=Frequently=3, Oc=Occasionally=2, Ra=Rarely=1 and N=Never=0

CI= Composite Index.

Besides, intercropping is helpful for maintaining the fertility of soil. Even to meet the increasing food demand of the increasing population of Bangladesh mixed or intercropping might be a very time befitting mean. Not only inter-cropping, using hybrid seeds is also a positive signal of development. In this study it was revealed that almost all the farmers (86%) used high yielding varieties of seeds (Table 15 & 15/A).

Table 15: Changes in crops due to disasters

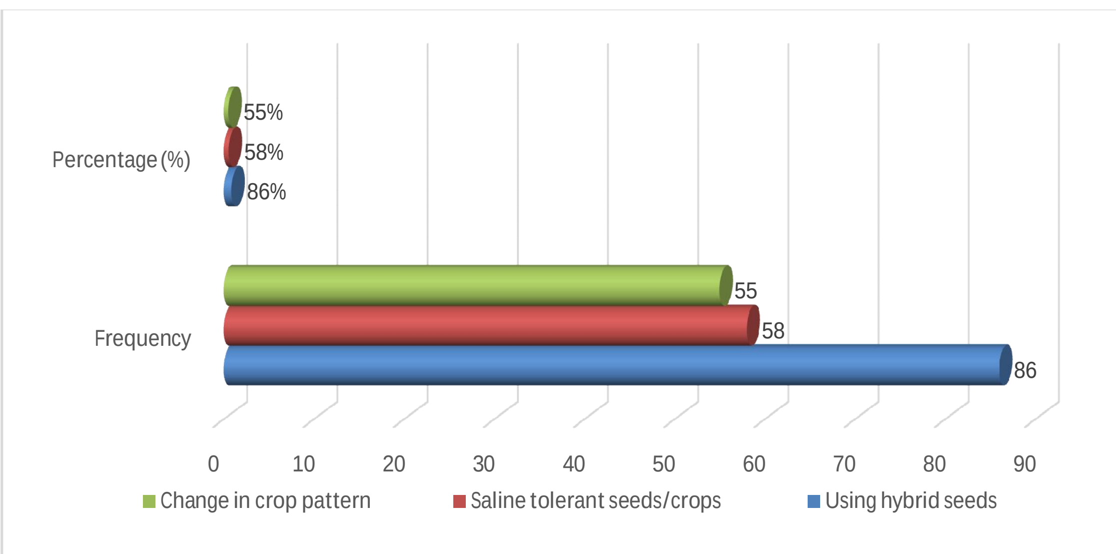
Changes	Frequency	Percentage (%)
Saline tolerant seeds/crops	58	58%
Change in crop pattern	55	55%
Using hybrid seeds	86	86%

Table 15/A: Extent of practice of coping strategies related to Changes in crops:

Coping strategies of crop changing	Extent of practices					CI	Rank
	Re	Fre	Oc	Ra	N		
Saline tolerant seeds/crops	31	18	9	20	22	14.89	2nd
Change in crop pattern	26	20	9	25	20	14.27	3rd
Using hybrid seeds	56	16	14	10	4	21.37	1st

Re=Regularly=4, Fre=Frequently=3, Oc=Occasionally=2, Ra=Rarely=1 and N=Never=0, CI= Composite Index.

Fig. 7: Changes in crops due to disasters:



A satisfactory number of farmers (58%) used saline tolerant seeds (figure 7). It was also found that almost all the farmers used hybrid seeds of paddy and potato (Table 16).

Table 16: Types of crops introduced to cope with disaster

Crops	Frequency	Percentage (%)
Hybrid paddy	98	98%
Hybrid potato	80	80%
Water melon	56	56%
Sunflower	52	52%
Robi crops	43	43%
Vegetables	33	33%
Fish farming in crop land	24	24%
Wheat	14	14%
Mango	4	4%
Banana	2	2%

The most remarkable changes took place in the adaptation process is the production of robi crops (winter vegetables), sunflower, hybrid potato and water melon. More than half (52%) of the farmers of the study area used to produce sunflower and 56% used to cultivate water melon. It bears the testimony to the commercial production of the farmers of the study area. A very noteworthy finding was that during the disaster especially the cyclone, flood, flow tide and so on which were frequently confronted by the farmers of the coastal areas when their farm lands were under water, at that time they produced the water tolerant crops and in that fields they at the same time reared fish. But the alarming situation is that a remarkable number of farmers changed their occupation. If the farmers give up their profession only for disasters, the new generation will not be inspired for cultivation. In this study it was seen that almost all (92%) those who had left their profession joined as industry labors (Table 17 & ranked 1st at the table 17/A).

