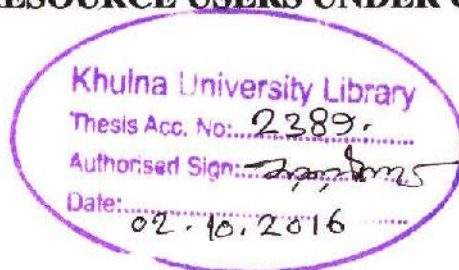


**ONGOING ADAPTATION MEASURES OF THE SUNDARBAN
MANGROVE RESOURCE USERS UNDER CHANGING CLIMATE**



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Examination Roll No: MS-130619



Fisheries and Marine Resource Technology Discipline

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April, 2014

**ONGOING ADAPTATION MEASURES OF THE SUNDARBAN
MANGROVE RESOURCE USERS UNDER CHANGING CLIMATE**

A Thesis

By

Anup Kumar Paul

Examination Roll No: MS-130619

Session: 2012-2013

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

In

Coastal and Marine Science

Fisheries and Marine Resource Technology Discipline

Khulna University

Khulna

April, 2014

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Approved as to the style and content by



A handwritten signature in black ink, appearing to read "Ayaz Hasan Chisty", written over a horizontal line.

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Declaration

Ongoing adaptation measures of the Sundarban mangrove resource users under changing climate

The results presented in the thesis with the above mentioned title are entirely of the candidate's own investigations and no part of the results has been accepted for any degree nor is it being concurrently submitted for any degree.

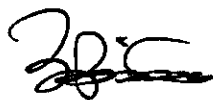


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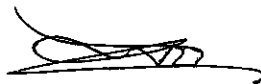
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DEDICATED

TO

MY BELOVED PARENTS





Acknowledgement

All praises are due to Omnipotent, Omniscient and Omnipresent God who enables me to pursue my education in Fisheries Science and to complete the research as well as submit the thesis for the degree of Master of Science in Coastal and Marine Science.

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Anup Kumar Paul

ABSTRACT

Sundarban, the largest mangrove is full of resources such as fish, crustacean, mollusk, shrimp, wooden trees, herbs, honey, golpata etc. Local peoples directly or indirectly depend on those valuable resources. Climate change affects the ecosystem of Sundarban. The resource dependents are vulnerable with climate change. An attempt was made to perceive the adaptation measures of the Sundarban mangrove resource users under changing climate. The study was conducted in different points of Sundarban mangrove forest. The study covered the environmental impacts, livelihood conditions, adaptation mechanisms of the resource users. One hundred and fifty resource users were randomly selected from Sundarban west, Shyamnagar upazila, Satkhira and interviewed with a structured questionnaire from July 2013 to March 2014. Data interpretation showed that the fishermen, wood cutters, honey collectors, golpata collectors, shrimp PL collectors and others were in the range of 20-above 80 years and had been fishing, woods cutting, honey collecting, golpata collecting, PL collecting for their livelihood. They mentioned that the abundance of fishes, fuel woods, honey, golpata and shrimp PL was reduced considerably since few years ago. Majority of them reported caused behind the changes as less rain fall, high salinity, high temperature, siltation of water bodies, intensity of drought and irregular seasonal variation. The resource users adapt themselves by changing their occupation (29.3 %) and 3.3 % respondents were almost work less, depend on other people of their family. Among the 29.3% occupation changed people, 6.7 % is day labor, 4.7 % brick worker, 4 % motor cycle driver, 3.3 % patty business, 3.3 % building maker, 2.7 % construction worker, 2.7 % carpenter and 2.0 % fish farmer. About 2.7 % people mentioned that their families members migrate towards town, 10 % people produce saline tolerant rice (BARI dhan 40, 41, BINA Dhan 7), fish (Tilapia, koi), carrot, sugar beat. About 10.7 % respondents are engaged in golpata collection, 8 %, 7.3 %, 6 % and 5.3 % respondent is engaged in PL collection, honey collection, shrimp culture and wood collection respectively. About 7.3 % Women are participated in work homestead gardening (4 %) and salt cultivation (2.7 %). About 36 %, 33.3 %, 17.4 %, 11.3 % and 2 % resource users followed the above adaptation mechanism to adapt cyclone, flood, salinity intrusion, river erosion and drought respectively. The study mentioned the climate hazards and ongoing adaptation measures of the Sundarban mangrove resource dependent peoples with climate change.

