IMPACTS OF CLIMATE CHANGE ON CROPPING PATTERN IN COASTAL REGION OF BANGLADESH: A CASE STUDY OF SHARANKHOLA UPAZILA, BAGERHAT

A Dissertation for the Degree of Master in Disaster Management

By
Md. Mohosin Ali
Student ID: 11268016

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Postgraduate Programs in Disaster Management (PPDM)
BRAC University, Dhaka, Bangladesh

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Abstract

Natural disaster occurs almost every year in Bangladesh due to climate change. Crop agriculture is often constrained by different hazards and disasters such as floods, droughts, soil and water salinity, cyclones and storm surges (MoEF 2009b). It is very common phenomenon in coastal regions of this country. Southwestern part (Khulna region) of Bangladesh is one of the worst affected regions facing the early impacts of climate change particularly in agricultural and socio-economic sector. Every year it causes extensive damages to the agriculture sector in Sharankhola Upazila and change cropping pattern day by day. The Farmers of Sharankhola face a lot of problems to bring all of their arable land under crops cultivation, especially, during winter Boro crops season a lion portion of their land remain untilled only due to salinity problem, and unavailability of quality seeds and agricultural equipments. The dominant crop grown in the saline areas is local transplanted Aman rice crop with low yields. The cropping patterns followed in the coastal areas are mainly Fallow-Fallow-Transplanted Aman rice.

The crop yield is negatively impacted by rise in temperature, erratic rainfall, flooding, salinity, etc. and among which water logging and drainage congestion are the major problems. The ecological conditions are more vulnerable which is very likely to be alerted though slowly but surely due to climate change and sea level rise. Salinity causes unfavorable environment and hydrological situation that restrict the normal crop production throughout the year. The factors which contribute significantly to the development of saline soil are, tidal flooding during wet season (June-October), direct inundation by saline water, and upward or lateral movement of saline ground water during dry season (November-May). Dependency on fertilizer and irrigation is increasing which leads to permanent fertility loss of the land, loss of biodiversity, extinction of local verities, ground water scarcity, loss the sustainability of production. However, adaptations to climate change like agronomic manipulations, sustainable climate-resilient agriculture, shifting the planting dates, using short duration crop cultivars can reduce vulnerabilities, delay the process and increase food security.

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List of acronyms

ADB – Asian Development bank
AEO – Agriculture Extension Office
AR4 – Fourth Assessment Report
BARI – Bangladesh Agricultural Research
BBS – Bangladesh Bureau of Statistics
BIDS – Bangladesh Institute of Development Studies
BMD – Bangladesh Meteorology Department
BRRI – Bangladesh Rice Research Institute
CC – Climate Change
CO – Carbon-di-oxide
DAE – Department of Agriculture Extension
DMG – Disaster Management Goal
ds / m – desicymole / meter
FAO – Food and Agriculture Organization
FGD – Focus group Discussion
GDP – Gross domestic product
GM – Genetically Modified
GOB – Government of Bangladesh
HYV – High Yielding Variety
IPCC – Intergovernmental Panel on Climate Change
K – Potassium
KII – Key Informant Interview
MPO – Master Plan Organization
MSL – Mean Sea Level
N – Nitrogen
NGO – Non Government Office
P – Phosphorous
PET – Potential Evapotranspiration
PPDM – Postgraduate Program in Disaster Management
S – Sulpher
SLR – Sea Level Rise
TAR – Third Assessment Report
UNO – Upazila Nirbahi Office
WARPO – Water Resources Planning Organization
WB – World Bank

CHAPTER 1
INTRODUCTION

1.1 Background of the study

Climate change is a significant and long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years. It may be a change in the average weather conditions or a change in the distribution of weather events with respect to an average, for example, greater or fewer extreme weather events. Climate change may be limited to a specific region, or may occur across the whole Earth (IPCC).

The impact of global climate change on agriculture has been studied extensively for various crops at different scales in many countries of the world. Available reports show those tropical and subtropical countries would be more vulnerable to the potential impacts of global warming. It is believed that climate change would increase the disparities in cereal production between developed and developing countries. The production in the developed world would benefit from climate change, while that in developing nation would decline (Walker and Steffen, 1997).

Global warming and land degradation are two of the most pressing environmental challenges facing the world today. According to the UN's Intergovernmental Panel on Climate Change (IPCC) global warming will affect much of life on earth this century. Global warming is the immediate consequence of increased greenhouse gas emissions with no offsetting increases in carbon storage on earth.

The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) has reported that the average global surface temperature has increased by 0.74˚C during last 100 years. It is also reported that the sea level rose at an average rate of 1.8 mm per year over 1961 to 2003, mountain glaciers, and snow cover have declined on average in both hemispheres. Project global warming in this century is likely to trigger serious consequences for mankind and other life forms, including global temperatures rise between 1.8˚ C and 4.0˚ C by 2100 depending on emissions of greenhouse gases and that global sea levels are likely to rise from anywhere between 180 mm and 590 (IPCC, 2007).

For South Asia, IPCC report predicts that monsoon rainfall will increase, resulting in higher flows during monsoon season in the river system. It has also predicted that sea level rise will be between 0.18 to 0.79 meters which will lead to salinity intrusion and coastal flooding. This climate change would have a direct effect on crops, water balance, soil organic matter content, and other soil properties.

The overall effects of climate change are:

- Increase of greenhouse gas concentrations in the atmosphere;
- Increasing mean, maximum and minimum temperatures;
- Gradual changes in precipitation:
    - Increase in the frequency, duration and intensity of dry spells and droughts;
    - Changes in the timing, duration, intensity and geographic location of rain and snowfall;
- Increase in the frequency and intensity of storms and floods;
- Greater seasonal weather variability and change in start/ end of growing seasons.

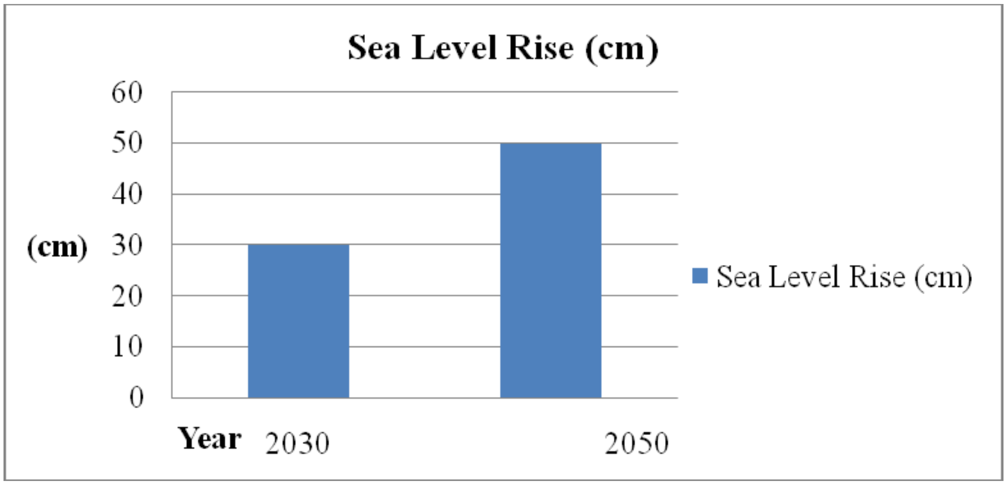


Figure 1.1: Projected Sea Level Rise (Sources: IPCC, 2007)

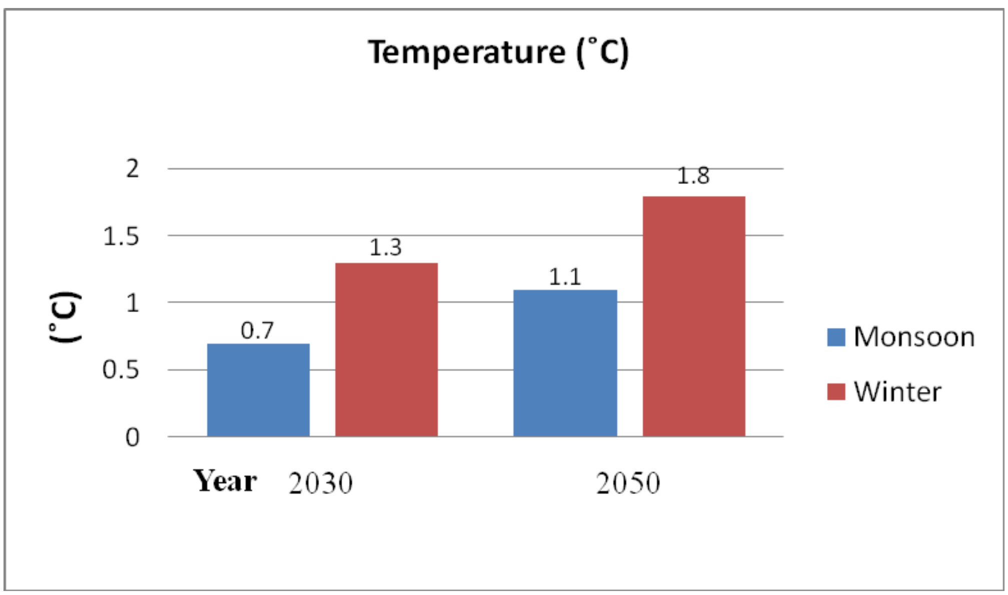


Figure 1.2: Projected Temperature Increase (˚C) (Sources: IPCC, 2007)

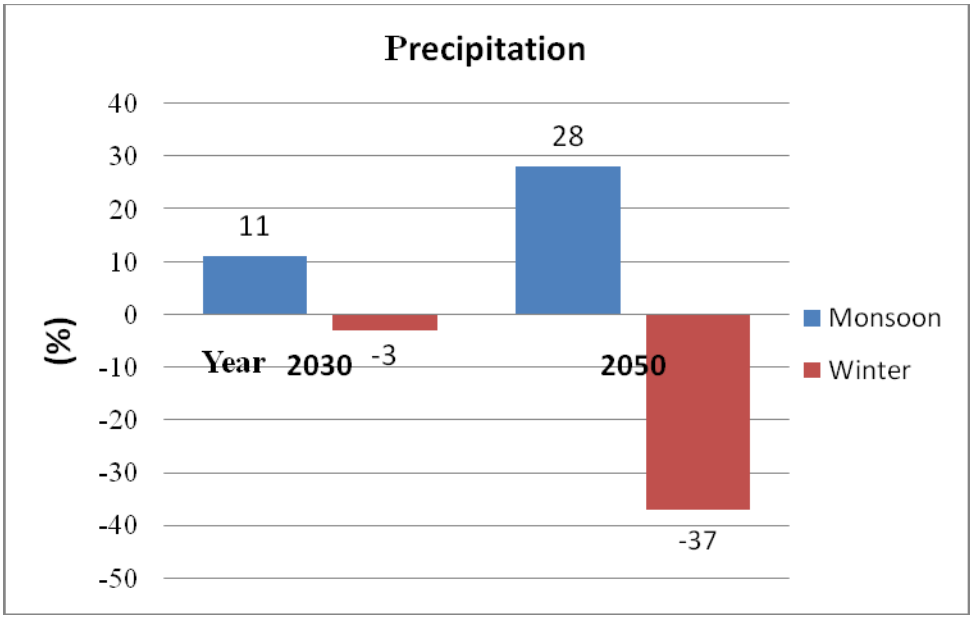


Figure 1.3: Projected Precipitation Fluctuation Compared to 1909 (%)
(Sources: IPCC, 2007)

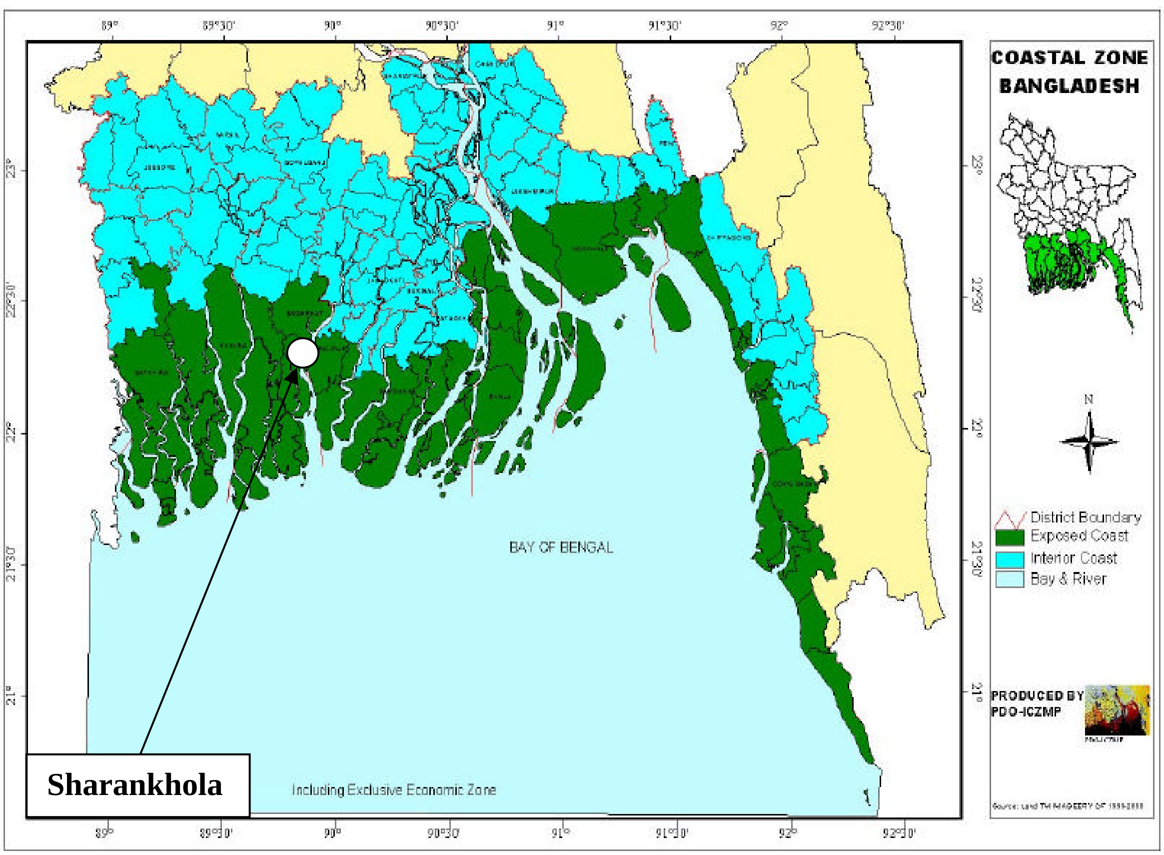
Bangladesh is already vulnerable to many climate change related extreme events. It is expected that climate change will bring changes in characteristics of extreme events and gradual changes phenomenon of the physical and natural systems. Due to higher level of dependency on natural resource base, overall impacts of climate change on Bangladesh would be significant.

Bangladesh is one of the most vulnerable countries facing the adverse impacts of climate change. Bangladesh lies between 20˚ 34′ to 26˚38 North latitude and 88˚ 01′ to 94˚45′ east longitude. This is due to its unique geographic location, dominance of floodplains and low-lying topography, high population density, high levels of poverty, and overwhelming dependence on natural resources and services, many of which is climate sensitive.

The total area of Bangladesh is 147, 570 km2. The coastal region covers about 20% of the country and over 30% in the total cultivable area of Bangladesh. It extends inside up to 150 km from the coast (Petersen & Shireen, 2001).

Out of 2.85 million hectares of the coastal and offshore areas about 0.83 million hectares are arable lands, which cover over 30% of the total cultivable lands of Bangladesh. A part of the coastal area, the Sundarbans, is a reserve natural mangrove forest covering about 4,500 km2. The remaining part of the coastal area is used in agriculture. The cultivable areas in coastal districts are affected with varying degrees of soil salinity. The coastal and offshore area of Bangladesh includes tidal, estuaries and river floodplains in the south along the Bay of Bengal. Agricultural land use in these areas is very poor, which is roughly 50% of the country's average (Petersen & Shireen, 2001)

Tidal and estuarine floodplains cover almost 98% of the coastal area. Small areas (2%) with river floodplains and peat basins are found in the northern part of the coastal area. Tidal floodplains occur in Satkhira, Khulna, Bagerhat, Pirozpur, Jhalukhati, Barisal, Patuakhali, Chittagong and Cox's Bazar district. They cover a total of 18, 65,000 ha or about 65% of the coastal area. Estuarine floodplains occur in Noakhali, Bhola and Patuakhali districts and in the north-western part of Chittagong district. They cover about 9, 37,000 ha or about 33% of the coastal (Karim *et al.*, 1982).



Map 1.1: Coastal region of Bangladesh

The coastal zone consists of 19 districts and 147 upazillas with a total area of 47,201 km2, which is about 31% of the total area of Bangladesh, 147,570 km2.
The variability of climate change has become a challenging issue for agriculture due to global warming. Agricultural crops of Bangladesh are especially sensitive to the different variables of climate such as temperature, rainfall, humidity, day-length etc. as well as different natural disasters like floods, drought, salinity and storm surges etc. Therefore, adaptation measures have to be looked at for the sustainability of agriculture.
The negative impacts of climate change on Bangladesh agriculture are as follows: (Mondal, 2008)

- Increasing temperature will lead to increase evapotranspiration and droughts, causing water scarcity for irrigation and domestic uses in north –west Bangladesh;
- Extended flooding of arable land narrowing scope fir crop production, especially in the vast low land areas;
- Increased inundation and salinity intrusion, limiting crop cultivation with the existing varieties, especially in the coastal regions;
- Increased intensity of flush floods in Meghna basin and north eastern haor region, damaging standing Boro rice crop;
- Increasing loss of land to river erosion, reducing land-based livelihood opportunities, and increased drainage congestion and water logging due to sedimentation of rivers, limiting production options for the char dwellers.