Table 17: Changes in occupation

Occupation	Frequency	Percentage (%)
Rickshaw/ van/motor cycle driver	60	60%
Small business	41	41%
Industry labors	92	92%
Fishing in sea	58	58%

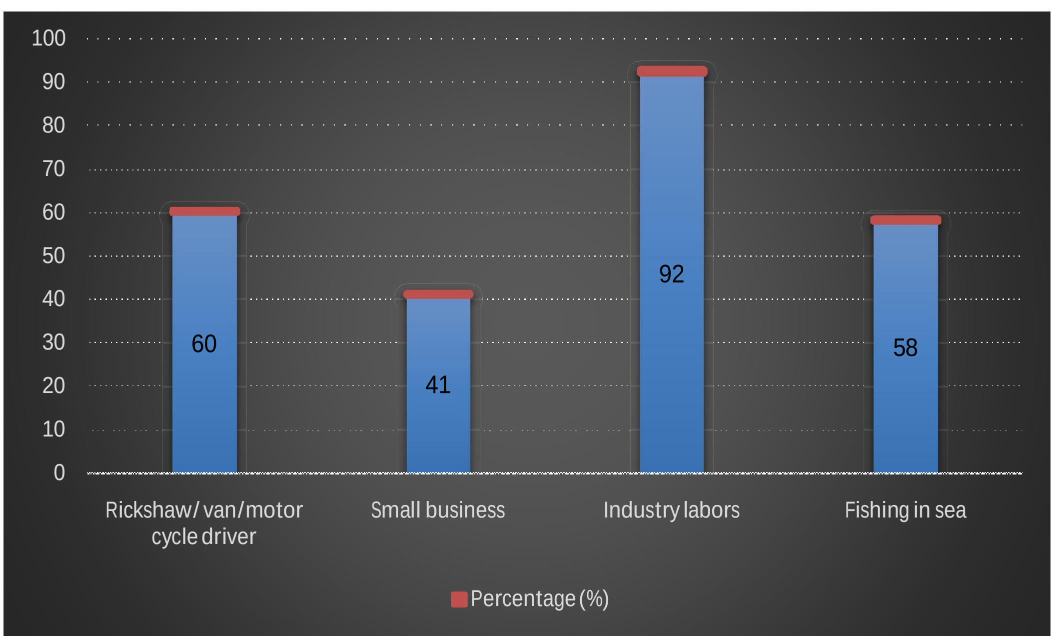
Table 17/A: Extent of practice of coping strategies related to Changes in occupation:

Coping strategies of Changes in occupation	Extent of practices					CI	Rank
	Re	Fre	Oc	Ra	N		
1. Rickshaw/ van/motor cycle driver	29	20	19	17	15	15.93	2nd
2. Small business	16	28	31	11	14	15.24	3rd
3. Industry labors	46	24	6	11	13	19.24	1st
4. Fishing in sea	30	14	20	16	20	15.03	4th

Re=Regularly=4, Fre=Frequently=3, Oc=Occasionally=2, Ra=Rarely=1 and N=Never=0

CI= Composite Index.

Fig. 8: Changes in occupation:



But here there is the possibility to be optimistic about the adaptation capability of the farmers. In this study it was seen that almost all the farmers were using modern technologies.

Table 18: Usage of modern technologies:

Technologies	Frequency	Percentages (%)
Applying chemical fertilizer	100	100%
Using tractor	97	97%
Using insecticides	98	98%
Hybrid varieties of crops	91	91%

Table 18/A: Extent of practice of coping strategies related to modern technologies:

Coping strategies of modern technologies	Extent of practices					CI	Rank
	Re	Fre	Oc	Ra	N		
1. Applying chemical fertilizer	67	18	12	3	0	24.06	1st
2. Using tractor	51	33	7	3	6	22.07	2nd
3. Using insecticides	54	29	11	2	4	22.55	3rd
4. Hybrid varieties of crops	25	24	11	13	27	14.27	4th

Re=Regularly=4, Fre=Frequently=3, Oc=Occasionally=2, Ra=Rarely=1 and N=Never=0, CI= Composite Index.

In the study area all the farmers applied chemical fertilizers in their field. The farmers considered insecticides as the most devastating natural cataclysms in the coastal area. And so, to get rid of this problem almost all the farmers used insecticides (Table 18 & 18/A).

The challenges of local farmers in changing crop pattern:

In the study area it was seen that the farmers took some initiatives to cope with the changes due to the natural and man-made disasters by means of changing crop patterns. In the study it was seen that almost all the farmers (90%)considered frequent natural disaster as the most terrified challenges to them (Table 19).

Table 19 Problems faced by the farmers due to changing patterns of crop production

Challenges	Frequency	Percentages (%)
Scarcity of agro based labour	66	66%
Some crops are fully/partly extinct	86	86%
Repeat natural disaster	90	90%
Lack of storage facilities	68	68%
Fragile coastal embankment	77	77%
High labour price	07	07%

The non-existence of some crops, especially the indigenous varieties was the challenges according to the second highest number of farmers (86%) in the study area (Table 19). If the farmers were ensured with sufficient amount of labour with rational labour cost, storage facilities and durable embankment the adaptation process would be enhanced. There were also some suggestions from the farmers. All the farmers suggested that there should have water reservoir for the irrigation in the dry season (Table 20). They had also suggested that the reservoir might be made by digging cannels. As most of the farmers were poor they (84%) thought that they would be able to irrigate their crops at the most cost effective ways if cooperative societies could be formed.