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CHAPTER I
INTRODUCTION

Introduction

1.1 Background of the study

The Sundarbans is the largest mangrove forest in the world where about 300 species of trees and herbs and about 425 species of wildlife including the Royal Bengal Tiger exist. The Sundarbans, also a World Heritage Site, covers about 4.2 % of the total Bangladesh where forests cover only 10.2 % of the land area. It is located at the south-western part of the country, lying between longitude 89° and 90° east and latitude 21° 30' and 22° 30' north. This mangrove forest generally bears the salt-tolerant forest ecosystem excepting some amongst which about 856.7 million Sundari (*Heritiera fomes*) trees are less salt-tolerant. These trees are now on the verge of extinction primarily due to suffering from top-dying disease caused mainly due to increasing salinity in surrounding waters. The Sundarbans has an extreme length along the sea face of the Bay of Bengal stretching about 165 miles starting from the Baleswar river in Bangladesh to the Hugli river in India.

Categorized as “Reserved Forest” the Sundarbans is very important for being the source of forestry products and fish that enrich the local and national economy, as well as for being the protector from the heavy ravages of periodical cyclones and tidal surges originating from the sea. According to an ESCAP survey, 0.5 million to 0.6 million people depend directly on the Sundarbans for their livelihood (Gain, 2002).

Mangrove wetlands act as a barrier against cyclones, avoid coastal erosion and provide nursery grounds for a number of commercially important fish, prawns and crabs. Some of these mangrove wetlands play an important role in enhancing the fishery production of the adjacent neritic waters by exporting organic and inorganic nutrients (Alongi, *et al.*, 1992). The environmental setting of this multiple-use ecosystem is governed by physical forces such as geomorphology of the coast, climate, tidal amplitude and duration, and quantity of freshwater inflow (Blasco, 1984).

Water related impacts of climate change will likely be the most critical for Bangladesh – largely related to coastal and riverine flooding, but also enhanced possibility of winter drought in certain areas. The effects of increased flooding resulting from climate change will be the greatest problem faced by Bangladesh. Both coastal flooding (from sea and river water), and inland flooding (river/ rain water) are expected to increase.

At present four major types of livelihood activities are practiced, such as Agriculture, Fishery, Wood Collection, and Honey Collection. Approximately 65% of the total

populations are dependent on agriculture based economy. Paddy, Potato, Green Chili, Pumpkins etc. are the major crops. Fishing activities are prevalent at various scales in the Sundarbans catering to livelihoods amongst 15% of the population. Organized large scale fishing activity occurs in sea and deep water. Small scale fishing activity in the delta region (half of them are illegal). Micro scale fishing activity in the shallow river bed is operated mainly to collect the prawns/shrimps post larvae. Approximately 3% of the total population involved with honey collection. Approximately 5% of the total population involved with wood collection. (Sengupta, *et al.*, 2003)

The Sundarbans plays an important role in the economy of the southwestern region of Bangladesh as well as in the national economy. It is the single largest source of forest produce in the country. The forest provides raw materials for wood based industries. In addition to traditional forest produce like timber, fuel wood, pulpwood etc., large scale harvest of non-wood forest products such as thatching materials, honey, bees-wax, fish, and crustacean and mollusk resources of the forest takes place regularly. The vegetated tidal lands of the Sundarbans also functions as an essential habitat, produce nutrients and purifies water. The forest also traps nutrient and sediment, acts as a storm barrier, shore stabilizer and energy storage unit. Last but not the least, the Sunderbans provides a wonderful aesthetic attraction for local and foreign tourists.

Constituting 51% of the total reserved forest estate of Bangladesh, it contributes about 41% of total forest revenue and accounts for about 45% of all timber and fuel wood output of the country. A number of industries (e.g. newsprint mill, match factory, hardboard, boat building, furniture making) are based on the raw materials obtained from the Sundarbans ecosystem. Various non-timber forest product and plantations help generate considerable employment and income generation opportunities for at least half a million poor coastal population. It also provides natural protection to life and properties of the coastal population in the cyclone prone Bangladesh. (FAO, 1995).