In quantitative terms, IPCC estimates that, by 2050, changing rainfall patterns with increasing temperatures, flooding, droughts and salinity (in coastal belt) could cause decline in rice production in Bangladesh by 8% and wheat by 32% , against 1990 as the base year (MoFE, 2008).
The recent estimates using different models with changed assumptions predicts for 2050 reduction in production by 1.5 – 25.8% for Aus rice, and 0.4 – 5.3% for Aman due to the effect of high temperature. For Boro rice production could be increased by f1.2 – 9.5%, assuming the temperature would not exceed the 35˚C threshold limit for rice production (Hussain, 2008).

By the middle to the end of the current century (21^{st}), winter temperature is predicted to rise by 1.5 – 2.5˚C. Such elevation of temperature is likely to pose a great threat to the winter or Rabi crops (WARPO, 2006).

Climate change effects in the coastal area:

Climatologically, the coastal belt is most vulnerable and mangrove forests in Bagerhat are most vulnerable.

WARPO (2006) estimates that 14, 32, and 88 cm sea level rise will occur in 2030, 2050 and 2100, respectively which may inundate about 8, 10 and 16% of total land of Bangladesh. As per World Bank report (2001), sea–level is rising by about 3 mm/year. Cyclone, floods and tidal surges are common disasters in the coastal regions.

1973	2000	2009	Salt affected area increased during last 9 years (000'ha) (2000-2009)	Salt affected area increased during last 36 years (000'ha) (1973-2009)
Salt affected area (000'ha)				
833.45	1020.75	1056.19	35.44(3.5%)	222.74(26.7%)

Table 1.1: Increase of soil salinity in coastal region during 1973 to 2009

(Source: WARPO, 2006)

Among the adverse impacts of climate change, water resource related impacts would likely be the most critical for Bangladesh, including coastal and river flooding, droughts and salinity intrusion in coastal zone. Salinity in both soil and water is a major concern for the coastal zone of Bangladesh. Intrusion of salinity towards interior coast will cause direct impact on fresh water source and food production. The possible factors, which can lead to increase in salinity intrusion, are decrease of fresh water flow during the dry season, or due to penetration of tide into the river system. Intrusion may also be aggravated by upstream withdrawal of water or by climate change impacts like a decrease in dry season rainfall and sea level rise (Rifat QuamrulL Alam, Marita Sarker and Md. Mujibur Rahman).

Flood and cyclone are the very common phenomenon in this country. Every year it causes extensive damages to the lives and properties. Cyclone SIDR attacked on November 15, 2007 and AILA attack on May 25, 2009 to the South and Southwestern part of Bangladesh and caused devastating damage to the socio-economic and physical sectors. Damage of agriculture sector was havoc in SIDR and AILA, especially to the hardest hit **Sharankhola** area. Farmers have been facing a lot of problems to bring all of their arable land under crops cultivation, especially, during winter Boro crops season a lion portion of their land remain untilled only due to salinity problem, and non-availability of quality seeds, agricultural equipments, timely low interest or interest free loan.

There are number of environmental issues and problems those are hindering development of **Sharankhola**. Salinity is a current problem, which is expected to exacerbate by climate change and sea-level rise, affecting food grain production. Salinity intrusion due to reduction of freshwater flow from upstream, stalinization of groundwater and fluctuation of salinity's are major concern of **Sharankhola**.

Rice (Oryza sativa), wheat (Triticun aestivum) and potato (Solanum tuberosum) are major food crops in Sharankhola growing at different cropping seasons with various temperature and rainfall requirements. Climate change already has brought some changes on crop production in reference to growing periods and cropping pattern. Changing rainfall patterns with increasing temperatures, flooding, droughts and salinity causes decline in rice production in Bangladesh by 8% and wheat by 32%, against 1990 as the base year (CCC, 2009). The recent estimates using different models with changed assumptions predicts for 2050 reduction in production by 1.5-25.8% for Aus rice, and 0.4-5.3% for Aman due to effect of high temperature. Similarly, wheat production is also sensitive to temperature. It requires low temperature at certain stage to get desirable yield of wheat. On the other hand, disease infestation in potato is accelerated due to foggy weather. Late blight disease of potato, responsible for long foggy weather, reduces potato yield drastically every year (Anonymous, 2008).

Climate change effects in Sharankhola are:

- Increase of soil and water salinity,
- Inland salinity intrusion,
- Water-logging, loss of crops and their yields,
- Loss of mangrove and fisheries diversity, and disease in crops, fishes and animals.

There are different types of crops are practiced in Sharankhola Upazila. The major cropping patterns of the area are namely Fallow - T.Aman. There are three types of seasons namely Kharif-1(mid-March to mid July), Kharif-2 (mid July to mid October) and Rabi (mid-October to mid-March). During the **Kharif–1** season farmers cultivate aus rice, oil seeds and different types of vegetables. During the **Kharif-2** season T. Aman is the dominant crop. Different types of T. Aman rice such as BR 11, BRRI 33, BRRIdhan 40 & 41 and local varieties are practiced during this season. In the **Rabi** season, boro rice such as IRRI 28, IRRI 44, IRRI 26, and IRRI 29 are practiced. Other crops that are practiced are mustard, pulses and different types of vegetables. The farmers of Sharankhola are changing their cropping patterns due to climate change especially after SIDR and Aila. Increase in salinity intrusion and increase in soil salinity will have serious negative impacts on agriculture. Once salt gets to the roots, it becomes detrimental to the whole plant. The presently practiced rice varieties may not be able to withstand increased salinity. The food production does not seem to have a better future in the event of a climate change. Most farmers follow cropping patterns that involve sequential cropping, mixed-cropping, and relay cropping.

1.2 Rationale of the study

It is mentioned in the daily and weekly that due to the damage of embankment by intrusion of saline water to the land are a common phenomenon at the coastal belt area. This scenario will prevail for longer time, subsequently use of land in agriculture sector will substantially reduce, and as a result, the ultimate impact will increase the vulnerability of the coastal region people specially in Sharankhola beside the Baleswar River.

In this present study region people were involved in assessing their damage and future crop cultivation plan. This study was undertaken to raise their knowledge regarding demand, to make them aware about high yielding and salt-tolerant crops varieties.

Through the present study in Sharankhola Upazila it was tried to assess the actual amount of land, not brought under cultivation and the causes behind it. In farmers' opinion on crops variety, seeds, services and problems they faced to bring back all their arable land under cultivation was searched. To recover the enormous loss of Climate Change, especially the loss of agricultural sector and minimizing the gaps between farmers and development workers which were untraced were also identified through this study.

In the past, many studies have been conducted on climate change issues by different organizations and future impact scenarios have also been developed. Different adaptation measures, technologies and strategies have already been developed by different organizations as well as by communities to adapt with climate change. As agriculture is the main sector of this economy, it is essential to identify suitable adaptation technologies or varieties of agricultural crops through field-testing and community awareness for sustainability. Suitable adaptation measures and varieties of crops have been identified through this study. The results will give hope and confidence to farmers in adapting their crops for climate change.

1.3 Objectives of the study

The main objectives of the research are as follows:

a. To find out the impact of climate change on crop patterns in Sharankhola

b. Identify the local practices of adapting to the climate change impacts

c. Identify options to address the challenges to adaptation in agriculture.

1.4 Methodology

1.4.1 Area Selection

Bagerhat consists of 9 upazilas. Among them Sharankhola is one the worst affected upazilas, where serious damage is occurring in agriculture sector due to climate change such as salinity, storm surge, cyclone, sea level rise, flood . As my study topic is impact of climate change on cropping pattern in coastal area of Bangladesh, so I think that Sharankhola is the right place for my research.

1.4.2 Data Collection tools and techniques

Firstly, the professionals (Sharankhola) were selected who are directly involved in agriculture. Among them I have interviewed randomly with six farmers, NGO workers, govt. officers (AEO), Agricultural product traders and labors.

Sharankhola Upazila is consisted of 4 union parishad. Data were collected from all unions of Sharankhola. A total of 37 farmers' were selected from 5 villages (5 villages from 4 unions). From each of a village 7-10 farmers' were sampled and data were collected for the study. Union wise mostly affected village list was collected from Agriculture Extension Office (AEO), Sharankhola. Among the selected farmers, there were mixed groups of marginal, poor farmers and day laborers. Occupational changes and displacement was a major point to know from them through focus group discussions, in this regard key informants' were interviewed. Besides, local govt. (UP-Chairman & members) and officials (AEO) were also interviewed.

Questionnaires were finalized after field test. Observation techniques were also adopted to understand the cropping activities practical view of farmers due to climate change.

Focus group discussions were conducted with the farmers to know about cropping patterns, occupational changes and their future plan for cultivation. Their thinking about the problems they face in cultivation and the way they are planning for solution of their problems were also addressed in this study.

Data were collected from rice and non-rice crops growing farmers of the villages using questionnaire. Before interview, the selected farmers were contacted when they were available. During the interview of the farmers, all data were recorded properly in a notebook. If any data seems to be confused, data was corrected through revisit. I took help from the previous researchers to collect information. The collected data was manually coded according to the objective of the study. All the collected data were summarized and scrutinized carefully. Then data were made MS Excel.
For this study primary data and secondary data were collected where the information of the cropping production issue.

1.4.3 Primary data collection

Primary data are first-hand information, data were collected through various methods such as observation, interviewing, transect walk, key informant interview, focus group discussion etc. from the farmers and communities.

1.4.3.1 Key Informant interviews (KII)

Interviews were taken with different professionals for experiencing the true gradual impact of climate change in this particular area. Because of the locals are direct observers of the changes. But they do not have immense idea about the hidden causes of the changes. So I feel need the experience of the experts of that particular area. Making sense with my own knowledge, I have tried to analyze the fact with checking and rechecking their ideas.
The key informants were selected based upon their expertise on the relevant subject matters required for analyzing the issue rigorously. For the current study, five Key Informants Interviews were taken from GOs (Upazilla Agriculture Extension Officer), NGOs workers in local offices (BRAC, Muslim Aid) and Dealers (seeds & fertilizers) respectively. Majharul Islam (Dulu) in Rayenda bazaar has 9 years experience in

marketing and servicing the farmers to make the better result about crop production in Sharankhola and Omar Faruk (Ostad) in Khontakata bazaar has 15 years experience about crop production. The seeds & fertilizers Key informants were interviewed face to face and over telephone using semi-structured questionnaire. Apart from questionnaire, their comments were also taken into consideration.

1.4.3.2 Focus Group Discussion (FGD)

The FGD was organized 19 November 2012. Researching there on time, the program was started with greeting and thanks giving. The FGD was conducted with farmers. Then, they were asked different types of questions related with climate change specially they were asked question regarding the climate related hazard, livelihood, agricultural production, income generation, and food security and adaptation technique applied in the locality. It helps to gather a wide range of information in a relatively short time. The data collected from FGD was cross checked by a interviewing from the farmers. Four FGD were arranged and 37 participants were actively participated.

The following questions were focused:

a) What change do you notice in the seasonal pattern in your area? What is your idea about the reason of this changing?

b) How changing seasonal pattern is affecting your agricultural practice?

c) What type of problem do you face currently in irrigation? What do you do to overcome the problem?

1.4.4 Secondary data collection

The information about the agriculture related issues was compiled by cross matching among different sources. The information had been taken from different relevant books, articles, Reports, maps, journals, research paper, website, daily newspapers, library, Sharankhola Upazila office, Reports from local NGO offices, Field study report (DMG-605, PPDM) under BRAC University etc.

1.4.5 Data analysis

I have decided to adopt qualitative method because qualitative analysis configures observation and narrative explanation rather than numbers. Therefore, conceptualization is required to bring order of understanding in a systematic manner. To analyze and interpret narrative data, three steps were followed as developed which are: 1. Get to know the data, 2. Focus the analysis, 3. Categorize information.

The questionnaire/forms has been organized in one place, and checked whether they are completed. The irrelevant and inappropriate questionnaire/forms and irrelevant answer has been screened out.

1.5 Limitation of the study

Farmers in the study area grow different crops whose yield potential is different. To estimate the yield loss and decline in crop size, the respondents were asked the common questions. Both farmers and wage laborers were asked the same questions regarding affect of salinity in agriculture but the farmers, who are directly involved in crop growing, the answer was more reliable than others. However, in the paper, we have used the average of the response which reduces robustness of the study. Moreover, samples were taken only from three villages which have been used to construct a general scenario for the interior coast, more specifically Bagerhat district. Such small number of sample does not reflect the whole scenario of the interior coast or even the district, but the study could open a new window in climate change research for coastal Bangladesh which demands more comprehensive study involving multidisciplinary approach. The whole study was conducted within six months. Due to budget constraints, the sample size was small. However, data were rechecked and compared with established literature to maintain the rigor of the study.

CHAPTER 2
LITERATURE REVIEW

According to **IPCC** Report (2007), effect of saline water intrusion in the estuaries and into the groundwater would be enhanced by low river flow, sea level rise and subsidence. The adverse effects of saline water intrusion will be significant on coastal agriculture and the availability of fresh water for public and industrial water supply will fall. Agriculture is a major sector of Bangladesh's economy and the coastal area of Bangladesh is very fertile for growing rice. Increase in salinity intrusion and increase in soil salinity will have serious negative impacts on agriculture. The presently practiced rice varieties may not be able to withstand increased salinity. The food production does not seem to have a better future in the event of a climate change. In Bangladesh, rice production may fall by 10 % and wheat by 30 % by 2050 (Climate change in Asia 'too alarming to contemplate'-report, IPCC, 2007).

Agriculture is one of the most vulnerable systems to be affected by climate change in the south Asian region. The climate in Bangladesh is changing. It is becoming more unpredictable every year and its variability is being experienced more frequently than ever before. Hazards like floods, droughts, cyclones and others are likely to be aggravated by climate change. Salinity intrusion would be a more acute problem in the coastal region. This will have extra bearing on the agriculture and the potable water in that region. The salinity conditions in the coastal area of Bangladesh could further exacerbate due to reduced dry-season freshwater supply from upstream sources resulting from climate change (IPCC, 1998) and saline water intrusion due to sea level rise.

According to **Sikder** (Climate Change 2007: Synthesis report), the study reveals that the crop yield would be negatively impacted by rise in temperature, erratic rainfall, flooding, droughts, salinity, etc. and among which water logging and drainage congestion are the major problems. The ecological conditions are more vulnerable which is very likely to be alerted though slowly but surely due to climate change and sea level rise. Dependency on fertilizer and irrigation is increasing which leads to permanent fertility loss of the land, loss of biodiversity, extinction of local verities, ground water scarcity, loss the sustainability of production. However, adaptations to climate change like agronomic manipulations, sustainable climate-resilient agriculture, shifting the planting dates, using short duration crop cultivars can reduce vulnerabilities, delay the process and increase food security.

According to **Haque** (2007), the main obstacle to intensification of crop production in the coastal areas is seasonally high content of salts in the root zone of the soil. The salts enter inland through rivers and channels, especially during the later part of the dry (winter) season, when the downstream flow of fresh water becomes very low. During this period, the salinity of the river water increases. The salts enter the soil by flooding with saline river water or by seepage from the rivers, and the salts become concentrated in the surface layers through evaporation. The saline river water may also cause an increase in salinity of the ground water and make it unsuitable for irrigation.

A direct consequence of sea level rise would be intrusion of salinity with tide through the rivers and estuaries. It would be more acute in the dry season, especially when freshwater flows from rivers would diminish. According to an estimate of the Master Plan Organization, about 14,000 sq km of coastal and offshore areas have saline soils and are susceptible to tidal flooding. If some 16,000 sq km of coastal land is lost due to a 45 cm rise in sea level, the salinity front would be pushed further inland. The present interface between freshwater and saline water lies around 120 to 160 km inland in the southwest, and this could well be pushed northward as far as central Jessore region in the event of a sea level rise (BIDS/ADB 1994).

According to **Walker and Steffen** (1997), it is believed that climate change would increase the disparities in cereal production between developed and developing countries. The production in the developed world would benefit from climate change, while those in developing nations would decline (Walker and Steffen, 1997). Farm level adaptation would be inadequate in reducing the disparities. Even an extensive farm-level adaptation in the agricultural sector would not entirely prevent such negative effects. In general, the tropical and subtropical countries would be more vulnerable to the potential impacts of global warming through effects on crops, soils, insects, weeds and diseases. On the other hand, elevated carbon-di-oxide (CO) concentrations will have beneficial effects on crop production. Impacts of climate change would cause enhanced vulnerability to the crop production systems in Bangladesh.

According to **Briefing Report-2008** (Climate Change and Agriculture in Bangladesh Information), Sea level rise affects agriculture in three ways, i.e., by salinity intrusion, by flooding and by increasing cyclone frequency and its depth of damage. Combined effects of these three factors decrease agriculture production in the coastal zone. Salinity intrusion due to sea level rise will decrease agricultural production by unavailability of fresh water and soil degradation. Salinity also decreases the terminative energy and germination rate of some plants. The loss of rice production in a village of Bagerhat district was investigated and it was found that rice production in 2003 was 1,151 metric tons less than the year 1985, corresponding to a loss of 69%. Out of the total decreased production, 77% was due to conversion office field into shrimp pond and 23% was because of yield loss.

Sea level rise cause inundation of more area, damage of agricultural crops will be more in future. About 1/3 of Bangladesh or 49,000 sq. km. area are influenced by tides in the Bay of Bengal. It is clear that the inundation coastal inundation area will be increased in future with an adverse effect on crop production. If sea level rise up to 1 meter, normal flood waves can be expected to increase from presently 7.4 meters to 9.1 meters. In Bangladesh, about 15-17 million people will be displaced from the land inundation by sea level rise that will cost 12-16% of total land area

Cyclone cause huge damage to production of crop. Food and Agriculture Organization/ GIEWS Global Watch (2007)16 reported at the time of the passage of cyclone SIDR, the main 2007 "*Aman*" rice crop, accounting for about 70% of the annual production in the most affected area, was nearing harvest. According to the estimate by Department of Agricultural Extension of Bangladesh, the loss in rice equivalent is at some 1.23 million tonnes, with 535,707 tonnes in the four severely affected districts, 555,997 tonnes in badly affected 9 districts and 203,600 tonnes in moderately affected 17 districts in Bangladesh.