Table 20: Suggestions from the farmers to solve the problems faced by them

Suggestions	Frequency	Percentages (%)
Cold-storage facilities	41	41%
Cooperative irrigation	84	84%
Tractor/equipment supply	61	61%
Strengthening capacity for coping with cyclone	20	20%
Digging canal /water reservoir for irrigation	99	99%
Ensuring rational crop price	7	7%
Increasing subsidies in agriculture	4	4%

The third highest numbers of farmers (61%) thought that they should have been provided with modern farm technologies like tractor and so on for better adaptation (Table 20).

3.2. Qualitative Data Findings (Observation, FGD, KII and other Documents):

For this study, four Key Informants Interviews (KII) were taken those are mentioned previously. They were Deputy Director of Agriculture (Barguna district), Upazila Agriculture Extension Officer (Patharghata), Block Supervisor (Baliatali Union Parisad, Barguna Sadar) and a dealer/seller (seeds & fertilizers) of Patharghata. The key informants were selected based upon their expertise on the relevant subject matters required for analyzing the issue rigorously. On the other hand, only one Focus Group Discussion (FGD) has been conducted at Patakata village in Barguna Sadar upazila. Some important data findings have been unveiled through observation technique along with both KII and FGD. Here is a gist of all qualitative data are presented here in accumulation from the study area.

Tropical storms, extreme temperatures, increased salinity, drought, floods, river erosion and erratic precipitation are the negative impacts on crop production. These are all likely to grow because of climate change. From the focus group discussion, literature review, interviewing and observation by key informants I found some positive and negative crop pattern trends in the coastal belt.

Photograph 3.2.1*: Focus Group Discussion, Patakata village*

The biggest impact of the rising sea level is the reduction of the availability of fresh water by salinity intrusion. The main obstacle to intensifying production of crops in the coastal areas is seasonally high salt levels in the soil root area. Saline water enters inland via streams and networks, especially in late dry seasons when fresh water flows downstream very little. The salinity of the river water increases during this time (FGD). The salts enter the dry soil either through floods by saltwater or through water from the rivers, and through evaporation the salts are concentrated in the surface layers. The saline river water may also increase ground water salinity and cause irrigation to become unsuitable. An intrusion of salt with the tide through rivers and estuaries would have a direct consequence of sea level rise. In the dry season in Patharghata it would be more acute, in particular when water from rivers decreases (KII-UAEO).

Salt would affect the agricultural lands in the coastal area; the soil quality would be deteriorated and flooding would lose production. The rise in flood speed and the duration of flooding will have an impact on the production of Aman. The increase in sea level will increase the salinity of water and soil, which is damaging Aman's cultivable soil. Water and salinity logging is expected to reduce the paddy area of Aman and Boro due to the longer flood duration and irrigation restrictions. The high yielding verities of Aman paddy would begin to lose more and more land for cultivation in Patarghata, as a result of the increase in sea level. Every year, therefore, Patharghata farmers lose their crops because of climate change. They are interested in alternative farming (KII) because of a lack of fresh water for farming.

The total production of rice decreased due to the decrease in rice fields when rice is transformed into another crop. During the year farmers could not produce two rice crops, as one vegetation cycle used as fallow ground instead of crop production, for another small production or for maintaining soil. As such, the rise in the sea level has an impact both on agriculture and on changing crop patterns in the area. With the rise of sea level, the salinity of both water and soil in Barguna will be increased, destroying normal coastal agricultural characteristics. On the other hand, in the various estuaries and water inlets, crossed with rivers, saltiness levels have increased in domestic swamps, ground water supplies and agricultural land.

The congestion of drainage can become a serious threat because of climate change. It is a serious problem because of the joint effect of drainage channel networks in many parts of the coastal area, slump and poor maintenance. The reduction in capacity for natural drainage (World Bank, 2000) is aggravating this.

In the monsoon, the coastal areas are inundated and water is collected in areas of the basin during the dry season. Tidal fluxes through a network of tidal streams and drainage canals connected to the main fluvial system flood the soil, impregnating it with soluble salts, making the top as well as the subsoil saline. In the summer, the high tide goes beyond the general terrain. The highest tide could flood lands on the Eastern coast of the Sundarbans where protective barrages were not built. A seasonal low flood which affects approximately 60 per cent of the total area is the most important feature in hydrology in terms of agriculture development. Water from October to the end of December drops in those areas. As a result, a vast coastal land is being flooded with salt water to prevent further agricultural land (KII, DD Agriculture).

The saltwater comes mostly in the dry season from the rivers Baleswar, Bishkhali and Payra. The river Bhola, the neighboring river of Barguna, however, plays a vital role during the dry season in the eastern part of Barguna. It brings water from various rivers and passes through various canals through the eastern part of the study area. The Boro and Aus plants are damaged. There is no fresh water for the farmers to cultivate crops. Furthermore, there is no lack of fresh water in various vegetables. Since Barguna is a very salty area, the variety is very popular because farmer can use canal and pond water in the reserve before rising sea level. In the Aus and Boro seasons the farmers could not use river water because the water remained salty at that time. Currently, some areas of coastal land are not used for crop production because of soil salinity in particular, and under a climate change scenario, that situation would further deteriorate. The aridity index would increase in winter under the changing climate conditions. Higher rates of capillary action as the topsoil aridity rate increases would thus increase the problem of salinity. In the past, very little attention was given to the Salinity issue. However, symptoms of such earth degradation are too pronounced to be ignored in recent years.