Climate change due to global warming is predicted to cause an annual temperature rise of 0.4 degrees Celsius in Bangladesh and result in greater frequency and intensity of cyclonic storms. The sea level is also predicted to rise by 4 millimeters every year. These phenomena will result in an increase in salinity and a decrease in the sweet water flow in the Sundarbans and hence will destroy major forest resources. Climate change creates resource shortages and

unreliable job markets that lead to the increased migration of men, leaving women alone with additional agricultural and households duties.

1.2 Objectives of the study

The study has been conducted to know the following objectives:

- To identify the impact of climate change on the Sundarbans mangrove forest;
- To find out the adaptation measures taken by resource users of Sundarbans.

CHAPTER II
LITERATURE REVIEW

Literature review

2. Review of literature

Barua, *et al.*, 2010 carried out research on climate change and its risk reduction by mangrove ecosystem of Bangladesh. This paper discusses about the possible impact of climate change through tropical cyclones, storm surges, coastal erosion and sea level rise in the coastal community of Bangladesh and how they cope with these extreme events by the help of mangrove ecosystem. Mangrove ecosystem provides both goods and services for coastal community, helps to improve livelihood options and protect them from natural disaster by providing variety of environmental support.

Chowdhury, 2010 carried out a study on resource-dependent livelihoods in the Sundarbans. It is observed that People living within or near the Sundarbans mostly depend on its resources to satisfy many of their basic needs, such as food, fuel, materials for construction of houses, boats, furniture and fishing implements, medicinal herbs and many other items for trade and commerce. Some people, however, extract resources beyond their needs. Due to misuse and mistrading the natural resources are decreasing. There is a clear scope for gentle regulation, in the interest of the very people who depend on the resources. One observation was a surprisingly low awareness of the resource dependency and the resource utilization implications. An improved awareness seems a viable measure, given the fair literacy and education level. Another observation was an apparent attractive scope for introduction of alternative or supplementary livelihoods and income generation, including involvement by the female part of the population.

Chowdhury, *et al.*, 2010 carried out a study named climate change and its impact on fisheries resource in Bangladesh. The paper represents that Climate change affects the rainy season, increases the precipitation, creates the flood, and increases the fish habitat and if we take the proper adaptation method, it will boost up the production of inland capture fisheries. In coastal area, soil-water salinity and sea level rises have both positive and negative effect. Soil-water salinity and sea level rises may increase the shrimp and other brackish water fish and shell fish culture area, which will increase the production of high value fish products. Climate changes also

affects the Sundarbans, the world largest mangrove forest, resulting the loss of nursery ground of many marine fish species and also abolish them. As a consequence of climate change, pH change, temperature increase may affect the marine fish species and also increase the occurrences of intensive tropical cyclone and surge in the Bay of Bengal.

The intergovernmental panel on climate change (IPCC, 2007) reported that atmospheric temperature would rise by 1.8-4⁰ C globally by 2100. This warming would be accompanied by rising sea temperature, changing sea levels, increase acidification of sea, altered rainfall patterns and river flow and higher incidence of extreme weather events. A report by UNESCO, named Case Studies on Climate Change and World Heritage has stated that an anthropogenic 45-cm rise in sea level, combined with other forms of anthropogenic stress on the Sundarbans, could lead to the destruction of 75 % of the Sundarbans mangroves.

A 45 cm sea level rise would inundate 75% of the Sundarbans, and 67 cm sea level rise could inundate all of the system. Extrapolating from this information Smith et al., 1998 calculated that a 25 cm sea level rise would result in a 40% mangrove loss.

The accumulation of sediment by the roots in mangrove forests also helps build land mass. Mangrove vegetation can alter topography and bathymetry through the process of sedimentation; reduce the vulnerability of the landscape to inundation due to sea level rise. Further, mangroves promote clear water by filtering and assimilating pollutants. It seems clear that in regions of the coast where extensive mangrove forests exist, they will help ameliorate the impacts of the climate change (Hossain, 2009).