From the above literature I can conclude that Agriculture is the most vulnerable sector because the productivity totally depends on climatic factors. Crop production is adversely influenced by erratic rainfall, temperature extremes, sea level rise and increased salinity, floods, river erosion, cyclone and storm surges, and drought. All of which are likely to increase as a result of climate change. Increased extreme weather events and sea level rise has the potential to increase the demand on the agricultural sector whilst limiting the amount of cultivatable land. Salinity causes unfavorable environment and hydrological situation that restrict the normal crop production throughout the year. The effect of the tides is manifested in a regular alternation of rise and fall of the water level of the sea and the estuarine/tidal channels and creeks. The saline river water may also cause an increase in salinity of the ground water and make it unsuitable for irrigation. Scarcity of irrigation water fresh would be a problem especially during the winter months which will again have negative implication of the yield of B*oro* rice. It affects crops depending on degree of salinity at the critical stages of growth, which reduces yield and in severe cases total yield is lost.

CHAPTER 3
THE STUDY AREA

3.1 Geography

The upazila is situated in the Southwest part of Bangladesh and is located between 22 °13′ and 22 ° 24′ North latitudes and between 89 °46′ and 89 °54′ East longitudes on the western part of the lower Meghna River with an altitude of 3.0-3.5m from Mean Sea Level (MSL).

The lower Meghna is one of the largest river systems in the world that conveys the combined flow of Ganges, Brahmaputra (Jamuna) and Meghna through the estuary to the Bay of Bengal. The quantity of discharged water through the lower Meghna to the Bay of Bengal is the 3rd highest around the world (Ministry of Water Resource 2003).

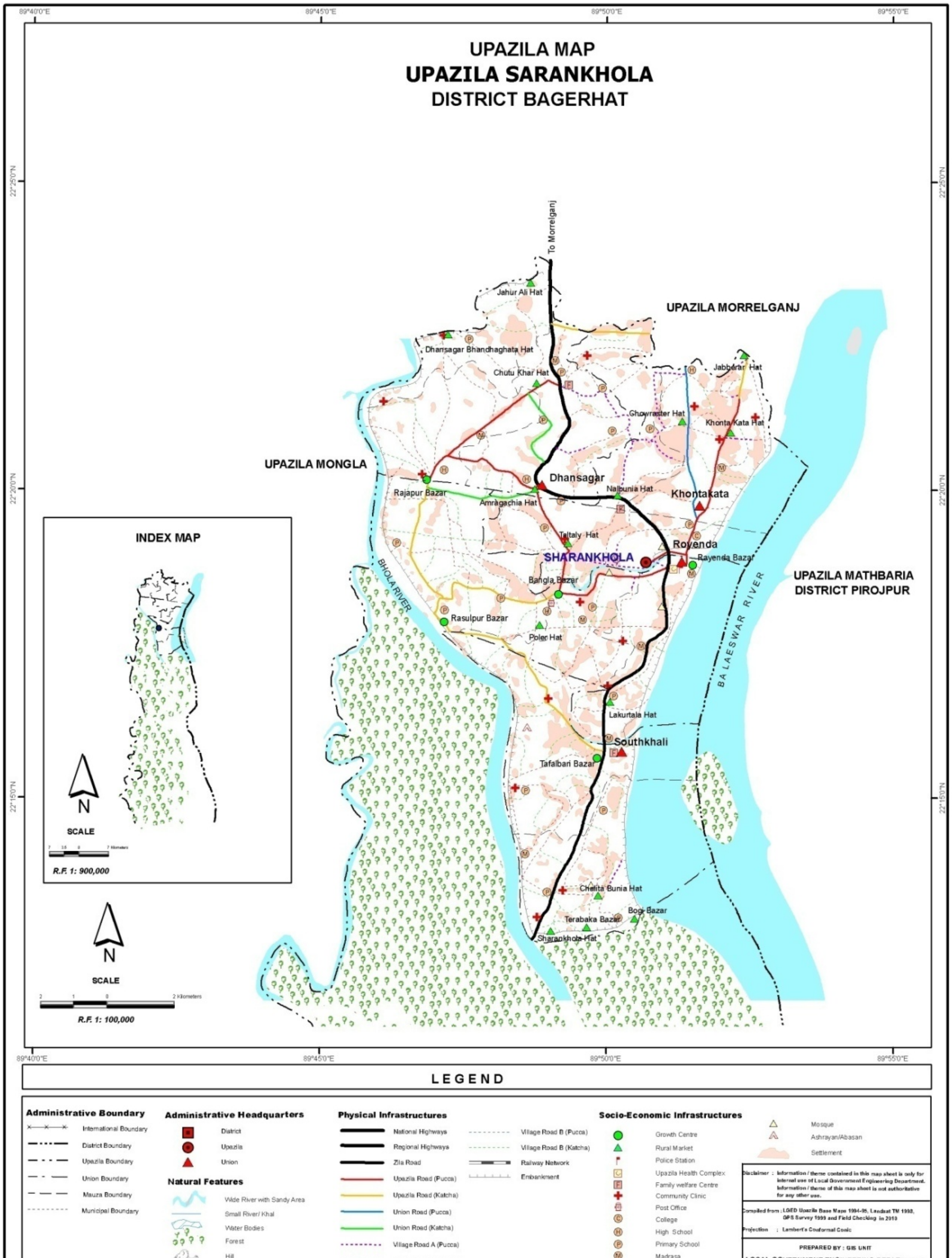
3.2 Demography

As of the 2011 Bangladesh census, Sharankhola has a population of 1, 19, 084. Males constitute are 51.28% of the population, and females 48.72%. Total Households are 28, 581. Sharankhola has an average literacy rate of 58.90% (7+ years), and the national average of 58.10% literate (Census 2011).

3.3 Physical infrastructures of the study area

It occupies a total area of 756.60 sq.km including 594.58 sq.km forest areas. It consists of 4 Union Parishads, 12 mouzas and 44 villages (UNO). The upazila is bounded on the north by Morrelganj upazila, on the east by Baleswar River and Mathbaria upazila of Pirozpur district and Patharghata upazila of Barguna district, on the south by the Bay of Bengal and on the west by Sundarbans and Mongla upazila.

Communication facilities are: Pucca road 25 km, semi pucca road 34 km and mud road 150 km. Nature of the transportation can be categorized as palanquin (extinct), horse carriage and bullock cart (nearly extinct) and boat.



Map 3.1: Sharankhola Upazila

Land is used: Arable land 11,616 hectares and fallow land 829 hectares. single crop 53.02%, double crop 26.67% and triple crop land 20.31 %; cultivable land per head 0.09 hectare.

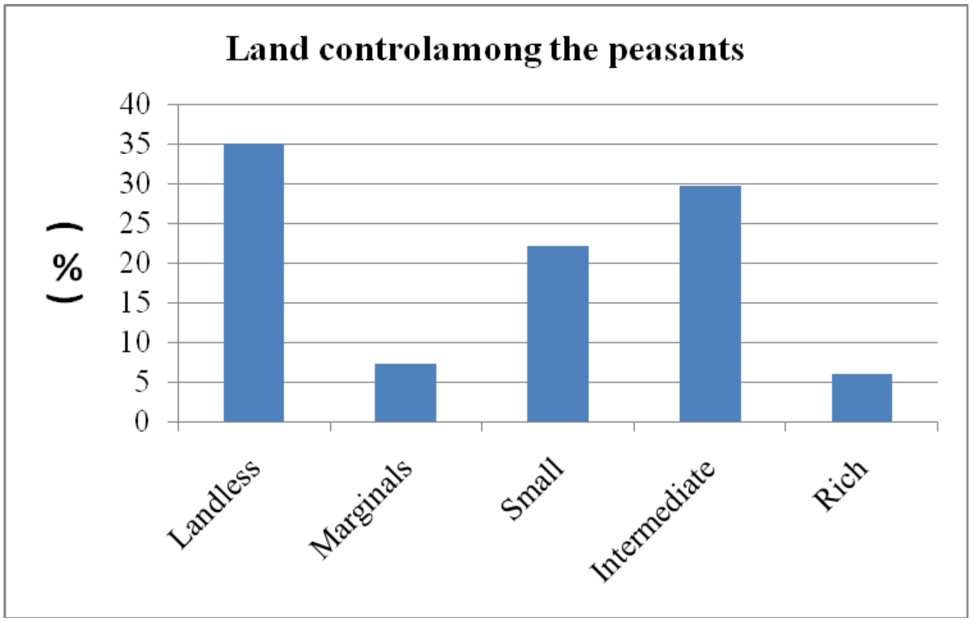


Figure 3.1: Land control among the peasants (Sources: Upazila Nirbahi Office)

The mangrove forest Sundarbans is connected Southwest part of Sharankhola with many channels. During the dry season Saline water comes through the channels in low land and damages the crop field. This saline water is very harmful for crops. Salinity causes unfavorable environment and hydrological situation that restrict the normal crop production throughout the year. The high tide during summer rises up to 1.3 meter above the general ground level. On the east coast of the sundarbans, the highest tide could inundate lands up to a depth of 2.0 meter, where protective bunds were not erected. The River Baleswar plays a vital role for Cyclone and Storm Surge.

Coastal areas are classified based on proximity to the Sea and indicators like tidal movement, salinity and cyclone risk. The zone is divided into exposed and interior coast according to the position of land. The upazillas that face the coast or river estuary are treated as exposed coastal zone. Total number of upazillas that fall on exposed coastal zone is 48 in 12 districts. A total of 99 upazillas that are located behind the exposed coast are treated as interior coast. The exposed coast embraces the sea directly and is subject to be affected highly by the anticipated sea level rise. Among them, Sharankhola upazila has already met or crossed the threshold limit of the three parameters and known as exposed coast. All of them are under cyclone risk at high or low level and face the sea or the Meghna estuary. (PDO-ICZMP 2003)

The average annual rainfall is about 1500 mm, but most of the rainfall occurs during the monsoon season. The maximum monthly average temperature varies from 26-36° C during the months of March-August, whereas the monthly average minimum temperature varies from 13-15° C during the rest of the year. The monthly average relative humidity ranges from 69% to 88%.

There are many river channels connected with river Bhola, Haringhata and Posur come from the Sundarbans and enter into the mainland. The freshly deposited alluviums from upstream in the coastal areas of Bangladesh become saline as it comes in contact with the sea water and continues to be inundated during high tides and ingress of sea water through creeks. The factors which contribute significantly to the development of saline soils are, tidal flooding during wet season (June-October), direct inundation by saline or brackish water and upward or lateral movement of saline ground water, during dry season (November-May).

3.4 Socio-economic condition

The socio-economic conditions of the population in Sharankhola upazila were explored to have an understanding of their social and economic strength.

The status of primary occupation of the household heads largely varies. Percentage of people is involved in agriculture (28.32%) and agricultural wage laborer 12.46%. Moreover, 32.27% people are involved in fishing. Fishing is the second dominant livelihood strategy like the agriculture labor. Fishing is predominant livelihood strategy at Sharankhola. 9.81% people are involved in collecting wood, wax and honey from Sundarbans. 10.14% people are service holders. Other 7% are also involved in fish business, rickshaw pulling, shrimp culture and shrimp fry collection and other occupations.

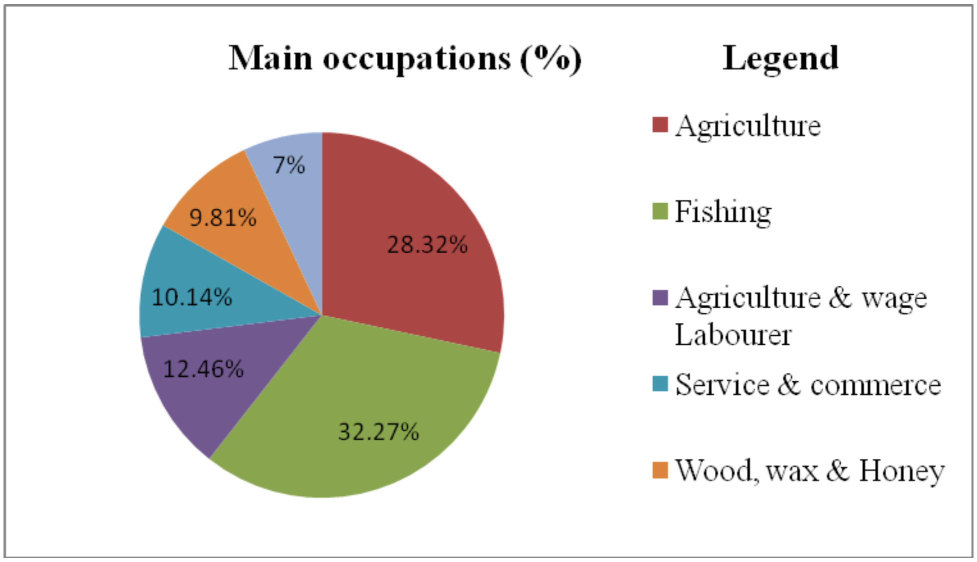


Figure 3.2: Main occupations (Sources: Upazila Nirbahi Office)

Livestock is an important property and its ownership patterns cross culture have some significance as far as rights and social status is concerned. In Sharankhola about 77% HHs have livestock and 23% households do not rear any livestock. Households having poultry and goats are more evident in this area. But cow rearing households are more evident. As the cow price is much higher than poultry and goat, it means more valuable livestock assets are owned by households. About 81% of the households are poor and among them, 35% are extreme poor, who do not have adequate income to maintain the cost of minimum demands of survival. The highest percentage of extreme poor is (47%). About 34% are moderately poor. About 3% of the families can be considered as rich in Sharankhola.

About 98% of the households in Sharankhola have to use pond water for the purpose of drinking, cooking and washing. Only 2% households of Sharankhola use tube wells water.

Various latrines are being used in Sharankhola upazila such as pucca or sanitary toilets 9%, pit latrines 49%, ring slab 30% and others 12%.

Agriculture is the main source of income and the nonagricultural sources are predominant in Sharankhola. Fishing and shrimp fry collection as an income source is also significant. These are the major income sources of people at Sharankhola.

The deficit amounts in income and expenditure has been covered by variety of ways. Seek loan from Bank, NGO and local mohajan in Sharankhola to cover their income deficit. Through daily laboring people try to cover this deficit. Some people starve and take only one meal a day to cover this deficit. Other strategies are undertaken by people to meet up the deficit are: mortgaging land, selling paddy, crops and milk.

3.5 Cropping: Seasons and Patterns

3.5.1 Cropping Seasons

Food supply varies according to the season, with domestic food supplies being scarce during the lean seasons in March–April and October–November, prior to harvesting. The lean seasons are characterized by a lack of agricultural employment opportunities, low agricultural wages and high rice prices.

Farmers themselves are changing their cropping pattern within their plots. Farmers sow pulses, oilseeds, potatoes and vegetables on the plots previously in rice-wheat. Commonly used 2-crop combinations are Aman-Boro rice, Aman-Aus rice and Aman-Boro rice.

Rice	Sowing Period	Harvesting Period
Aus	Mid March to mid April	Mid July to early August
Aman-Broadcast	Mid March to Mid April	Mid November to Mid December
Aman-Transplanted	End June to early September	December to early January
Boro-Local	Mid November to mid January	April to May
Boro-HYV	Dec to mid Feb	Mid April to June

Table 3.1: Sowing and harvesting period of different varieties of rice (Source: FGD & KII)

The crop-growing period is divided into two main seasons, Kharif and Rabi. Crops (such as rice, jute, maize, millets, etc) which are grown during the Kharif season are called Kharif crops and those (such as wheat, mustard, chickpea, lentil etc) grown during the

Rabi season are called Rabi crops. The Kharif season extends from May through October, while the Rabi seasons starts from November and continues up to April. In addition to these two main seasons, another transition season called Pre-kharif has been identified. This season starts from March-April and ends in May-June.

3.5.1.1 Pre-Kharif Season (Aus)

Aus (Mid March to Mid July) is characterized by unreliable rainfall and varies in timing, frequency and intensity from year to year, and provides only an intermittent supply of moisture for such crops as broadcast Aman, Aus, amaranths, teasle gourd, etc. During this transition period, soils intermittently become moist and dry. The relative lengths and frequency of such periods depend on the timing and intensity of pre-monsoon rainfall during this season in individual years. With the expansion of irrigation facilities, some of the Pre-kharif crops are now grown under irrigated conditions. These include sugarcane, maize, jute, amaranths, groundnut, banana, sesame, lady's finger, teasle gourd, sweet gourd, white gourd, bitter gourd, ribbed gourd, ginger, turmeric etc.

3.5.1.2 The Kharif Season (Aman)

Aman (Mid -July to Mid October) starts from May when the moisture supply and from rainfall plus soil storage is enough to support rainfed or un-irrigated Kharif crops. The season actually begins on the date from which precipitation continuously exceeds 0.5 Potential Evapotranspiration (PET) and ends on the date when the combination of precipitation plus an assumed 100 mm of soil moisture storage after the rainy season falls below 0.5 PET. During the greater part of this season, precipitation exceeds full PET and water can be held on the surface of impermeable soils by bunds. The period of excess precipitation is called the humid period.

The crops most extensively cultivated during the Kharif season are Aus, broadcast Aman, Transplant Aman, sesame, different kinds of summer vegetables, ginger, turmeric, pepper, green chilli, different kinds of aroids, cotton, mungbean, black gram, etc. Most Kharif crops are subject to drought and flood in areas without water control.