The salt weather diminishes the houses ' durability. Hard-workers especially farmers go to other places and earn money for different work. The saline weather is making life hard. The farming lands lose day by day their fertility. Its fertility due to crop decrease at rapid pace people migrate in search of livelihood from different places. Those who remain face the cultivation problem and other purposes. Salinity limits people to move their job (FGD).

Rainfall for crop production is one of the main climatic factors. All crops need water for growth and development at critical stages. Moreover, flooding and water logging conditions can lead to excessive rainfall and crop loss as well. Aman rice production was found to have decreased by 0.036, 0.230 and 0.292 tons (KII, UAEO) by 1 mm rainfall in phases of vegetative, reproductive and maturation. Rainfall variability, uncertain dates of onset, seasonal flood recession and drought-restrictive risk of Aman and Aus rice cultivation. Uncertain delays in planting and damage to floods Aus and Aman crops. High monsoon precipitation causes delay in Aman transplantation. It is essential to plant quickly Rabi (winter) crops in the coastal saline belt with short winter season but this is limited to late Aman rice collection. Late rainfall many times causes serious harm to plants in Robi season at the end of the rainy season. Because of the rain water in their cropland due to climate change they cannot farm vegetables in due time. This is why crop production is reduced daily. The reason is that the behavior of weather patterns is changing. The continuous moisture of the soil is affected by erratic precipitation and consequently by the planting time. In order to reduce the loss burden, it may be necessary to collect premature standing crops (vegetables, spinach etc.) if the risk of such crops becomes inundate. Different insects and diseases attack rice plant and vegetable and spinach etc. (FGD).

Cyclones cause enormous damage to crop production. Food and Agriculture Organization / GIEWS Global Watch (2007) reported the main rice crop "Aman," accounting for about 70% of annual production in the area most affected, at the time of the cyclone SIDR (2007). By analyzing data from item wise crops it was established that Aman plants and summer vegetables (Bitter Gourd, pumpkin, etc.) were in the field during the SIDR (15 November 2007). During the summertime farmers grow more Aman paddy land and less vegetable land. Right before SIDR farmers cultivated 96% (184.79 hectares) of Aman's land, and 4% (8.34 hectares) of summer vegetables land. On the other hand, farmers cultivated winter crops during Aila (29 May 2009), at which time the winter harvest was nearly over. The farmers were therefore preparing for the seed bed of Aman. Boro paddy was then present in a total of 21.62 hectares of land, seed beds and 12.55 hectares of winter vegetables. It was evident that land cultivation was only about 18% just before Aila; of course, the damage caused by Aila was less than that of SIDR. As mentioned earlier, the problem of salinity and the scarcity of sweet water farmers could not bring all arable land to Boro culture in winter. But whatever farmers tried to cultivate just before Aila, cyclone Aila destroyed it all.

The temperature and precipitation changes could affect the planting, blooming and harvesting of crops, or slow-but-continuous processes such as land fertility degradation, salinity intrusion, or increased extreme weather events and further calamities directly and effectively. Every year, an important global amount of agricultural production is lost due to various calamities resulting from the sources above. The potential for wheat and potato growing would be greatly affected with the change in temperature (by 20 ° C and 40 ° C). The loss of production may exceed 60% of the achieved yield. Higher temperatures also have a negative impact on organic soil.[30]The land farmer cannot cultivate lack of fresh water when the temperature is high in the dry season. The salinity of the river increases during the dry season due to its high temperature.

By cultivating local rice varieties, the area's people got better results. Due to its frying quality and taste, the local rice is ever higher than the HYV. It is also more environmentally friendly because it needs fewer fertilizers and pesticides and therefore also reduces production costs. By using the rice farming system and choosing the salt tolerant oil / dal seed varieties, such as sunflower, mung bean, pea, etc., people in the area benefit more from the same land by integrating local rice species in these plants. It also affects your society positively. By exchanging rice seeds and obtaining cash when needed, people become closer together.

Bangladesh's heavy rainfall is typical for flooding every year. However, the flood is alluvial and the soil is fruitful. BRRI (1991) reports that Aus rice requires extra irrigation during the early stage of its growing season, whereas Aman is nearly entirely monsoon rain-fed rice, although additional irrigation is required during planting, and in some cases during the flowers depending on the availability of rain-waters. In contrast it is completely irrigated, because Boro rice grows in the dry winter and in the warm summer. The variability of rainfall in the three rice varieties varies significantly.

Adapting to climate change adverse effects is crucial to reducing climate change impacts currently taking place and to improve resistance to impacts in future. Knowledge of local coping strategies can benefit greatly from Community-based adaptation. The Secretariat has developed a local coping strategies database to facilitate the transfer to community groups that may be beginning to face these challenges as a result of climate change, of the long-standing coping strategies and expertise from communities that are accustomed to specific threats and climate conditions. However, in the application of adaptation, farmers face a problem.

BR 11, BRRI 33, BINA 8, BRRI 47 and Aloron are now grown by farmers. We know this variety from the UAEO and some NGOs (BRAC) is salinity tolerant rice variety for the Aus and Boro season. The variety must be distributed as quickly as possible. Resistance to moderate inundations, dry resistance or low consumption of water, moderate salinity resistances, moderate storm housing and suitability for culture in deep-sea environments are the positive elements of coping with these varieties.