Masum, 2012 carried out a study named climate change impact on the poor people of the Sundarbans community in Bangladesh. He reported that majority (80.1 %) of the poor household heads of the Sundarbans community are farmer (34.4 %), day laborer (21.6 %), housewife (14.0 %), and small business (10.1 %). A notable portion (6.3 %) of the household heads is not doing anything. The occurrences of natural calamities (cyclones, tornadoes and tidal bores), water scarcity and salinity, river erosion are identified as the main causes of livelihood insecurity and

food insecurity. According to the one-third of the poor households, climate changes already have negative impact on access to food (33.2 %), availability of food (32.4 %) and livelihood (34.4 %). Nearly four-fifth (79.0 %) of the community reported to rely on dry food during disaster period. One-tenth (9.6 %) of the poor households depend on whatever is available to survive. Besides, more than half (53.5 %) the poor households are unable to preserve/store any surplus food for the disaster period due to lack of option for storage or preservation of food in their household. About 83.9 % of the poor households of the Sundarbans community reported that rainfall has reduced significantly due to climate change. More than two-fifth (43.1 %) poor households have experienced inundation of their household due to flood and more than half (56.0 %) reported about flood at the surroundings of their household. More than one-fourth (27.0 %) experienced the increasing trend of temperature or sweltering hot than before.

Ahmed, 2003 carried out a study named climate variability and flood: climate variability and flood: observed coping mechanisms in Bangladesh. The poor people of Bangladesh have coped with climate related disasters many times understanding such local and national level coping mechanisms provides valuable insights into management of future high intensity extreme climatic events. Living in a flood-prone area is a risky affair that requires a high degree of adaptation to climate variability. Traditionally, the Bangladeshi poor people have learned to live with floods. Rural population no longer considers a moderate flood as a cause of concern. With limited institutional support, they have successfully coped with very high intensity floods in the recent past.

Alam, *et al.*, 2005 carried out a study named facing up to climate change in south Asia. This paper provides an overview of the likely impacts of climate change in three least developed countries in South Asia: Bangladesh, Bhutan and Nepal. In these countries, climate change will include changes in temperature, distribution of rainfall, sea-level rise and increase in the frequency and intensity of extreme weather events. These least developed countries are at risk because of their high vulnerability and low adaptive capacity. Weak economies, inadequate infrastructure, poor social development, lack of institutional capacity and high dependence on natural resources all contribute to this vulnerability.

Chadwick, *et al.*, 1997 carried out a study named from flood to scarcity of water: re-defining the water debate in Bangladesh. The paper report that various coping strategies have been developed to deal with the problems associated with lack of monsoon flood waters. Farmers with higher land have adapted new cropping patterns and now tend to plant crops such as sugarcane, bananas and timber that require less water where they previously grew rice. Fishermen and part-time fishermen now have to go further a field to fish and tend to be concentrated on fewer water bodies, adding to competition for ever declining fish stocks and leading to disputes between village communities and professional and part-time fisher folk. Several professional fisher folk appear to have given up and switched primary livelihood activities, with many becoming fish traders and buying in fish from elsewhere. Others have abandoned fishing completely and own small shops and tea stalls or operate cycle rickshaws.

CHAPTER III
MATERIALS AND METHODS

Materials and Methods

This chapter deals with the materials and methods that were followed to achieve the objectives of the study including selection of the study site, target groups, Sundarbans resource users, tools of data processing and analysis.

3.1 Description of the study area

The study area were selected for the present study on the basis of following reasons-

Sundarban is one of the disaster prone areas in Bangladesh. Climate change affects the Sundarban largely on various ways. The resource users are the direct victim of climate change. So to achieve the study objectives these spots were selected.

To carry out the present study different spots in Sundarbans mangrove forest were selected. The study area covered Sundarban west, Shyamnagar upazila, Satkhira in Bangladesh.

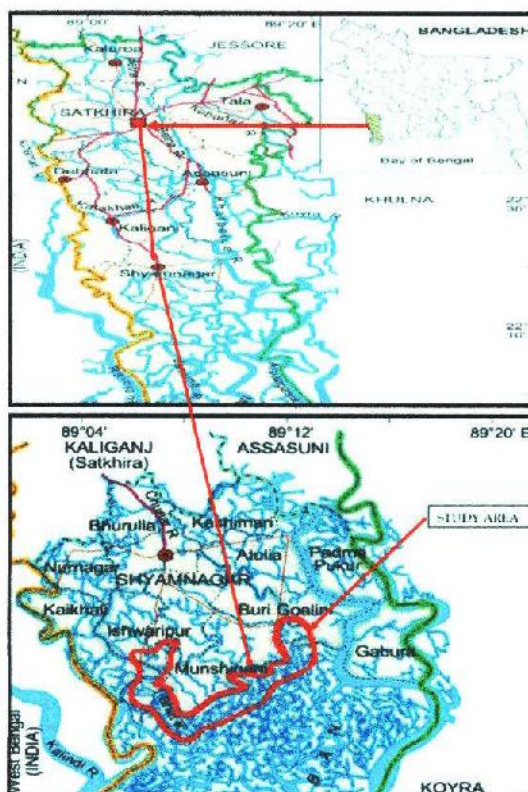


Figure 3.1 Map showing the study area

3.2 Study period

The study was conducted for a period of 9 months from July, 2013 to March 2014.