3.5.1.3 The Rabi

Rabi (Mid- October to Mid- March) season starts at the end of the humid period and lasts to the pre-kharif season. The mean length of the Rabi growing period range from 100-120 days in the extreme west, to 140-150 days in the northeast of the country. The mean starting date of the Rabi season ranges from 1-10 October in the extreme west, to 1-10 November in the Northeast, and in central and eastern coastal areas. The mean end dates range from 1-10 February in the following year in extreme west to 20-31 March in the Northeast. Most common Rabi or winter crops are wheat, maize, Boro rice, mustard, groundnut, sesame, potato, sweet potato, sugarcane, lentil, chickpea, grass pea etc. On lowlands, very lowlands and bottomlands where flooding continues even after the end of rainy season, the Rabi season starts from the date when flooding ends.

3.5.2 Cropping Patterns

A large number of cropping patterns are practiced across Bangladesh, depending on land type, soil texture, flooding regimes, rainfall (amount and distribution) and the resource base of the farmers. Some dominant cropping patterns under variable crop production environments in Khulna region are as follows:

Rainfed Condition	***Rabi***	***Kharif-I (Aus)***	***Kharif-II (Aman)***
	Wheat/potato/pulses/oilseeds/sugarcane	Boro (local) Aus	Fallow
Irrigated Condition	Wheat/Boro/potato/winter/vegetables	Fallow/T. Aus	T. Aman/ fallow

Table 3.2: Irrigation system with cropping pattern (source: FGD & KII)

Generally, deep-rooted crops (such as jute) are grown after shallow-rooted crops (such as rice), which helps the uptake of soil nutrients from different depths and also helps to improve soil quality.

3.6 Current cropping practices in Sharankhola

3.6.1 Paddy

Three seasonal rice groups are recognized in Bangladesh and it dominates the cropping pattern throughout the country. These three groups are cultivated in Sharankhola throughout the year as Aus, Aman and Boro. The varieties of Aman are transplant, broadcast and high yielding variety (HYV), varieties of Aus are local and HYV and varieties of Boro are local, HYV and hybrid. Among these cropping Aman is most important and occupies. Transplanted Aman is grown throughout Sharankhola and broadcast Aman is grown very rare in Sharankhola. Aus is cultivated scattered in Sharankhola.

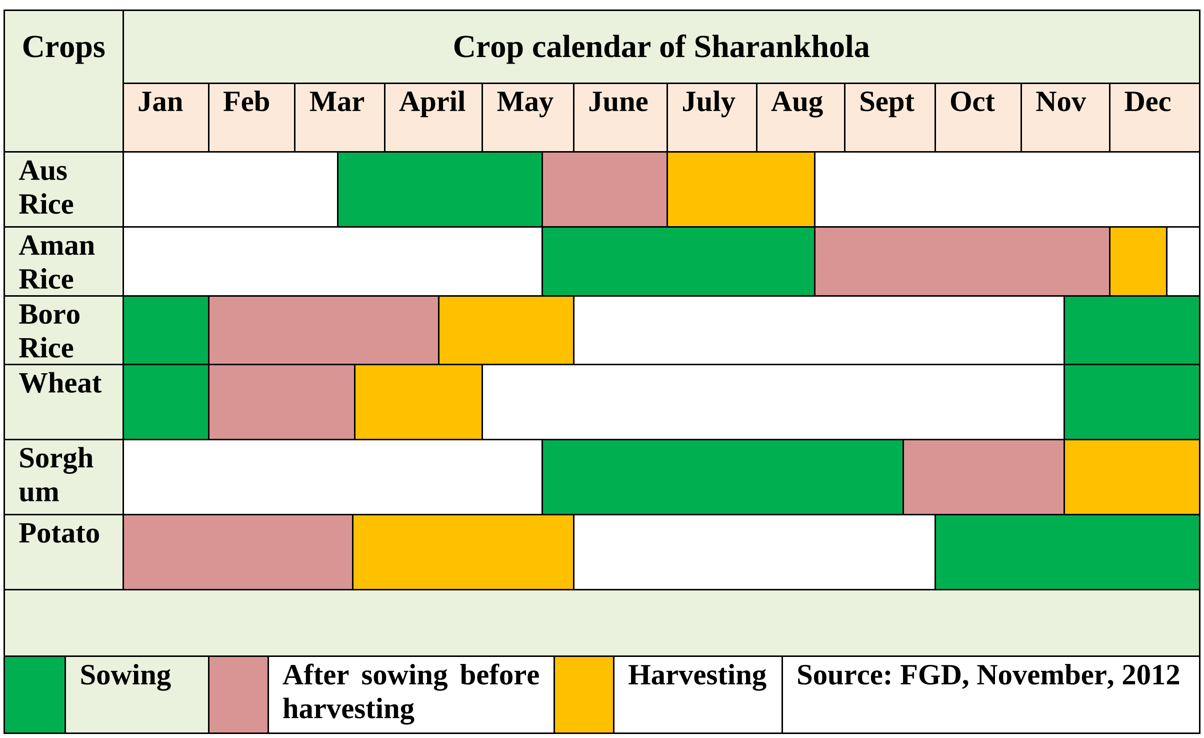
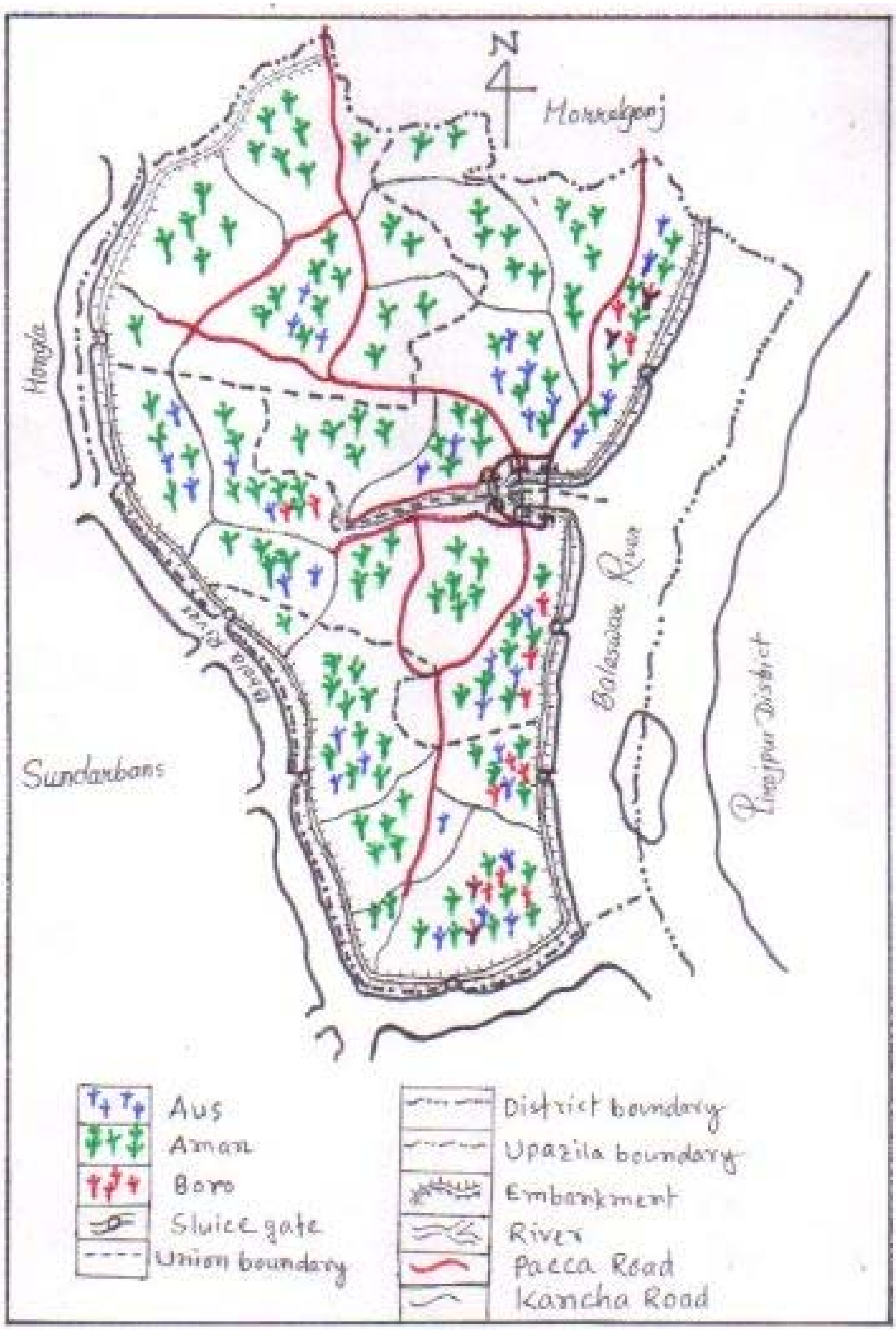


Figure 3.3: Crop calendar of Sharankhola



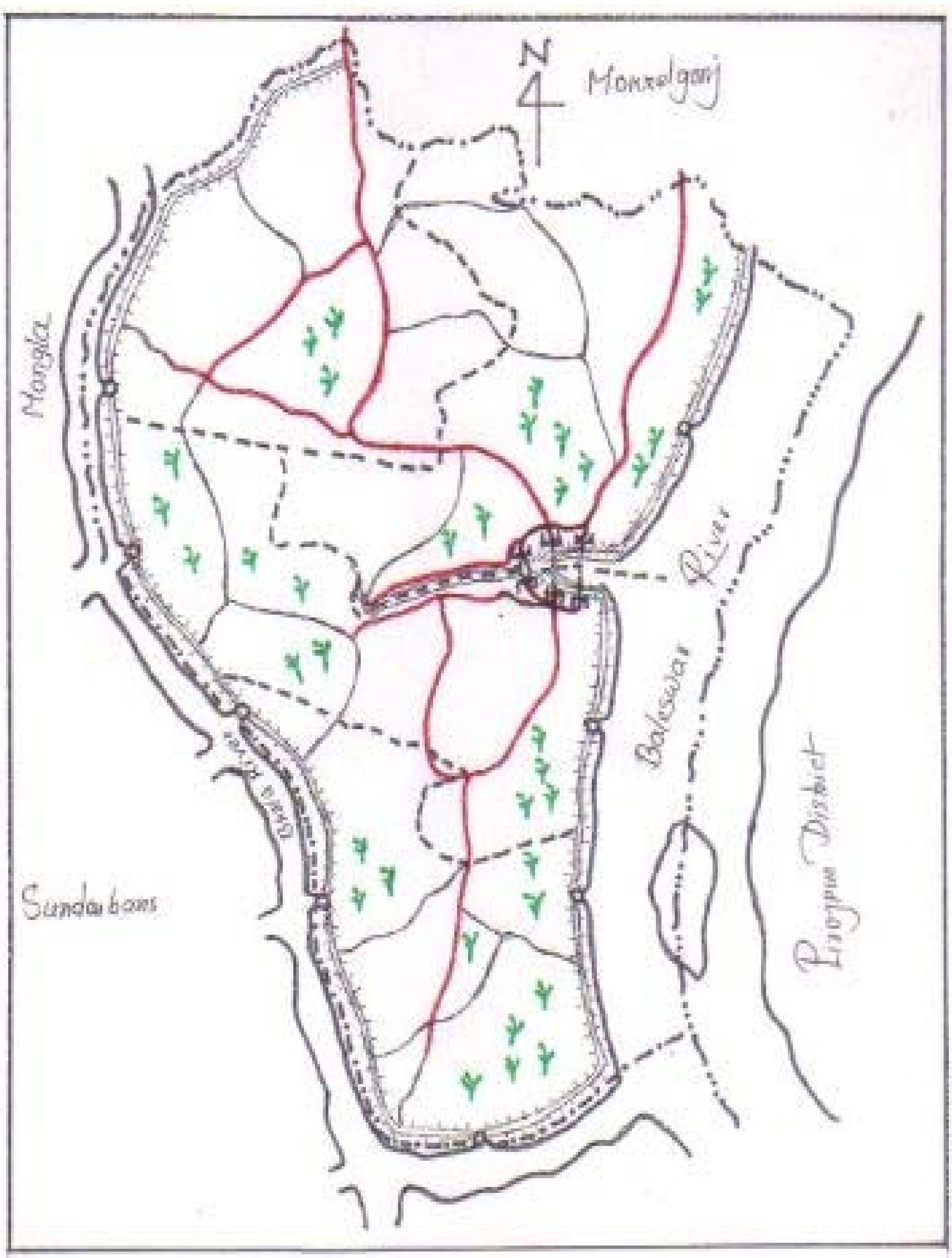
Map 3.2: Various paddies cultivation, Sharankhola (Source: AEO)

Aus paddy is sown in the pre-monsoon season and harvested in the monsoon season, grown both as a dry land crop (broadcast Aus) and as transplant Aus. Aman paddy growing in the monsoon season and harvested after the monsoon season; and Boro, grown in the dry season. Aman is divided into deepwater Aman, mainly sown as a dryland crop pre-monsoon, growing in the monsoon season, and harvested post-monsoon; and transplanted Aman, sown in seedbeds in mid-monsoon, transplanted to fields in August-September, and harvested post-monsoon. Boro paddy is always transplanted and is mainly irrigated.

Photograph 3.1: Focus Group Discussion, Rajapur village (making crop calendar about sowing and harvesting)

3.6.1.1 Aus rice

Most of the land of Sharankhola is not cultivated lack of fresh water in Aus season. Because they have no capacity enough to reserve the rain water in the rainy season to use cultivation. They reserve the rain water in khal and pond but it is very less than according to their demand. The farmers can’t use river water in this season because of salinity. For this reason the production of Aus rice goes down. Farmers cultivate short duration crop in their field due to climate change. After SIDR and Aila, various NGOs help the farmers to cultivate crops giving seeds (Hybrid, HYV), fertilizers, power tillers free of cost. The saline water can't enter into the crop land normally in dry season because embankment protects it.



Map 3.3: Aus rice cultivation in Sharankhola (Source: AEO, 2012)

Aus rice production is shown in figure 3.4 that Climate Change has affected cropping pattern in Sharankhola. Local Variety is more affected due to climate change in study area than HYV & Hybrid. So the farmers of Sharankhola are interested to cultivate HYV & Hybrid in Aus season instead of Local Varieties. Because of the HYV & Hybrid (Aloron) is more saline tolerant and short duration crop than Local Varieties.

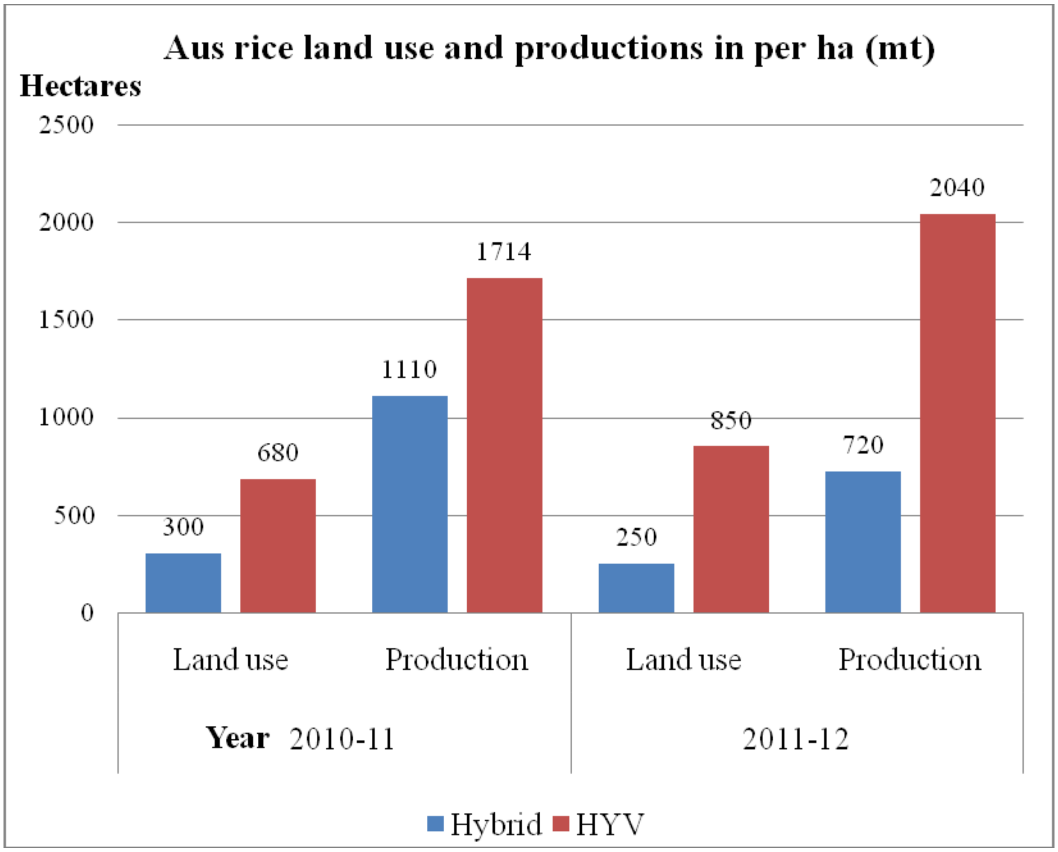


Figure 3.4: Aus rice land use and production, Sharankhola (Source: AEO, 2012)