Photograph 3.2.3: *(BRAC Final report of CIP 2015): Hybrid rice (alloron variety) at a maturity of Barguna district, 2014.*

Narrow technological base for salt tolerant crops limit crop choices. On the other hand, due to extensive cultivation of a particular cultivar of crop year after year makes the crop susceptible to pests and diseases attack. Pests and diseases like hispa, leaf-hopper and virus are prevalent in the region and extensive damage is caused by these almost every year. Growth in crop farming and productivity finally depends on what the country's system of technology can offer shorter seed quality maturity. Farmers are involved in cultivating short crops in order to avoid common diseases and improved irrigation. Short yield plants are high yield plants such as BRRI 49, BRRI 33. In the Aus season, Aloron and BR 11 are very common. In the Boro season, hybrid species are often grown. These varieties have already been created, but more is needed for different ecological niches. Recent crops include maize, high yield rice, some commercial crops etc., local rice and vegetables have taken place instead of mouth etc. Other crops, such as sunflower and watermelon, are grown.

Table 22: various crops in Robi season (mt. /ha)(Source: UAEO, Barguna, 2015)

Crops/production	2011-12	2012-13	2013-14
Wheat	72	26	25
Maize	90	455	350
Sweet potato	240	350	360
Potato	1800	1440	1200
Mustard	14	16	24
Khesari	2155	3800	3200
Chili	38	44	45.5
Sugarcane	660	750	-
Sunflower	11.5	18	122
Onion	56	70	49

Table 23: Summer season vegetables (Source: UAEO, Barguna Upazila, 2014)

Types of crop	Land use in hectares				Production in per hectares (mt)			
	2011-12	2012-13	Increase	Decrease	2011-12	2012-13	Increase	Decrease
Pumpkin	85	100	√	-	18.0	20.0	√	-
Amaranth	43	50	√	-	6.50	8.0	√	-
Corolla	28	25	-	√	6.20	6.0	-	√
Lady's finger	9	10	√	-	5.23	6.0	-	√
Borboti	8	10	√	-	7.31	8.0	√	-

Table 24: Winter season vegetables (Source: UAEO, Barguna Upazila, 2014)

Types of crop	Land use in hectares				Production in per hectares (mt)			
	2011-12	2012-13	Increase	Decrease	2011-12	2012-13	Increase	Decrease
Olkapi	35	50	√	-	8.0	10.0	√	-
Brinjal	40	53	√	-	7.0	8.25	√	-
Bean	25	30	√	-	0.7	0.9	√	-
Tomato	8	7	-	√	18.0	20.0	√	-
Radish	5	5	-	-	12.0	15.0	√	-
Carrot	2	2	-	-	4.0	4.50	√	-
Cauliflower	2	1	-	√	1.30	0.9	-	√
Cabbage	3	2	-	√	1.0	0.8	-	√

The farmers are not well educated and trained. They are therefore unable to grow crops properly. They need training because they are not able to grow such crops. Seedlings must be transplanted within 25-30 days to better cultivate. If they delay transplantation, farmers will receive less production which hinders their socioeconomic status. More fertilizers must be used for a short time for more production.

Long-standing needs for strong regulatory and certification mechanisms need to ensure fertilizer and pesticide quality. Urea is typically used by farmers in recommended doses. Due to high prices, the P and K fertilizers are applied at rates well below the recommended level. Normally organic organic fertilizers are not integrated with chemical fertilizers. Thus, it has become apparent that farmers do not use balanced, high-productivity fertilizers. For most farmers, fertilizers are too expensive. The use of insecticides in vegetables is now negligible and in the agricultural sector the use of herbicides has not yet commenced. Total crops sometimes fail due to insect and pest attacks. In this case, an insecticide is used because of ignorance, lack of the required insecticide, lack of sprayer, high cost and a lack of knowledge of application, and the risk of risks to health.

In their homes and around the pools, some farmers are trying to farm innovative farming practices. Using bamboo pillars inside the reservoir, they grow vegetables. They do so in order to meet their domestic vegetable demand. Pumpkin, Gourd, Bean, Gourd Bitter, Cucumber and Borbati are growing there. Some farming innovations for non-rice crops that help to avoid salinity.

The participatory FGD identified and documented some promising adaptability practices for sustainable agricultural production in the coastal area during stakeholders' consultation, observation, household survey and KII. The following are:

- ✓ Sustainable adaptation options for improvement of coastal agriculture may include the introduction of some salt tolerant crop variants (viz. wheat, maize, millet, mung beans, soybeans, chickpeas and rice) for coastal areas.
- ✓ Sorjan system of cultivating year round vegetables, spices and fruits on raised beds and creeper vegetables on bed edges making trellis on ditches and cultivation of fish in ditches during wet months in the water-logged/tidal surge areas.