3.3 Target group

A large number of fishermen, honey collectors, golpata collectors, wood cutter and resource harvesters are involved as resource collection. Their livelihood usually depends on resources of Sundarban. They always face challenges of climate change, which directly or indirectly affects their livelihood. For survival they have to require adaptation. So the resource users were the target group for this study.

3.4 Sampling frame and size of sample

Every research needs a standard sampling frame. The sample size of this study was 150. These 150 samples consist of both male and female respondents of the selected areas. The respondents are basically climate change-induced vulnerable people. Besides the individual interview, five focus group discussion (FGD) had been performed.

3.5 Survey method

The aim and objectives of the study depend upon the survey. The survey was completed through 6 times individual field visit. During the visit 150 respondents were interviewed individually.

3.5 Questionnaire preparation and pre-testing

For data collection from resource users a questionnaire was prepared in accordance with the objectives set for the study. Before preparing the questionnaire, a draft questionnaire was developed and then tested in the study area. The questionnaire was then changed, modified and rearranged according to the experience gathered in the testing. The final questionnaire was then developed in logical sequence so that the resource users could answer chronologically. Questionnaire was constructed English and translated to Bengali during face to face interview.

3.6 Data collection

In order to collect relevant data the interview technique i.e, primary data were collected directly from the fishermen, honey collectors, wood cutters, golpata collectors and other resource users.

Six times visit were made during study period. After each and every visit the collected data were checked for accuracy and clarity. The questionnaire is shown in Appendix I.