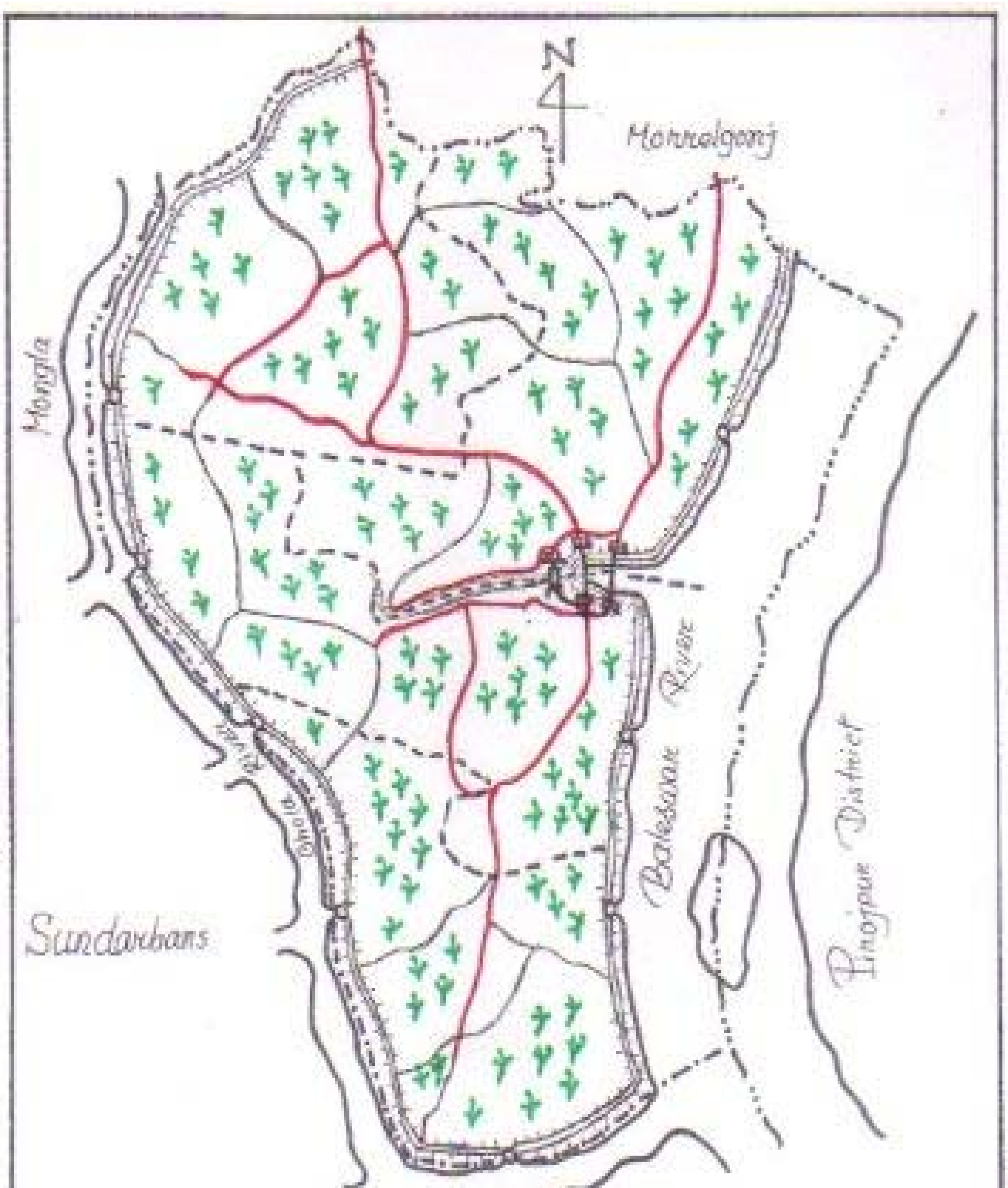
3.6.1.2 Aman rice

The average crop yield is very low in the region, which is obviously due to salinity problems, low soil fertility, erratic rainfall, and lack of fresh water in the dry season. The dominant crop in the coastal area is the local T-Aman rice. Although rice is the predominant crop of Bangladesh, modern rice cultivars tolerant to saline soils are few in number.

While walking through the Embankment along Baleswar River, through the village pave and kancha road, or connecting road from Upazila to different village, it was observed that the agricultural activities were running in full swing at Sharankhola Upazila. There were green paddy and paddy all over the field. Very near to the houses and by the side of the ponds, even at the edge (aile) of paddy fields still there were several vegetables plots. Pumpkin, bitter gourd was seen hanging on the bamboo made platform (macha).

Photograph 3.2: HYV rice at maturity (Aman season), Sharankhola

The people of that area have been cultivating saline tolerant rice varieties for more than 50 years. The farmers of Sharankhola usually cultivate traditional varieties and harvest about 1.64-2.5 mt/ha/year. Water Development Board (WDB) constructed an embankment on the outer side of Sharankhola Upazilla to protect the Upazilla from tidal fluctuations and salinity. The inner side of the embankment was used at that time for cultivating indigenous rice varieties. After the introduction of the HYV Aman varieties, they started to cultivate the HYV also. They cultivate local varieties of rice in their fields, varieties which are saline tolerant and especially suited to the present circumstances to the area. These rice varieties include Jotabalam, Ashfall, and ghunshi.



Map 3.4: Aman rice cultivation in Sharankhola (Source: AEO, 2012)

Though the yield of these local varieties is very poor, the people continue planting them because of their suitability to the area. In the early 1980's the people of the area also started to cultivate the BRRI dhan40 and 41. Due to high salinity levels, it is difficult to cultivate any HYVs, such as HYV Aman (BR 11, BRRI 33, *BRRIdhan 40* and *BRRIdhan 41*). As a result, people continue to cultivate the local varieties because they perceive them to be not only saline tolerant, but they also have greater plant height, comparatively low planting costs, are tasty and above all are easily manageable. There is a fodder shortage, the rice straw upon which the people depend entirely. Ashfall and Benapol varieties have the same qualities as the two above but they are destined for other agricultural farms. Jotabalam has the highest yield among them. In the Aman season people use different techniques for cultivating Aman rice within the shrimp farm. After harvesting the rice, the people cultivate the other varieties in other fields.

The people select the rice varieties by assessing the production, consumption, distribution and existing marketing facilities, while also taking into account the nutrient value of the produce.

Photograph 3.3: Seeds dealer Mr. Nazmul Hossain (Dulu), Rayenda Bazar and Fertilizer dealer Omor Faruq (Ostad), Khontakata bazaar (KII)

Farmers store local seed varieties at home for planting at a later time. Flooding is a huge problem during farming season as submersion of land results in stagnant fields. In fact there is no salinity effect in the coastal region during the T.Aman crop growing season (salinity ranges 1.5-3 dS/m) due to high rainfall and upstream river flow. But at the later stage, there is some sort of salinity (ranges 4.6 dS/m) impact in the coastal zone. Yield reduction in T.Aman is mainly due to tidal floods preventing growing HYVs, cyclone increased pest-incidences etc due to climate changes.

During wet season, HYV and local Aman rice are grown extensively in the coastal saline areas with normal yields between 2.5 and 3.0 tons per hectare. Transplanted Aman-fallow is the most dominant cropping pattern in Sharankhola.

Aman rice productions are shown in figure 3.5 that the production of Hybrid is less than the HYV and Local varieties in Aman season. So the farmers are interested to cultivate the HYV and Local varieties.

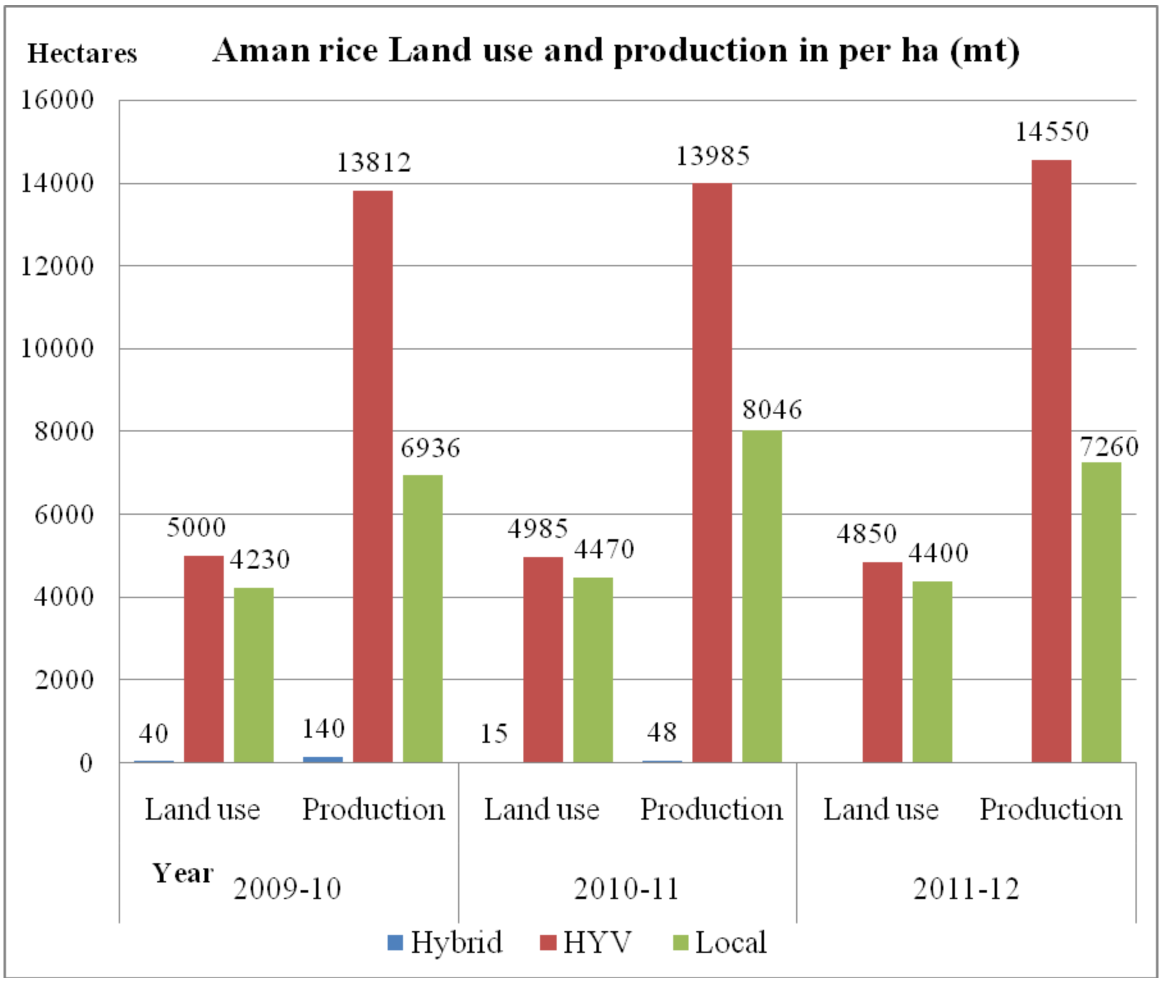
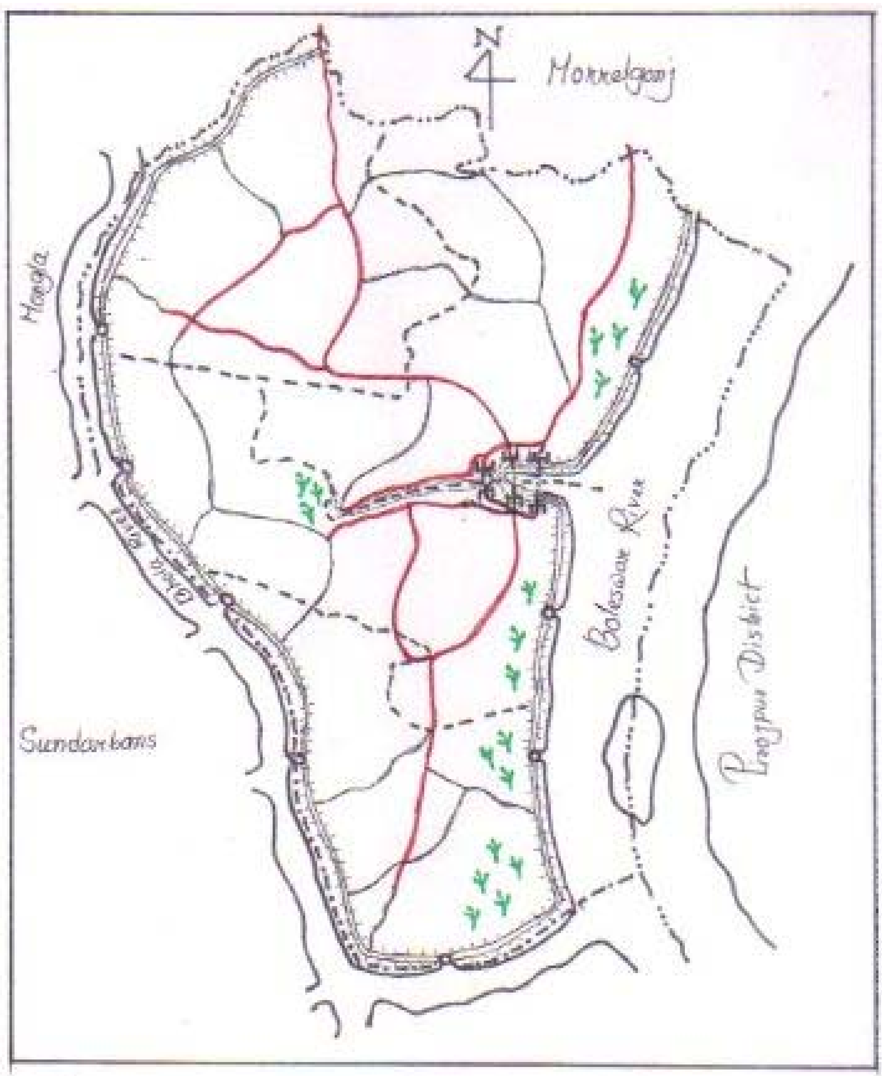


Figure 3.5: Aman rice land use and productions, Sharankhola (Source: AEO, 2012)

3.6.1.3 Rabi

The common varieties of rice crops grown in this area are: BR 28 & 29, IRRI 26 & 44 *Boro Bichi* etc. BR29 is the most productive variety with 40-50 mound/acre yields. Seeds are bought from the local bazaars, which can be difficult. Farmers store local seed varieties at home for planting at a later time. Flooding is a huge problem during farming season as submersion of land results in stagnant fields. *Boro Bichi* is well adapted to floods, since the stalk is taller than other varieties and do not be submerged in the flood water easily.



Map 3.5: Boro rice cultivation, Sharankhola (Source: AEO, 2012)

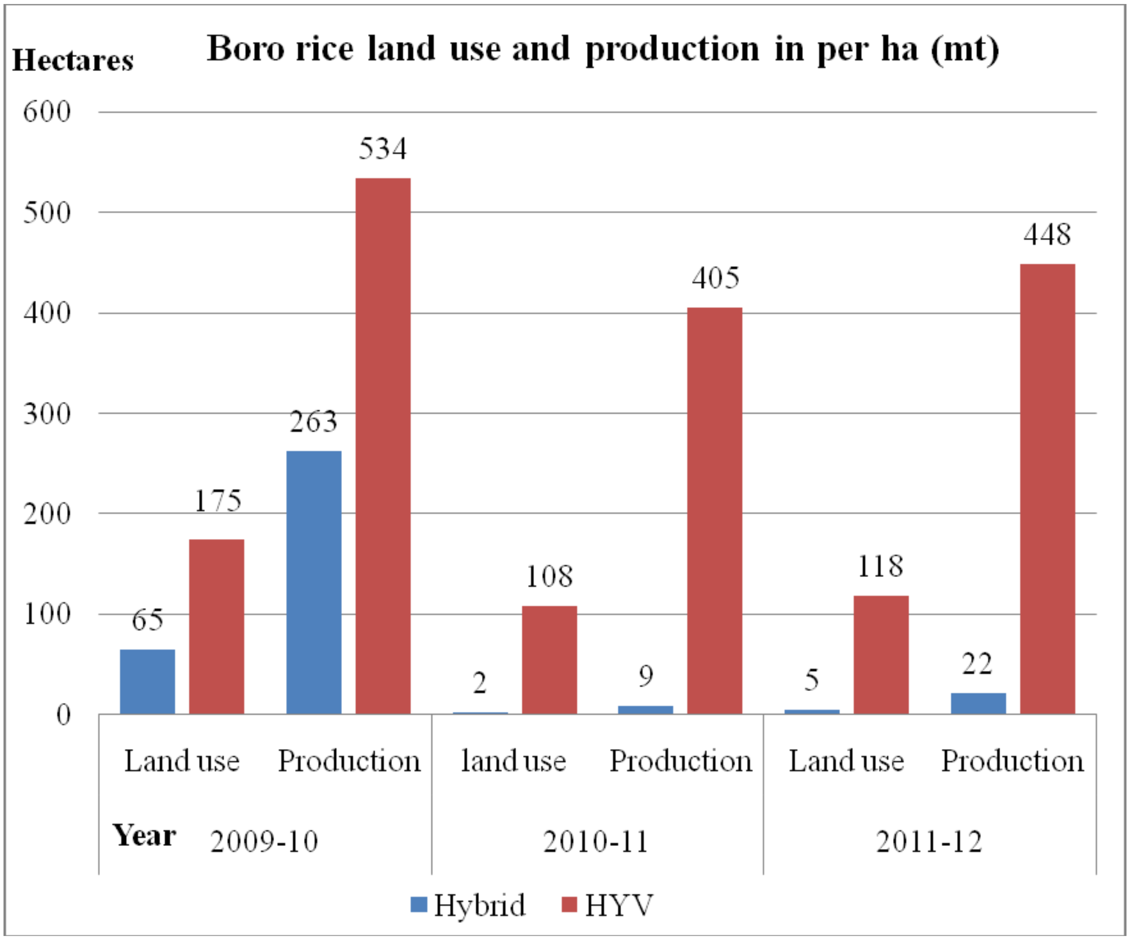


Figure 3.6: Boro rice land use and productions, Sharankhola (Source: AEO, 2012)

The land of Sharankhola is suitable for minimum two crops and sometimes three crops with Potato or other winter crops. The low land use in saline area is mainly due to unfavorable soil salinity in dry season and unavailability of quality irrigation water. Scarcity of quality irrigation water during dry season limits cultivation of Boro rice and Rabi (winter) crops, and Aus cultivation during kharif-1 (March-July) season. In the coastal saline belt with short winter season timely sowing/planting of Rabi (winter) crops is essential but this is restricted by late harvest of Aman rice.