- ✓ Zero tillage cultivation of maize, potato and garlic. Introduction of zero tillage (wheat, potato, pulses), short duration & salt-tolerant rice varieties and cultivation of ground nut, chili & relay cropping of khesari, mung bean & mustard.
- ✓ Floating bed farming (planting and vegetable harvesting) with hyacinth beds of water.
- ✓ Ring method / Kalsi of watermelon cultivation.
- ✓ The use of bunds to grow seasonal vegetables, fruit and spices and promote the scientific method of double cultivation of rice-fish. Similarly, compost making and use of composts in homestead gardening practices.
- ✓ Digging ponds and canals for rain water harvest. On the other hand, utilization of canal water by digging canals for cultivating boro crops in large fallow lands.
- ✓ Many non-farm risk management actions are now becoming less common, and climate change can further push these practices and cause unemployment. The farming community's livelihoods in vulnerable areas will change. So, a future study on Community Based Adaptation Strategies and Options should be taken up in identifying and implementing phase-wise adaptation options for increased production and improving the livelihood of vulnerable people.
- ✓ Women’s involvement in agriculture and related activities needs to be enhanced in addition to capacity building and training of the vulnerable populations in promoting Adaptation Agriculture.
- ✓ Enhanced and increased health care with consumption of balanced diet by vulnerable communities, especially women and children in the coastal region should be promoted.

Chapter 4. Overview of the study:

Coastal Agriculture is highly vulnerable to climate change and natural disasters. The study showed that the main problem of irrigation system used in cultivation is most of the farmers of the coastal area depends on rain water (78%) and only 16% of them have the facilities of power pump for irrigation. According to 78% farmers, the main cause behind the shift to the modern cropping system is the traditional varieties are nowadays seems to a low crop yield. In the coastal belt transport system of marketing the crop products is lagged behind. 92% farmers used to carry their crop production by rickshaw or van whereas only 6% have the access of track/pick up for transportation. On the contrary, there have no modern storage facilities in where they can secure their over plus crops in deed.

In the coastal disastrous area most of the farmers (90%) used to cultivate mixed cropping, that is, intercropping instead of single cropping. Most of the farmers used to cultivate different types of pulses in the paddy-fields simultaneously. Fishing is also introduced recently in the paddy farms. In this study it was revealed that almost all the farmers (86%) used high yielding varieties of seeds and 58% farmers used Saline tolerant seeds/crops. The most remarkable changes took place in the adaptation process is the production of robi crops (winter vegetables), sunflower, hybrid potato and water melon. More than half (52%) of the farmers of the study area used to produce sunflower and 56% used to cultivate water melon. It bears the testimony to the commercial production of the farmers of the study area.

In this study it was seen that almost all the farmers were using modern technologies as well as were applying chemical fertilizers (100%) in their field. The farmers considered insecticides as the most devastating natural cataclysms in the coastal area. And so, to get rid of this problem almost all the farmers (98%) used insecticides. Local perception of the impacts of climate hazards in coastal areas was assessed during FGDs and household survey. The findings showed that the current climate in this region is behaving differently than in the past on a number of climate risk factors affecting crop production; These are: frequent cyclone, changes in seasonal rainfall pattern, in-seasonal rainfall, long dry spells, increase of soil salinity and tidal surges. In addition, it is perceived that temperature has increased over the years and duration of winter has been shortened affecting the potential growing period of winter crops in the coastal area.

Chapter 5. Conclusion and Policy Recommendations:

Climate change is not only a question of the environment but also of Bangladesh's development. It suggests that climate change must emerge from the environmental problem, to concentrate on the major challenges of development. Soil salinity is a global problem; Bangladesh is no exception. Salinization is one of the biggest natural threats to crop production in Bangladesh. Bangladesh's coastal area constitutes 20 percent of the country whose salinity varies by approximately 53 percent. In these regions, agricultural land use is very poor. Lower productivity with a shift to negative nutrient balances is one of the main food security concerns in the country. In the past, the question of salinity received very little attention. Increased population pressure is demanding more food. It has become imperative that the potential of these (saline) countries to increase the production of food crops is explored. The fight against land salinization is therefore vital for food security in the country by adopting a strategy for long-term land management. The vulnerability on the coastal region again varies spatially and temporally. People in these vulnerable regions require certain coping strategies for these climate change consequences so that they don't have to leave their homes. For these vulnerable communities, coping measures are urgently needed. One consequence of climate change is, however, that its impacts are still likely to be sluggish. Among other options for disasters are enhanced crop-based weather and flood forecasting systems, early warning system, better drainage, cultivation of resilient crops and the development of floating bed technology, rice and fish farming and integrated fisheries. Climate change has an undeniable effect on agriculture and is likely to worsen if policymakers and donors do not take appropriate action right now. In order to survive and prosper in the long term, Bangladesh needs immediate help to develop climate-resilient agriculture.

Climate change poses significant challenges for the agriculture sector (crop production) and consequently the livelihoods and overall economic development of the country. Adverse effects include increased soil salinity, saline intrusion of water and massive declines in the production of rice and wheat, which are driven by an overall warmer, weathered and less predictable climate. The increase in the precipitation and sea levels will particularly define new weather patterns while extreme events like floods, droughts and cyclones will also occur more frequently.