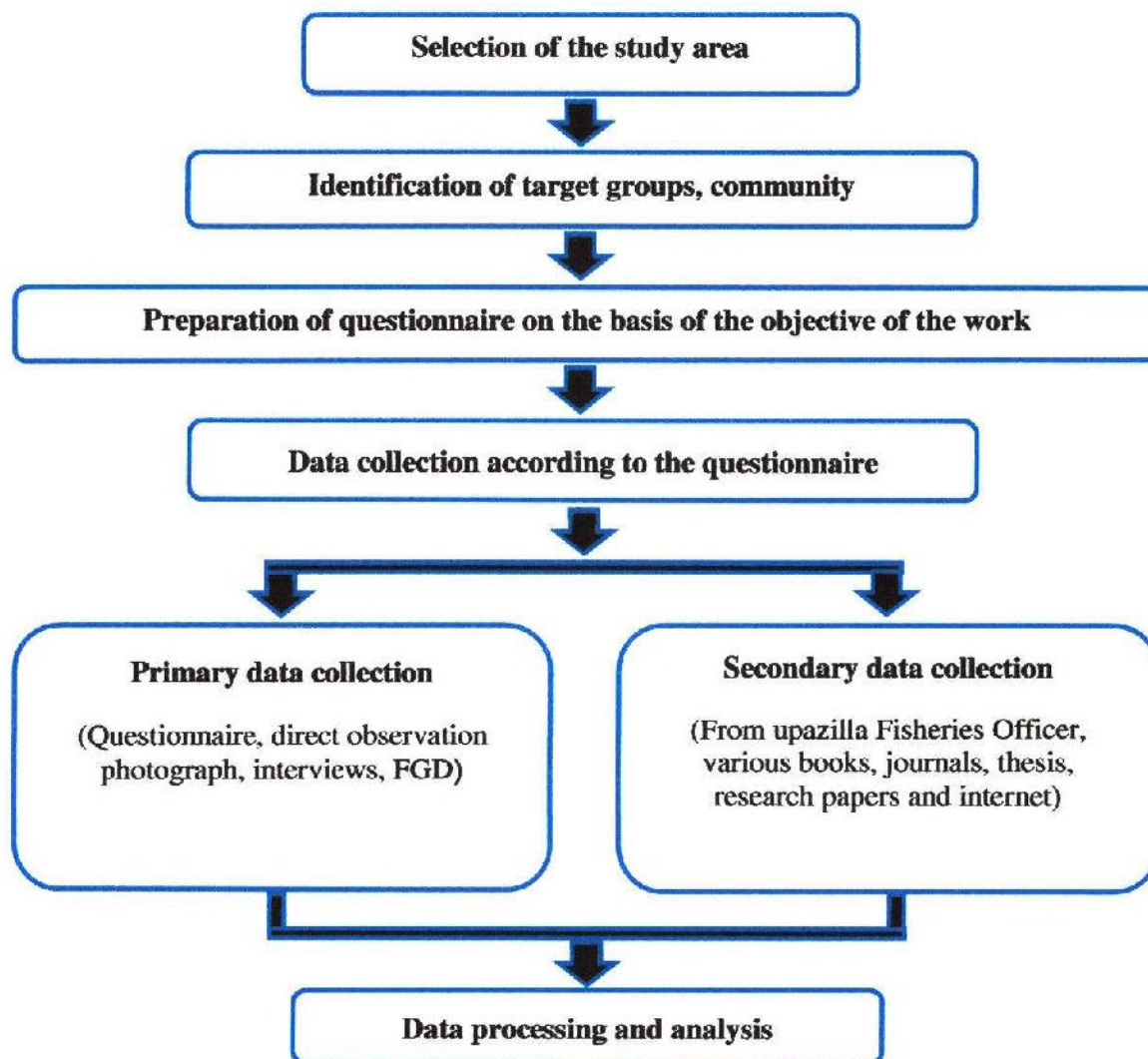


Fig 3.2.Methodology used for data collection.

3.6.1 Questionnaire interviews

Both quantitative and qualitative information was gathered through formal interviews with participants from each spots using a well define and pre-tested questionnaire. Major sections of the questionnaire were climate change impact and adaptation mechanism of the resource users. The interview was conducted in suitable places.

3.6.2 Focus Group Discussion (FGD)

Focus Group Discussion (FGD) was conducted with the mangrove resource users to acquire some information which were lack in the questionnaire interview. FGD is a group meeting where the target communities discuss selected points. In this research, FGD was used to get an overview of climate change indications, their livelihood and socio-economic condition, condition of resources, their adaptation measures etc.

3.7 Secondary data collection

Secondary information regarding climate change impacts over the last few years and adaptation measures that are being practiced were collected from different GOs such as Bangladesh Bureau of statistics (BBS), upazila fisheries office (Shyamnagar), Bangladesh forest department, NGOs like BRAC, Prodipan, DSK, Practical Action, Shushilon and DFID. Some data were collected from journals, research papers, thesis papers and internet.

3.8 Summarization, tabulation and reliability of data

After collection of data from the field, data were recorded in master table sheets. After completion of the pre-tabulation task, actual tabulation work was started. A number of tables were prepared on the basis of aims and objectives of the study. Finally, tabulated data were analyzed and condensed by using averages, percentages etc. to obtain the results.

3.9 Data processing and analysis

After collection of data, these were edited and coded by using Microsoft Excel-2007 and IBM SPSS Statistics 20 software. All the collected data were summarized and scrutinized carefully and recorded. Finally relevant tables were prepared in accordance with the objectives of the study. Data presented in tabular and graphical form because it is simple in calculation, widely used and easy to understand.

CHAPTER IV
RESULTS

Results

This chapter describes the results concerning impacts of climate change and ongoing adaptation measures of the Sundarban resource users.

The study is conducted in male (75.3 %) and female (24.7 %). The age structures of the respondents are 20-30 years (10 %), 31-50 years (43.3 %), 51-80 years (35.3 %), and above 80 years (11.3 %). Most of the respondents are muslim (76.0 %) and others are hindu (24.0 %).

4.1. Climate change hazard

Sundarban is prone to climate change hazard. The Sundarban's resource users were interviewed to know about 30 year's climate changing hazards which are shown in Table 4.1 and Figure 4.1. Respondents were faced cyclone (34 %), flood (6 %), drought (1 %), river erosion (2 %), salinity intrusion (5 %) and 52 % faced multiple hazard (such as cyclone, flood, salinity intrusion etc).