Farmers are using less land for paddy cultivation in Boro than in Aman season. They are now practicing vegetable cultivation in the high land instead of paddy because vegetables need short time, less irrigation, profitable and less risky of salinity and cyclones and submerge. Farmers of Sharankhola are not interested to cultivate Hybrid Boro rice because it is easily attacked by pesticides and diseases. So the farmers are cultivating HYV rice in lieu of Hybrid rice in Boro season.

High temperature and increased salinity reduce the yield of HYV Boro rice. Yield reduction of vegetables, pulses and oil seeds is due to late planting owing to late harvest of T.Aman rice, waterlogging and early tidal flood. Winter crops, such as wheat, potato and vegetables are grown, which cover a small area.
Most fields remain fallow during winter and Kharif-I season after harvest of T.Aman due to moisture stress. Growing crops with zero tillage (maize), mulching (potato), priming (chickpea), homestead gardening and dry land farming (sesame) are promising adaptation options.

Wheat: Wheat is grown under a wide range of climatic, and soil conditions and grows well in clay loam soils. It is a crop of Rabi season, requires dry weather and bright sunlight. Well distributed rainfall between 40 and 110 cm is sufficient for its growth. Depending on variety and weather conditions, 100-120 days are required from sowing to harvest. The harvesting time of wheat is March to mid April. Farmers of Sharankhola are not interested to cultivate wheat due to climate change. But now they are interested to cultivate sunflower instead of wheat because wheat is more favorable than wheat in this climate.

Potato: Potato varieties that are cultivated in Sharankhola and increasing day by day are broadly categorized into two groups: local and high yielding (HYV). In spite of poor yields, some of the local varieties are still being cultivated because of their taste and cooking qualities. The local varieties and high yielding varieties (HYV) of potato are cultivated. Most varieties are cultivated during the winter and harvested February-March. The production of potato is 16.0-19.0 mt/ha.

Pulse: The common pulses in Sharankhola are Masur (lentil), Mung (green gram), Kheshari (lathyrus or grass pea), and Motor (pea). Kheshari is widely cultivated, mostly as fodder, and also consumed by the farmers of study area. Masur is popular to all classes of people, and is taken in almost all meals. Pulses are cultivated as Rabi crop. The sowing period of Masur pulse is mid October to mid November and that of Kheshari is mid

October to mid December. The production of Kheshari is 0.8-1.2 mt/ha. The harvesting period of Masur pulse is early February to early March and that of Kheshari is mid February to mid April.

Sunflower: The successful cultivation of sunflower on 38 acres of land in Sharankhola upazila has rekindled hopes of the Sidr-affected farmers, as it has created an opportunity for them to ensure optimum use of their arable land which remains uncultivated after harvest of one crop (UAE office). The farmers will cultivate it on a larger scale next year, as the trial farming has proved an overwhelming success. People from different villages go to Khontakata in Sharankhola to learn about its cultivation process, as the farmers now look to cultivate the new crop on a larger area of land.


Photograph 3.4: Focus Group Discussion Rajoir village and Banglabazar (Khontakata and Rayenda union)

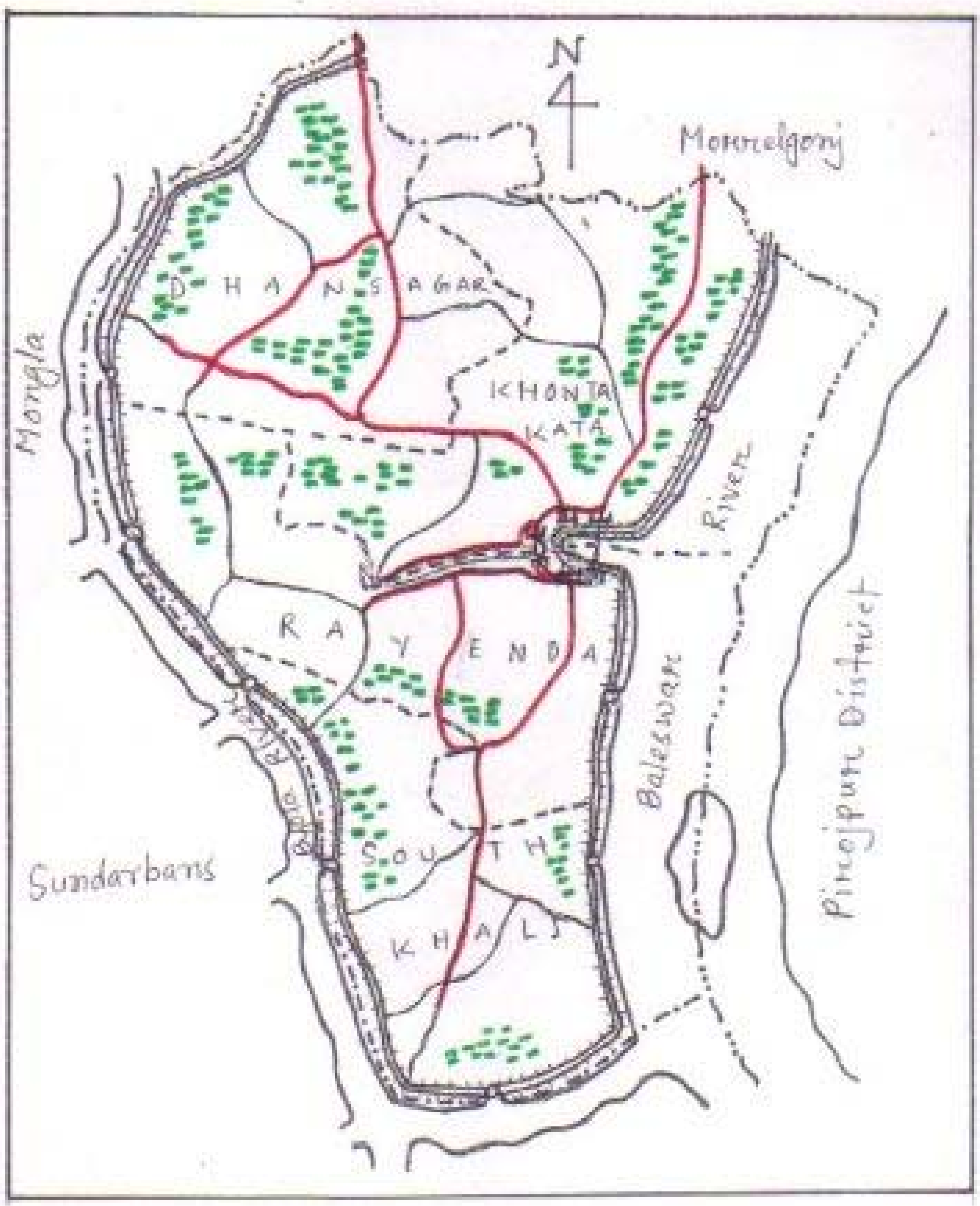
It has become a boon to the local farmers and they are no more haunted by the fear of crop loss in the backdrop of the changed weather pattern in the southern region. The crop is cultivated in December and can be harvested in 90 days after cultivation. Its profit margin is also high. The production of sunflower is 2.0-3.0 mt/ha Sunflower which can be a good source of cholesterol-free edible oil and a good import substitute can suffice the demand in the domestic market, if it is cultivated on a larger scale and the farmers are provided with proper marketing facilities. The local agricultural extension officials in association with anon-government organization (NGO) are encouraging the farmers to cultivate the crop on a larger scale next year.

Crops/production	2009-10	2010-11	2011-12
Wheat	72	26	25
Maize	90	455	350
Sweet potato	240	350	760
Potato	1800	1440	1200
Mustard	14	16	24
Khesari	2000	4800	3200
Chilli	38	44	45.5
Sugarcane	660	750	-
Sunflower	0.5	16	120
Onion	56	70	49

Table 3.3: various crops in Robi season (per ha –mt) (Source: AEO, Sharankhol, 2012)

3.7 Vegetables

The trend of vegetables is growing fast because of increasing demand and short duration. Day by day farmers are changing pattern of vegetables cultivation. Once they cultivated cabbage and cauliflower immensely but they are now cultivating Olkapi, Bean and Brinjal. Because cabbage and cauliflower cultivation is easily affected by pesticide and diseases and it rotes easily. Short duration of winter due to climate change is the major barriers of Cabbage and Cauliflower. Cultivation of Olkapi, Bean and Brinjal are comparatively less affected by pesticide and diseases. On the other hand its production cost is very low.



Map 3.6: Various vegetables cultivation in Sharankhola (Source: AEO, 2012)

Vegetable farming in study area can be grouped into 3 categories based on scale of production and objectives of farming: vegetable production on homestead, vegetable production for commercial market and vegetable farming for seed production.

Photograph 3.5: People grow vegetables in their homesteads for their own consumption

During winter when the land becomes dry, they cultivate some vegetables like red amaranth, bottle gourd, etc. Farmers of this village depend entirely on chemical fertilizers and insecticides and it is difficult for them to get access to these agricultural inputs in the rural areas. The farmers also shared their observation that the productivity of land is decreasing day by day due to excessive use of chemical fertilizers. Therefore, they need training on bio fertilizer and Integrated Pest Management (IPM). They have requested for more outreach and training from the Department of Agricultural Extension (DAE) at the union level.

The area under vegetable farming has increased over time. The major winter vegetables are Cabbage, Cauliflower, Tomato, Brinjal, Radish, Hyacinth Bean, Bottle Gourd, and major summer vegetables are Pumpkin, Bitter gourd, Teasle Gourd, Ribbed Gourd, Ash Gourd, Okra, Yard-long bean, and Indian spinach among others. Some vegetables like

Brinjal, Pumpkin, Okra, Lady's Finger and Red Amaranth are found to grow in both the seasons.

Photograph 3.6: Raised bed at Sharankhola under flood prone ecosystems

Various vegetables are grown in these seasons of the study area and its production is shown in the table 3.4 and 3.5.

Types of crop	**Land use in hectares**				**Production in per hectares (mt)**			
	2010-11	2011-12	Increase	Decrease	2010-11	2011-12	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	-	√

Table 3.4: Winter season vegetables (Source: AEO, Sharankhola Upazila, 2012)

Types of crop	Land use in hectares				Production in per hectares (mt)			
	2010-11	2011-12	Increase	Decrease	2010-11	2011-12	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	√	-

Tables 3.5: Summer season vegetables (Source: AEO, Sharankhola Upazila, 2012)

Photograph 3.7: People cultivate Lady's finger at raised land
(Remove weeds from cropping field)

CHAPTER 4
IMPACTS OF CLIMATE CHANGE

Crop production is adversely influenced by erratic rainfall, temperature extremes, increased salinity, drought, floods, river erosion, and tropical storms. All of which are likely to increase as a result of climate change.

From the focus group discussion, literature review, Key informant interview, personal experience and observation, data collection from government Agriculture Extension office I have found some positive and negative trends in the cropping pattern in Sharankhola. The negative trends are as follows:

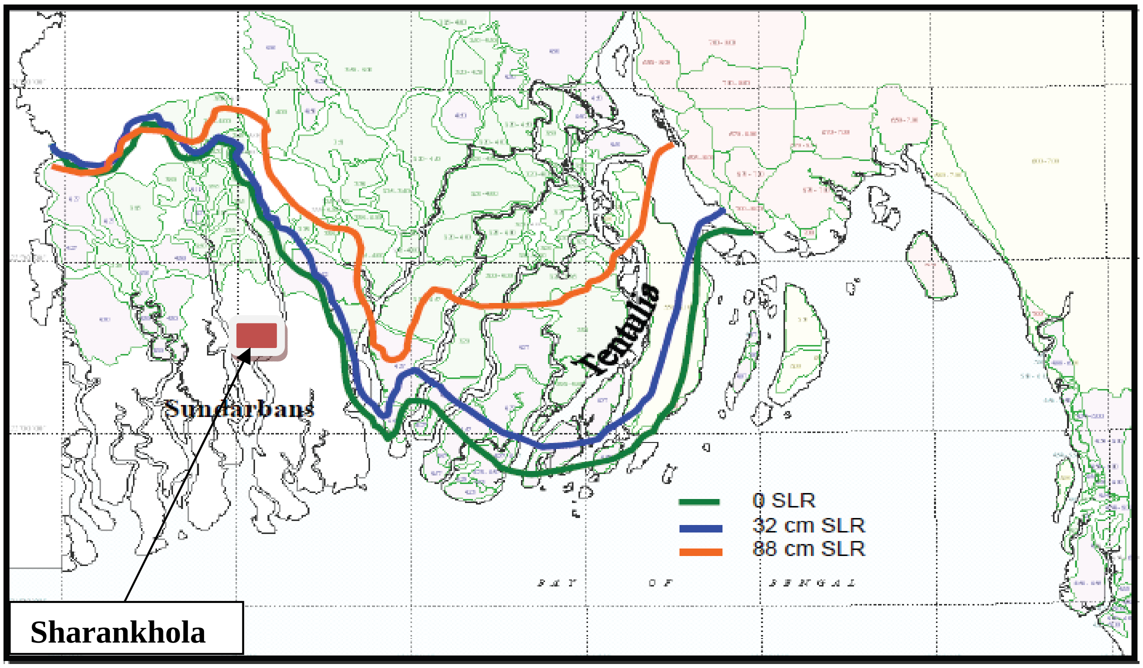
4.1 Sea level rise and salinity intrusion

The main impacts of sea level rise on water resources are fresh water availability reduction by salinity intrusion. The main obstacle to intensification of crop production in the coastal areas is seasonally high content of salts in the root zone of the soil. The salts enter inland through rivers and channels, especially during the later part of the dry (winter) season, when the downstream flow of fresh water becomes very low. During this period, the salinity of the river water increases (FGD, common). The salts enter the soil by flooding with saline river water or by seepage from the rivers, and the salts become concentrated in the surface layers through evaporation.

The saline river water may also cause an increase in salinity of the ground water and make it unsuitable for irrigation. The increase in water salinity of these areas has created suitable habitat for shrimp cultivation. Along with other factors, shrimp cultivation played a major role to increase salinity, particularly (FGD & KII - Khontakata & Dhansagar).

A direct consequence of sea level rise would be intrusion of salinity with tide through the rivers and estuaries. It would be more acute in the dry season in Sharankhola, especially when freshwater flows from rivers would diminish (KII-UEO)

Sea level rise will increase flood frequency and flooding duration, affecting Aman production. Due to sea level rise, salinity of water and soil will increase, and this will damage Aman cultivable land. Agricultural lands in the coastal area will be affected by salinity; soil quality will be degraded and flooding event will loss the agricultural production. Salinity and waterlogging, are possible reduction of Aman and Boro paddy area due to longer duration of flooding and restriction in irrigation. Due to Sea Level Rise the High Yielding Verities of Aman paddy would start losing increasing amount of suitable land for cropping in Sharankhola. So the farmers of Sharankhola are losing their



Map 4.1: Sea level rise scenarios (Source: IWM, 2005)

crops every year due to climate change. Lack of fresh water for cultivation they are interested to shrimp cultivation (FGD, common).

When the rice fields are converted into shrimp ponds, total rice production decreases because of decreased rice field areas. Farmers couldn't produce two rice crops during the year, as one vegetation cycle was used for shrimp cultivation instead of crop production. Thus sea level rise will have an impact on agricultural production. Both water and soil salinity in Sharankhola will be increased with the rise in sea level, destroying normal characteristics of coastal environment.

On the other hand salinity levels have already increased in domestic ponds, groundwater supplies and agricultural land, through the various estuaries and water inlets intertwined with Major River.