The following issues should be taken as the focus to address the effects of climate change and local farmers' coping strategies on changing crop patterns:

- To promote awareness at Community, national and international level, a specific agriculture development plan should be put in place based on costly livelihoods, ecosystems and economy.
- Improvement of capacity building as well as rehabilitating established institutional structures for governments and non-governmental bodies to allow them to address the challenges faced by climate change is necessary and would promote the successful implementation. Coordination and coordination between the respective government departments must also be strengthened.
- In order to efficiently scale up climate change adaptation projects, it is also necessary to implement a follow-up mechanism consisting of monitoring and evaluation processes. It should be assumed by an autonomous body consisting of members of government and non-government and relevant experts in both the national and regional administrative structures.
- Many farmers use their traditional knowledge to cope with crop pattern changes. However, these local measures should be combined with advanced, scientifically proven techniques in order to achieve more efficient results in terms of adaptation and benefits sharing. Knowledge on new technologies and agricultural practices must therefore be disseminated to a wider degree, such as through farmers' training programs.
- The cost of using climate-smart varieties is roughly equal to traditional ones, making the adoption of new varieties beneficial and encouraging the process of adjusting to climate change.
- Suggested creative practices for large-scale implementation in vulnerable areas should be encouraged to increase production, generate income, and improve the livelihoods of coastal communities.

- More innovative agriculture practices / technologies should be tested and adopted by means of on-farm tests and site production programs involving farmers, researchers and extension personnel.
- Improved weather forecasting systems on crops, early warning systems (e.g. community radio can play a key role) improved drainage, adaptive crops cultivated, floating bed agriculture technology developed, rice and fish cultivation and organized fisheries are some options for coastal farmers to cope with.
- The definition of food safety and the use of GM (genetically modified) technology should also be given due consideration in terms of the health of people.
- To measure the intensity of the salinity and its adaptations and practices, a soil test center should be established.
- In order to keep the community clean of freshwater reservoirs and cannels, the awareness raising program on environmental pollution issues should be introduced.
- Community-based forestation on the protective embankment can be introduced.
- To order to remove excess water and avoid the entry of salt water during high tide, the sluice gate must be built at the appropriate spot in the safety dam.
- In addition, the results should be disseminated to farmers in the regions. Input and technology required beginning farming practices in their respective fields with the recommended varieties and technology should be given to farmers.
- Future studies on location-specific coastal agriculture are required based on the suitability of soil-crop-climate through an acceptable soil limit, climatic risks, and socio-economic challenges currently affecting crop-production systems and the livelihoods of vulnerable peoples in the coastal region.

Sustainable adaptation activities based on the location and research are therefore necessary to cope with changing climate conditions. If this were not achieved, economies would be very difficult to become more resilient to adverse climate change effects and increase food security. Nonetheless, it is difficult to confirm that a crop is resilient to climate change situations with only one season of agricultural results. At least three years of experiment must be concluded whether a crop is adaptive or not in the selected regions in the context of climate change situations. Further trails should be verified for selected crop varieties, irrigation management, field pattern and crop intensification.

Rural farmers in the study area are already practicing some adaptation strategies to various extents, in order to cope with climate change-induced hazards and disasters. These include: excavating canals to conserve fresh water for irrigation, as well as planting saline-resistant rice varieties. In addition, irrigation and fish farming by the use of power pumps in cropland also provide a few coping strategies to combat increasing salinity in the face of rising marine standards and climate change. However, because of their lack of relevant knowledge and inadequate extension services, many farmers are not fully aware of the advantages of these adaptation technologies. Farmers are, however, generally prepared to adopt saline-resistant species and also have requested them in the area of study. Although fresh water can be an effective adaptability strategy for irrigation through excavation canals, it is often costly and beyond the affordable ability of marginalized farmers. The issues can be properly mitigated by Government and/or NGO initiatives.

Another important observation was that Bangladesh's various stakeholders are aware and try to include adaptation into policy and long-term plans documents and their adverse effects on agricultural production. The study also shows that extension employees work to promote technological advances in adaptive practices. Bangladeshi research agencies are also up to date in developing climate change adaptation methods and varieties. Many of the current adaptive varieties and agricultural techniques have been developed by local research agencies. Local farmers have already used adaptive measures using saline-resistant crops, better farming techniques and various types of irrigated products to support the claims of institutional stakeholders. Farmers and stakeholders agree unanimously that canals to resist salinity have to be excavated urgently. The costs of using adaptive varieties are similar to those of the traditional ones, which imply future use of adaptive varieties.

The policy makers as well as the researchers are required to come up with better practices for an improved coastal zone management. Countries like Bangladesh, India, Myanmar, Cambodia and Vietnam where coastal zones are very vulnerable to extreme events need more interaction and integration of the traditional ways of adaptation. The natural and traditional adaptation practices should be evaluated scientifically through habitat research, interaction with communities and in-depth analysis in the workshops and seminars involving stakeholders for a sustainable national and regional policy for coastal zone management.

References

---

1. Miah, M.M.U et al 2005. Soil and Fertilizer Recommendation Guide-2005, BARC, Dhaka.

2. Rahman M.M, 2012, Enhancement of Resilience of Coastal Community in Bangladesh through Crop Diversification in Adaptation to climate Change Impacts, BRAC University, Dhaka.

3. Mallick, B.; Rahaman, K.R.; Vogt, J. Coastal livelihood and physical infrastructure in Bangladesh after cyclone Aila. *Mitig. Adapt. Strateg. Glob. Chang.* **2011**, *16*, 629–648.