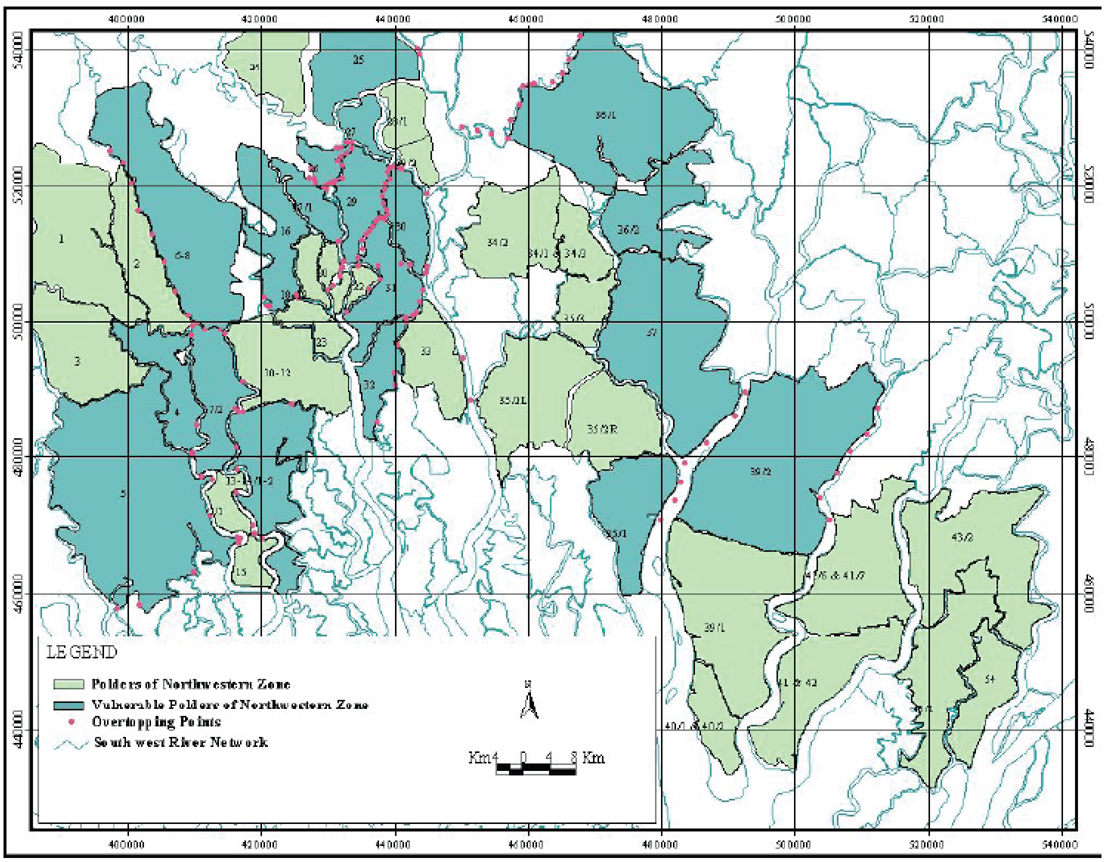
The saline weather decreases the longevity of the houses. People are going to other places for work and earn money. Saline weather makes the life difficult. The cultivable lands lose its fertility day by day. Its fertility as a result of crop diminishing at quick rate people migrate different places in search of livelihood. Those who are remaining there are facing the problem of cultivation and other purposes. Salinity bounds people to migrate (FGD, common).

4.2 Drainage congestion

Drainage congestion may become a serious threat due to climate change. It is being a grave problem due to the combined effect of siltation, subsidence, and poor maintenance of the drainage channel networks in many parts of the coastal zone. It is aggravated by reducing natural drainage capacity (*World Bank, 2000*).

The tidal floodplain has a distinctive, almost level landscape crossed by innumerable interconnecting tidal rivers and creeks. The estuarine islands are constantly changing shape and position as a result of river erosion and new alluvial deposition. Peat basins are located in some of the low lying areas between the Ganges river floodplains and tidal floodplains occurring in the western part of Khulna (Karim *et al.*, 1982). These areas are subject to flooding in the monsoon season and water logging in parts of the basin areas in the dry season. Tidal flooding through a network of tidal creeks and drainage channels connected to the main river system inundates the soil and impregnates them with soluble salts thereby rendering both the top and subsoil saline. The high tide during summer rises above the general ground level. On the east coast of the Sunderbans, the highest tide could inundate lands, where protective bunds were not erected. The most significant feature of hydrology in relation to agricultural development is the seasonal shallow flooding which affects about 60% of the total area. In these areas flood water recedes from October to late December.

This results in the inundation of a vast coastal land by saline water making additional agriculture lands uncultivable. Most of the saline water comes from the Baleswar River during the dry season. The river (Baleswar) is on the eastern part of Khontakata and Rayenda unions and southern part of Southkhali union. On the other hand Vola River of the western part of Sharankhola plays a vital role in the dry season. It brings saline water from various rivers and enters into the western part of Rayenda and Dhansagar unions through various canals. It damages the Boro and Aus crops. The farmers cannot cultivate crops lack of freshwater. Besides, various vegetables do not grow lack of fresh water. As Sharankhola is extreme saline prone area so short duration variety is very much popular because farmers can use reserve water from cannel and ponds before sea level rise and any form of cyclones and submerge. Farmers cannot use river water in both Aus and Boro seasons because at that time river water remains saline.



Map 4.2: Drainage congestion effects due to SLR (Source: IWM, 2005)

Perennial water-logging due to inadequate drainage and faulty operation of sluice gate facilities restricts potential land use of the low lands within the embankment areas.

4.3 Ingression of soil salinity

Salinity ingress also causes an increase in soil salinity, especially when farmers irrigate their lands with slightly saline surface water at the beginning of the low flow period. SRDI (1997) reported that, soil salinity levels south of Khulna and Bagerhat ranged between 8 to 15 ds/m during the low flow season. The anticipated results of salinity ingress will be, at a minimum, of the same order for climate change induced low flow regime compared to similar effects. The anticipated sea level rise would produce salinity impacts in three fronts: surface water, groundwater and soil. Increased soil salinity due to climate change would significantly reduce food grain production. Even at present, some parts of coastal lands are not being utilized for crop production, mostly due to soil salinity; and this situation would aggravate further under a climate change scenario. Under the changed climate conditions, the index of aridity would increase in winter. Consequently, higher rates of capillary action from an increased rate of topsoil desiccation would accentuate the salinity problem. Salinity problem received very little attention in the past. Nevertheless, symptoms of such land degradation with salinization are becoming too pronounced in recent years to be ignored.

In the saline soils rice, sugarcane, pulses, oilseeds, spices, vegetables and fruits are grown, but their contributions to cropping intensity vary greatly with Sharankhola. Local transplanted Aman rice (July-November) is the dominant crop in Sharankhola. During wet season, local Aman rice is grown extensively in Sharankhola with normal yields between 2.5 and 3.0 tons per hectare. Transplanted Aman-fallow is the most dominant cropping pattern. Winter crops, such as wheat, potato and vegetables are grown, which cover a small area (KII, UEO & seeds dealer).

Adopting of HYV rice cultivars varied considerably. Some coverage of HYV rice during Aman season is also found in Sharankhola. But almost no HYV Aus rice is grown here and Hybrid is very absent. However, there is potential to HYV Aman rice cultivation. The low land use in saline area is mainly due to unfavorable soil salinity in dry season and unavailability of quality irrigation water (FGD & seeds dealer, Khontakata).

4.4 Erratic rainfall

Rainfall is one of the major climatic factors for crop production. All crops have critical stages when it needs water for their growth and development. Moreover excessive rainfall may occur flooding and water logging condition that also lead to crop loss. It is found that1mm increase in rainfall at vegetative, reproductive and ripening stages decreased Aman rice production by 0.036, 0.230 and 0.292 ton respectively (KII, UEO).

Variability of rainfall, uncertain dates of onset and recession of seasonal floods and risk of drought restrict cultivation of Aus and Aman rice. Uncertain rainfall delays sowing / transplanting and flood damages Aus and Aman crops. Heavy monsoon rainfall causes delay in transplanting of Aman. In the coastal saline belt with short winter season timely sowing/planting of Rabi (winter) crops is essential but this is restricted by late harvest of Aman rice. Many times late rainfall at the end of the rainy season causes great harm of vegetables in Robi season. The farmers cannot cultivate vegetables in due time because of rain water in their cropland due to climate change. For this reason the production of crop decreases day by day. The reason behind this is the changes in the behavior of climatic patterns. Continued wetness of soil due to erratic rainfall, and therefore the sowing time of the crops, is also affected. Various insects and diseases attack rice crops and vegetables (FGD & KII – Fertilizer dealer).

In order to reduce the loss burden, it may appear to be necessary to harvest premature standing crops (vegetables, spinach etc.) if there is a threat of such crops being inundated.

4.5 Increase of Cyclone and Storm Surge

Bangladesh is subject to devastating cyclones, originating over the Bay of Bengal, in the periods of April to May and September to November. Often accompanied by surging waves, these storms can cause great damage and loss of life. One of the reasons why it hits Bangladesh coast often is the conical shape of the Bay of Bengal. Over the last 50 years, 15 severe cyclones with wind speed ranging from 140 to 225 km/hr have hit the coastal area of Bangladesh of which 7 hit in pre-monsoon and rest in the post-monsoon season (FAO/GIEWS Global Watch, 2007). Tropical cyclones are the most talked about climatic events in the subcontinent especially in Bangladesh and India. The coastal area of Bangladesh is more vulnerable to cyclones in the Bay of Bengal Regions.

Cyclone cause huge damage to production of crop. Food and Agricultural Organization/GIEWS Global Watch (2007)16 reported at the time of the passage of cyclone SIDR, the main 2007 “Aman” rice crop, accounting for about 70% of the annual production in the most affected area, was nearing harvest.

By analyzing item wise crops data it was found that during SIDR (November 15, 2007) there was Aman crops and summer vegetables (Bitter gourd, pumpkin etc.) in the field. During summer farmers cultivate more land for Aman paddy and less amount of land for vegetables. Immediate before SIDR farmers cultivated 96% (184.79 hectares) land for Aman crops and 4% (8.34 hectares) of land for summer vegetables. On the other hand during Aila (May 29, 2009) farmers cultivated winter crops and at that time it was almost the end of winter harvesting. So, the farmers were taking preparation for Aman seed bed. At that time there was Boro paddy in some 21.62 hectares of land, seed beds and a total of 12.55 hectares of winter vegetables in the field. It was noticeable that land cultivation immediate before Aila was only about 18%; naturally the damage amount due to Aila was less than SIDR. As it was mentioned before that for salinity problem and scarcity of sweet water farmers could not bring their all arable land under winter Boro crops cultivation. But whatever farmers attempted in crop cultivation immediate before Aila, cyclone Aila destroyed everything.

Name of Union	Paddy cultivation			Vegetable Cultivation		
	Land (hectares)	Damaged		Land (hectares)	Damaged	
		Land (hectares)	Production (MT)		Land (hectares)	Production (MT)
Dhansagar	46.96	42.67	91.99	1.16	1.16	12.17
Khontakata	38.95	35.43	106.32	4.52	4.52	50.83
Rayenda	52.55	43.20	112.22	1.92	1.92	20.19
Southkhali	46.32	46.32	70.41	0.74	0.74	9.30
Total	184.78	167.61	379.94	8.34	8.34	92.49
percent		(91%)	(BDT 5.65 million)		(100%)	(BDT 122 million)

Table-4.1: Crops damage due to cyclone SIDR (Source: Alamgir Hossain, 2009)

Name of Union	Paddy Cultivation			Vegetable Cultivation		
	Land (hectares)	Damaged		Land (hectares)	Damaged	
		Land (hectares)	Production (MT)		Land (hectares)	Production (MT
Rayenda	10.87	9.30	39.30	4.84	4.29	26.30
Southkhali	7.89	7.89	43.57	1.55	1.55	6.20
Khontakata	2.45	2.45	1.21	2.15	2.15	18.5
Dhansagar	0.40	0.40	1.40	4.01	3.94	39.70
Total	21.61	20.04 (93%)	85.48 (BDT 1.45 million)	12.55	11.93 (95%)	(BDT 1.15 million)

Table-4.2: Crops damage due to cyclone Aila (Source: Alamgir Hossain, 2009)

Photograph 4.1: Affected people and crop land by cyclonic surge of Aila, (Alamgir Hossain, 2009). A disappointed mother is going to cyclone shelter with her children for safety during disaster (Aila) leaving all her assets.

4.6 Unusual trend in temperature

"Bangladesh Country Case" mentioned that the future changes of temperature and rainfall will put overall adverse impact, especially on crop production. Habibullah and others in their report "Assessment of food grain production loss due to climate induced soil salinity" mentioned that the impact of climate change in agriculture production and food security in Bangladesh predicted that high temperature will reduce yields of HYVs of ` Aus', `Aman', and `Boro' rice in all seasons and it is particularly evident at a 4°C rise. Under a moderate climate change scenario the crop loss due to salinity intrusion could be about 0.2 Mt.

Agriculture is the most vulnerable sector as its productivity totally depends on climatic factors.

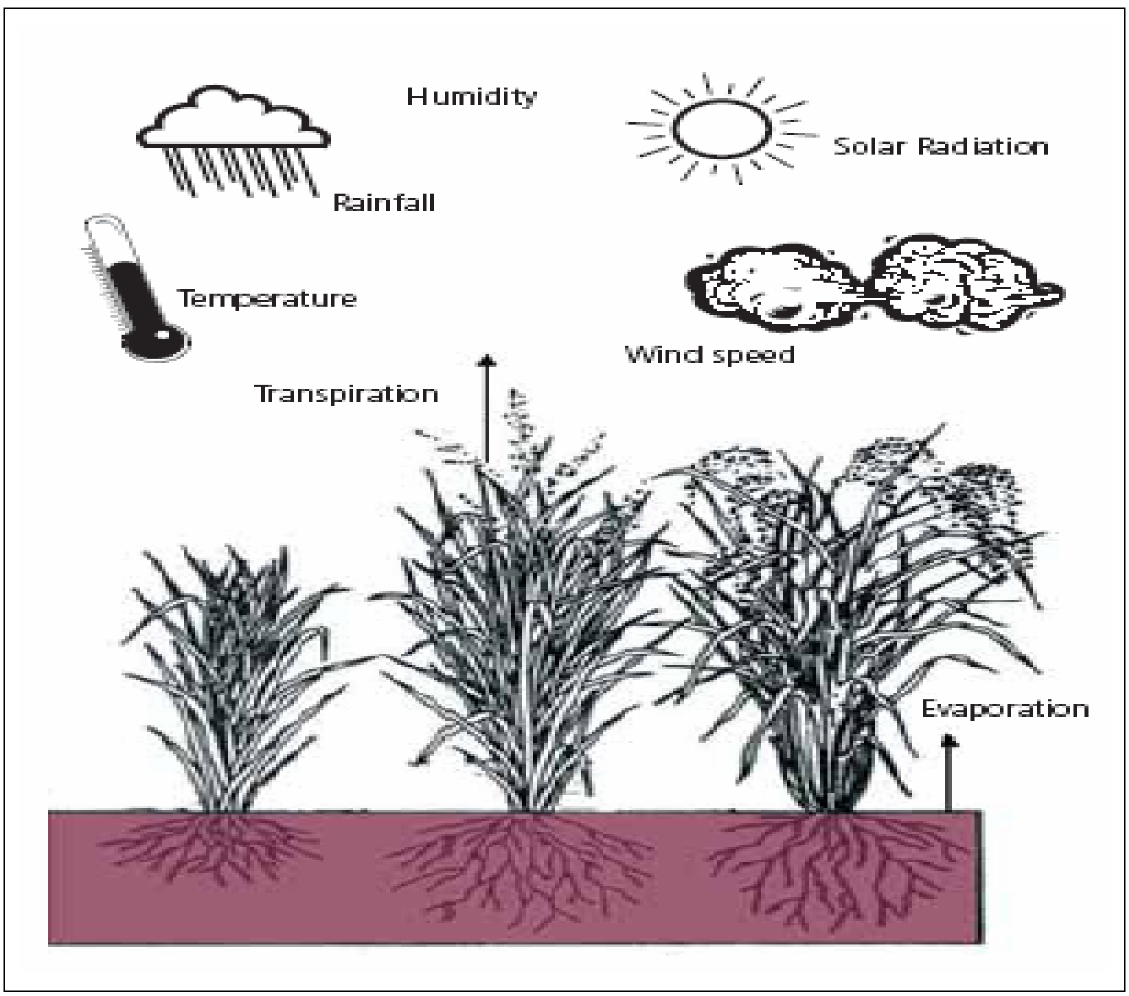


Figure 4.1: Climatic factors influencing crop production Source: UNISDR, 2007

The effect might be direct like change in temperature that might affect crop planting, flowering and harvesting time or slow but steady processes like degradation of land fertility, salinity intrusion, or increase in extreme weather events and other calamities.
Globally significant amount of agricultural production being lost every year because of different calamities derived from the above sources. With the change in temperature (by 20˚C and 40˚C), the prospect of growing wheat and potato would be severely impaired. Production loss may exceed 60% of the achievable yields. Higher temperature has negative effect on soil organic matter also (Karim 1996). If the temperature is high in dry season the farmer cannot cultivate the land lack of fresh water. During the dry season salinity in river water increases because temperature remains high.

4.7 Positive impact

The people of the area have been getting better results by cultivating the local rice varieties. The price of the local rice is always higher than the HYV because of its milling quality as well as its taste. It is also more environmentally sound because it requires less fertilizers and pesticides, thus also minimizing production costs. By practicing the Shrimp/Rice Farming System and selecting saline tolerant varieties, the people of the area have been getting more benefits from the same land by integrating local rice varieties with shrimp farming. It also has a positive impact on their society. The people become closer to each other by their activities of exchanging rice seeds and obtaining money when required.

Rainfall: Climate, thus, plays a crucial role in rice cultivation. Rainfall is one of the major climatic factors for crop production. All crops have critical stages when it needs water for their growth and development. Heavy rainfall is characteristic of Bangladesh causing it to flood every year. But the flood carries alluvial and make soil fertile. According to BRRI (1991), Aus rice requires supplementary irrigation during the initial stage of its growing season while Aman is almost completely rain-fed rice that grows in the months of monsoon, although it necessitates for supplementary irrigation during planting and sometimes in the flowering stage depending on the availability of rainwater. On the other hand, since Boro rice grows in the dry winter and the hot summer, it is thus completely irrigated (Mahmood, 1997). The variability in rainfall varies considerably among the three rice varieties.

Flood: Flood events can result in long-term benefits to agricultural production by recharging water resource storages, especially in drier, inland areas, and by rejuvenating soil fertility by silt deposition. In many natural systems, floods play an important role in maintaining key ecosystem functions and biodiversity. They link the river with the land surrounding it, recharge groundwater systems, fill wetlands, increase the connectivity between aquatic habitats, and move both sediment and nutrients around the landscape, and into the marine environment. For many species, floods trigger breeding events, migration, and dispersal. These natural systems are resilient to the effects of all but the largest floods.

The environmental benefits of flooding can also help the economy through things such as increased fish production, recharge of groundwater resources, and maintenance of recreational environments.

Areas that have been highly modified by human activity tend to suffer more deleterious effects from flooding. Floods tend to further degrade already degraded systems. Removal of vegetation in and around rivers, increased channel size, dams, levee bank and catchment clearing all work to degrade the hill-slopes, rivers and floodplains, and increase the erosion and transfer of both sediment and nutrients.

While cycling of sediments and nutrients is essential to a healthy system, too much sediment and nutrient entering a waterway has negative impacts on downstream water quality. Other negative effects include loss of habitat, dispersal of weed species, the release of pollutants, lower fish production, loss of wetlands function, and loss of recreational areas.

Many of our coastal resources, including fish and other forms of marine production, are dependent on the nutrients supplied from the land during floods. The negative effects of floodwaters on coastal marine environments are mainly due to the introduction of excess sediment and nutrients, and pollutants such as chemicals, heavy metals and debris. These can degrade aquatic habitats, lower water quality, reduce coastal production, and contaminate coastal food resources.

CHAPTER 5
ADAPTATION MEASURES TO CLIMATE CHANGE IMPACTS AND THE CHALLENGES

Adaptation to the adverse effects of climate change is vital in order to reduce the impacts of climate change that are happening now and increase resilience to future impacts. Community-based adaptation can greatly benefit from knowledge of local coping strategies. The secretariat has developed a local coping strategies database to facilitate the transfer of long-standing coping strategies and knowledge from communities which have adapted to specific hazards or climatic conditions, to communities which may just be starting to experience such conditions as a result of climate change. But farmers are facing more or less problem in the application of the adaptation. The specific adaptation and its challenges are given bellow.

5.1 Tolerant varieties

Farmers are now cultivating BR 11, BRRI 33, BINA 8, BRRI Dhan 47 and Aloron. They know that this variety is salinity tolerant rice variety for Aus and Boro season from UAEO and some NGOs (BRAC). The variety needs to be spread as fast as possible. The NARS will have to evolve varieties of crops (particularly rice) with the following characteristics:

• resistance to moderate flood levels,
• drought-resistance or low water consumption,
• salinity resistance— moderate,
• resistance to lodging in moderate storms, and
• suitability for cultivation in deep water areas.

Narrow technological and germplasm bases 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.

5.2 Short duration crops

Growth in crop agriculture and productivity depends finally on what the technology generation system in the country can deliver shorter maturity quality seeds. In each case, disease and pest resistance also have to be built in and proper agronomic practices developed for the optimal results. The conventional research method needs to be improved, and biotechnology research has to be encouraged for faster breeding and genetic improvement. Of course, there will have to be a proper regulatory system in such cases for risk assessment.

Develop shorter maturity varieties that can be harvested several weeks earlier than the normal harvest period, thus escaping the drier period. Farmers are shown interest to cultivate short variety crops to avoid frequent disease and better irrigation. Short yield varieties crops are high Yield Varieties (BRRI 49, BRRI 33). Aloron and BR 11 are much popular in the Aus season. Hybrid species are frequently cultivated in the Boro season. Varieties with such characteristics have been developed already, but more are needed to fit various ecological niches.

The farmers are not well trained. So they cannot cultivate crops in proper ways. They need training about it because they do not know how to cultivate such types of crops. For better cultivation seedlings need to transplant within 25-30 days. If they make delay to transplant, farmers will get less production which hampers their socioeconomic condition. They have to use more fertilizers for short duration.

5.3 Supply of quality seed

Key element of production for any crop is a reliable supply of inputs. This may require substantial expansion of capacity for seed multiplication as well as the establishment of a new system of seed collection, preservation, multiplication, certification, and regulation—not only for seeds developed in the conventional manner but also for genetically modified Information and Communication technologies and biotechnologically developed seeds. Quality seeds of various kinds of food crops and non-food crops should be preserved, multiplied, certified, and made available through large-scale dealership, in a public-private partnership system.

For seed preservation, farmers are using earthen jar or sack. After collecting the best quality seed, it is dried under the sun light and is put it into the jars with earthen plates and finally it is sealed with cow dung or clay. When the use sack, they just put the seeds inside and sewing the sack.

Contribution of private sector and NGOs to quality seed production is still insignificant because they lack costly seed preservation and processing facilities. They have to depend on BADC for seed processing. It may be noted that farmers' low quality seeds still meet about 95% seed requirement that is considered to be one of the major constraints to crop productivity (UAEO, KII). Bangladesh imports seeds of many varieties of seeds, almost all of which are hybrids and therefore, the import of such seeds is a recurrent process. Sometimes crops are raised from imported seeds without suitability studies. Often, crops from such seeds totally or partially fail; varieties of indigenous vegetables are usually poor in terms of productivity, uniformity, and quality, so it must develop our own varieties of both local and variety of seeds to assure a timely supply of quality seeds.

Since good quality seed is a prerequisite for good crop production, it must ensure a supply of quality seeds to grower. Non-availability of good seed is the biggest obstacle to increasing vegetable production in Sharankhola. There are no seed companies in this country. Even though the Bangladesh Agricultural Development Corporation supplies some quality seeds to growers, this does not satisfy more than 5 percent of the total requirement. There are many seeds merchants in the country who collect seeds from different sources to sell to the farmers. But with respect to quality, their seeds are not always reliable. Without other alternatives, many farmers continue to buy seeds from these merchants. A majority of the growers, however, use seeds collected from their own crop grown from unstandardized varieties of unknown description. Because of using unreliable seeds of improper or unknown description, many problems arise such as:

1. Total crop failure often occurs when early varieties are planted late. For example, buttoning in cauliflower is common when early varieties are planted late in the winter leading to total crop failure.
2. Crops mat fail due to seed borne disease.
3. Low yield is obtained when a variety is not genetically uniform in different characters
4. Low seed vigor at planting leads to poor germination and poor yield.

5.4 Crop diversification

In this region, there are introduced the change in cropping pattern. The people introduced new crop in their flood affected area. The newly practice crops are maize, high yielding variety rice, some commercial crop, etc have taken place of local rice and vegetables in place of mustard etc. In low rainfall people are supplying water in their paddy field from nearby canals and rivers by pumps. Alternative crop cultivations are practiced i.e. IRRI and Boro instead of Aus.

Diversification and specialization on of crop cultivation will reflect specific opportunities available to farmers: land availability, quality seed, extension services, and information and marketing services. If Aman yields become stable and improve over time, and if Boro yields also rise, farmers will release part of the land under Boro and put it under other Rabi crops, comprising most of the high value food and non-food cash crops. In some cases, farmers will need to be assured of stable rice prices if crop specialization is to be ensured. Non-rice crop specialization, particularly in problem soils, may not only ensure better use of land but may also mean higher income for farmers. In this case, awareness rising may be important, as farmers may not completely withdraw from rice due to subsistence considerations. While crop diversification and specialization may be useful strategies, they may not require completely new types of investments.

The land of Sharankhola is uneven so the farmers cannot make drainage system for irrigation for cultivable lands. They cannot bring their low land under cultivation due stagnant water during the rainy season and the rain water cannot pass away from the low land because there is not enough drainage system. That is why the farmers cannot cultivate the low land in time. The farmers grow low-yielding traditional rice (T.Aman) varieties only during the monsoon. Farmers cannot cultivate Aman paddy timely for untimely and late rain. It hampers crop rotation (cultivation of Maize, Sunflower, Potato, Mustard, Bitter Gourd, Wheat, Eggplant, Khesari, Bean, Tomato, Mung and Pumpkin) in timely manner. Traditionally after harvesting Aman paddy they indiscriminately use uncultivated land for feeding their cows. So small farmers cannot cultivate late variety due to cow feed practice discriminately which supposes to hamper their crops.

On the other hand in the dry (winter) season, the farmers cannot cultivate the high land lack of fresh water. Farmers practice Maize and Sunflower instead of Wheat. The Maize reduces the fertility of the soil. Some birds (Parrot, Dove) harm Sunflowers during the flowers and soil salinity make the roots rotten of the plants before blooming. No marketing facilities have been yet developed in Sharankhola. So farmers sell their products in very low price specially maize and sunflower. Crops (Bitter Gourd, Potato, Pumpkin and Eggplant) are mainly affected by some Bacteria, Virus and dense fog. Papri and Majra pests attack the leaves of the vegetables. It hampers the productivity of the particular crops. After the cyclone Sidr and Aila the farmers of Sharankhola become dependent on NGOs and Government for financial support. Fear of cyclone and storm surge is seen among the small growers. Sometimes they don't feel interest to continue their cultivation.

5.5 Storing of excess rainwater for irrigation

A part of the excess water stored in pond after meeting the requirements of the Kharif season can be utilized during the dry period for Rabi crops. Rain water is saline free water. If farmer stores it, it will help them in many ways. They can drink the reserve water, can use for irrigation and domestic work. In Sharankola Muslim Aids is seen people encouraging reserving rain water. Rain fed cultivation is very much cheaper and it decreases production rate.

Scarcity of quality irrigation water during dry season limits cultivation of Boro rice and Rabi (winter) crops, and Aus cultivation during kharif-1 (March-July) season. Conservation of rain water during monsoon is virtually non-existent that could be utilized for irrigating crops during dry season. Irrigation with surface water instead of underground water might reduce the vulnerability to hazards of climate change. Irrigation cost in Bangladesh is relatively high due mainly to high price of diesel. Crop yields are shrinking because of deeper saline intrusion due to a rising sea level of the Bay of Bengal. The impact of climate change on agriculture is undeniable and most certainly will worsen the situation if the government and donors fail to take suitable steps right now.

5.6 Fertilization and pesticides

There is a long-standing need for strong regulatory and certification mechanisms for ensuring quality of fertilizer and pesticides. Since, soils in general are poor in fertility with low organic matter content, it is necessary to apply appropriate fertilizers to boost up crop production. Potash fertilizer has an added advantage under soil salinity. It lowers down Na uptake by plants and of course increases K uptake. Thus K fertilization protects crops from harmful effects of Na.

Farmers normally use urea in recommended doses. Because of high prices, they apply P and K fertilizers at the rates that are far below the recommended amount. Chemical fertilizers are not normally integrated with organic manures. It is thus evident that farmers virtually do not use balanced fertilizers that are necessary for high productivity.

Fertilizers are too costly for most farmers. Today the use of insecticides on vegetables is negligible, and the use of herbicides has not yet started in the agricultural sector. Sometimes total crops fail due to attack by insect pests. Even under such a situation, an insecticide is nit used because of ignorance, unavailability of the required small amount of insecticide, lack of sprayer, high price and lack of application knowledge and danger of health hazards.

There are however a limited number of commercial crop growers who use both fertilizers and insecticides to reap a good harvest of quality produce. Due to a lack of knowledge about the safe time-lag between the last insecticide spray and consumption of the vegetables, it is often dangerous to eat the vegetable procured from these commercial growers. Unfortunately, the potential consumers are not generally aware of such danger.

5.7 Leveling of land

Land should be properly leveled to prevent accumulation of water in the low-lying patches with shallow ground water tables and to facilitate uniform drainage of excess water. It will help to apply irrigation water uniformly in the field in Rabi season, facilitate uniform germination of seeds and better growth of crops.

Perennial water-logging due to inadequate drainage and faulty operation of sluice gate facilities restricts potential land use of the low lands within the embankment areas.

5.8 Innovative farming practices

Some farmers are trying to cultivate innovative farming practice in their homestead and around the Gher (shrimp cultivation). They cultivate vegetables with supported by bamboo pillars inside the Gher. They do it to fulfill their domestic demand of vegetables. They grow there Pumpkin, Pumpkin Gourd, Bean, Bitter Gourd, Cucumber and Borbati. Some innovation farming practices for non-rice crops that will help to escape salinity.

As farmers cultivate the vegetables in small scale so they cannot use pesticide regularly. So most of the times leaves remain shrink which hampers production.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

Introduction of the high yielding salt tolerant variety BR 11, BRRI 33, BINA 8, BRRI dhan 47 and Aloron could produce sustainable grain yield in the coastal regions.

T. Aman season is a safe rice-growing season in the coastal area. There was no salinity impact on rice production due to the high rainfall that occurred during this season. But in the later part, when the rainfall ceased, it was assumed that the soil salinity might increase and go beyond the safe limit of rice crop (4 dS/m). So, salt tolerant T. Aman varieties like BR23, BRRI dhan 40 and BRRI dhan 41 may be the solution to overcome the salinity impact at later stage of crop growth.

The existing cropping pattern is Fallow-T.Aman (Local)-Fallow and Fallow-T.Aman (Local) - Boro (HYV). These patterns may be changed like Okra (Dharosh)-T. Aman – Boro (HYV) or Okra (Dharosh)-T.Aman-Tomato.

Non-rice Rabi crops hold a poor position in the agriculture of Sharankhola. As a result crop diversification is restricted. Tomato, Okra and Aroids could be grown successfully under improved management practices with raised bed and mulch in the medium saline soils of Sharankhola.

Climate change poses significant challenges to agricultural sector (crop production) and therefore to livelihoods and the country's overall economic development. Adverse impacts include increased soil salinity, saline water intrusion and massive declines in rice and wheat production, which are induced by an overall warmer, wetter and less predictable climate. New weather conditions will be particularly characterized by a rise in precipitation and sea levels, whereas extreme events such as floods, droughts and cyclones are also going to occur more frequently.

Climate variability and change devastate the predominant income source of the locals. Currently, farmers of Sharankhola (study area) can apply two main coping mechanisms to counter these developments: digging canals (khals) for freshwater reservation and cultivating saline-resistant crops. The majority of farmers prefer the latter option as the other option is beyond the affordable to marginal and small-scale farmers. Several barriers to effective adaptation have been identified through the study, including the lack of: freshwater, quality seeds, capacity building, and training for farmers. Furthermore, inorganic fertilizers and pesticides are found to be too expensive and thus are not applied to the required extent. On the other hand, farmers are hardly seen using organic fertilizer and pesticides due to their lack of knowledge and skill. The impact of climate change on agriculture is undeniable and will most certainly worsen if governments and donors fail to take suitable steps right now. Bangladesh urgently needs support to develop climate-resilient agriculture for its people to survive and prosper in the long term.

Adoption of modern rice varieties in Kahrif season is very low. The farmers need improved varieties of Aus, T. Aman and minor Rabi crops purposively suitable for coastal area. Drought resistant and saline tolerant crops like barley, triticale and other suitable pulse crops could be tried to grow for feed as well as food. Rapid expansion programme of BRRIdhan 27 in Aus Season and BR 22, BR23, BRRIdhan 40 and BRRIdhan 41 in Aman season should continue. Regional trial for searching new genotypes should strengthen.

However, sectoral cooperation and coordination is required for the success. A balance is to be maintained among the quality & quantity of food produced, maintaining sustainability of the environment and natural resources.

To address the impact of climate change and its adaptation, the following things should be considered as the major focus:

1. A specific agricultural development plan based on costal livelihoods, ecosystem and economy should be introduced to create awareness in the community as well as national and international level.

2. Enhanced capacity building for government and non-government authorities, as well as restructuring existing institutional frameworks in order to make them more capable of responding to the challenges imposed by climate change, are essential and would facilitate the effective implementation of activities. In addition, coordination and communication among the respective governmental agencies has to be improved.

3. The implementation of a follow-up mechanism consisting of monitoring and evaluation procedures is also required in terms of efficiently scaling up project initiatives

on climate change adaptation. An independent body comprising government and non-government representatives and topical experts operating in both national and sub-national administrative structures should conduct this.

4. Many farmers are currently using their traditional knowledge to cope with changes in climatic patterns. In order to achieve more efficient results regarding adaptation and benefit sharing, these local measures should be combined with advanced, scientifically-tested techniques, however. Thus, the information about new technologies and farming practices needs to be disseminated on a wider scale, for instance through farmer training programmes.

5. The fact that costs of using climate-smart varieties are approximately equal to those of traditional ones makes the adoption of new varieties favourable and facilitates the climate change adaptation process.

6. Suggested innovative farming practices should be promoted for large scale adoption in vulnerable areas for increasing production, income generation and livelihood improvement of the people living in those areas.

7. More innovative farming practices/technologies should be developed tested and adopted through on-farm trials and location-specific production programs involving farmers, researchers and extension personnel.

8. Improvement in the crop-based weather and flood forecasting systems, early warning system, improving drainage, cultivating adaptive crops, developing technology for floating bed agriculture, rice and fish culture and organized fisheries, etc. are some of the options for water logged areas.

9. Concept of food safety and the use of GM (Genetically Modified) technologies also deserve due attention as far as the health of the consumers are concerned.

10. Soil testing center should be established for measuring the intensity of salinity and its adaptation and practices.

11. Awareness raising program on environmental pollution issues should be introduced so that community can keep freshwater reservoirs and cannels clean.

12. Community based forestation can be introduced on the protective embankment.

13. Construction of sluice gate in the appropriate point of the protective embankment is necessary to remove excess water and prevent ingress of saline water during high tide.

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Appendix

FGD Guideline

1. Do you know about climate?

2. Can you tell anything about climate change?

3. What types of disasters usually happen here?

4. What types of disasters do you usually face in your locality?

5. Why does disaster happen and when? Or can you tell the causes of disaster?

6. What is the impact of climate change on cropping?

7. What types of crops are usually found in the disaster period?

8. Is there any problem you notice due to saline water? If yes, how do you overcome it?

9. Do you cultivate any saline tolerant variety? Can you name some paddy varieties which are saline tolerant?

10. What types of paddy varieties do you cultivate in Aush, Amon and Boro? What challenges do you face in cultivation due to climate change?

11. Do you have reservoir of sweet water for irrigation?

12. What type of crops do you cultivate using cannel water?

13. How do mitigate disasters?

14. What types of problems do you face due to irregular rain pattern?

15. What new varieties do you cultivate due to climate change?

16. What types of disease do you face in cultivation?

17. How do you overcome diseases? What types of pesticides do you prefer and Why?

18. Is there any change in using fertilizer?