4. Shamsuddoha, M.; Islam, M.; Haque, M.A.; Rahman, M.F.; Roberts, E.; Hasemann, A.; Roddick, S. Local Perspective on Loss and Damage in the Context of Extreme Events: Insights from Cyclone-Affected Communities in Coastal Bangladesh; Center for Participatory Research and Development (CRPD): Dhaka, Bangladesh, 2013.

5. Mallick, B.J.; Witte, S.M.; Sarkar, R.; Mahboob, A.S.; Vogt, J. Local Adaptation Strategies of a Coastal Community during Cyclone Sidr and their Vulnerability Analysis for Sustainable Disaster Mitigation Planning in Bangladesh. *J. Bangladesh Inst. Plan.* **2012**, *2*, 158–168.

6. Thomas, T.S.; Mainuddin, K.; Chiang, C.; Rahman, A.; Haque, A.; Islam, N.; Sun, Y.; Quasem, S. *Agriculture and Adaptation in Bangladesh Current and Projected Impacts of Climate Change*; The International Food Policy Research Institute (IFPRI): Washington, DC., USA, 2013.

7. Intergovernmental Panel on Climate Change (IPCC). Summary for policymakers. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2014; pp. 1–32.

8. Birkmann, J.; Cardona, O.D.; Carreño, M.L.; Barbat, A.H.; Pelling, M.; Schneiderbauer, S.;Kienberger, S.; Keiler, M.; Alexander, D.; Zeil, P.; *et al*. Framing vulnerability, risk and societal responses: The MOVE framework. *Nat. Hazards* **2013**, *67*, 193–211.

9. Füssel, H.-M. Vulnerability: A generally applicable conceptual framework for climate change research. *Glob. Environ. Chang.* **2007**, *17*, 155–167.

10. Adger, W.N.; Hughes, T.P.; Folke, C.; Carpenter, S.R.; Rockström, J. Social-ecological resilience to coastal disasters. *Science* **2005**, *309*, 1036–1039.

11. Ellis, F. *A Livelihoods Approach to Migration and Poverty Reduction*; Overseas Development Group, University of East Anglia: Norwich, UK, 2003.

12. Intergovernmental Panel on Climate Change (IPCC). 2007. Impacts, adaptation and vulnerability. Report of the working group-II.

13. IPCC, 2001. *Climate Change: Mitigation*, Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, UK.

14. Huque, S. and J.M. Ayers, *Critical list: the 100 nations most vulnerable to climate change*, in *IIED Sustainable Development Opinion*. 2007, International Institute of Environment and Development: London.

15. Harun-ur Rashid and M. Shirazul Islam (2007): Adaptation to climate change for sustainable development of Bangladesh Agriculture; BARI, Joydebpur, Gazipur

16. Khandaker Mainuddin & others: Planning and costing agriculture's adaptation to climate change in the salinity-prone cropping system of Bangladesh; *Bangladesh Centre for Advanced Studies*; October, 2011; p-37

17. Miah Md Muslem Uddin; Assessing Long-term Impacts of Vulnerabilities on Crop Production Due to Climate Change in the Coastal Areas of Bangladesh; *Final Report PR #10/08;* Bangladesh Center for Advanced Studies;*;* November 2010; p- 42

18. ICEAB (2010): The Impacts of Climate Change on the Coastal Belt of Bangladesh: An Investigation of Risks & Adaptations on Agricultural Sector; CC04

19. Bangladesh Center for Advanced Studies (2010): Assessing Long-term Impacts and Vulnerabilities on Crop Production due to Climate Change in the Coastal Areas of Bangladesh; Final Report PR #10/08

20. Gunasena H.P.M: Intensification of Crop Diversification in the Asia-Pacific Region: Professor and Director, Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka;2012

21. FAO **(**2011) Resilient Livelihoods – Disaster Risk Reduction for Food and Nutrition Security Framework Programme

22. FAO (2001): Crop Diversification in Asia-Pacific Region, Bangkok, Thailand

23 . World Bank (2011): CLIMATE-SMART AGRICULTURE; Increased Productivity and Food Security, Enhanced Resilience and Reduced Carbon Emissions for Sustainable Development

24 . LIN, Brenda B (2010): Resilience in Agriculture through Crop Diversification: Adaptive Management for Environmental Change

25 . FAO (2001): Crop Diversification in Asia-Pacific Region, Bangkok, Thailand

26 . BRAC Monitoring Report, 2011: Final Narrative Report on Crop Intensification Project

27. Rahman, M.M. and Ahsan, M. 2001. Salinity constraints and agricultural productivity in coastal saline area of Bangladesh, Soil Resources in Bangladesh: Assessment and Utilization.

28 . Effectiveness of Farm Programs of Bangladesh Betar: An Empirical Study.

29 . Mohammad H. Mondal, “Crop Agriculture of Bangladesh: Challenges and Opportunities,” *Bangladesh Journal of Agricultural Research*, Vol. 35, No. 2, June 2010, p. 238.

30. Karim, Z., S.G. Hussain and M. Ahmed. 1990. Salinity problems and crop intensification in the coastal regions of Bangladesh. Soils publication No. 33. BARC.