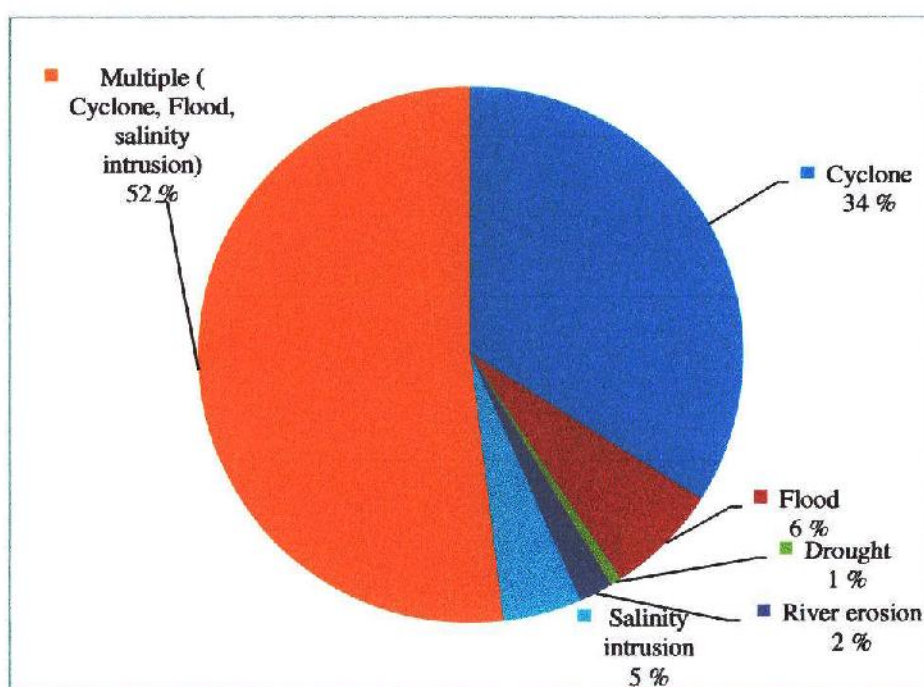


Figure 4.1 Climate change hazards of Sundarban



4.2. Dangerous natural disasters

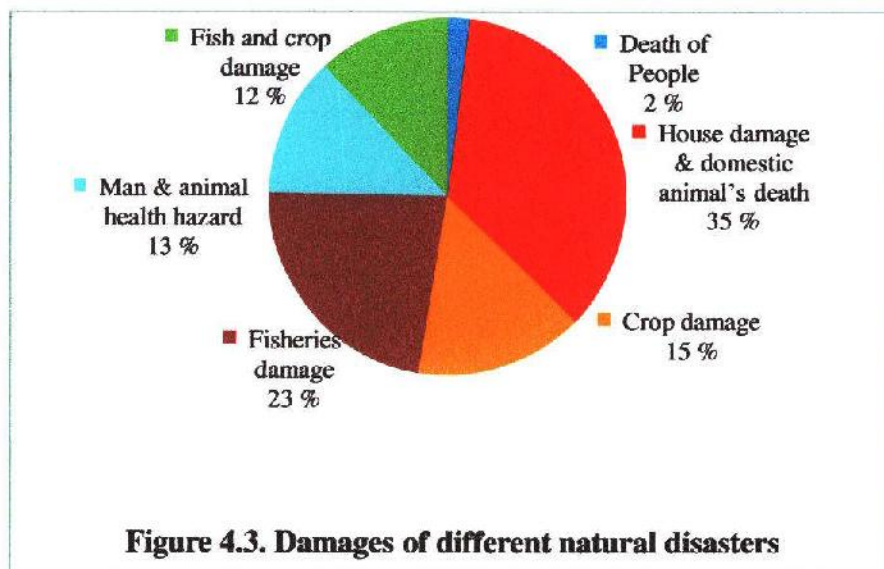
Disasters which affect more are represented in Table 4.2. Most of the respondents (39.3 %) reported that Aila was more dangerous, 22 % reported Sidr, 18 % reported cyclone of 1988, 15 % reported flood of 1998, 4.7 % reported cyclone of 1996 and 1 % reported cyclone of 1991 were very dangerous.

Table 4.2. Experience of the people with dangerous disasters

Year of Disaster occurrence	No. of respondent	Respondent (%)
24-27 November, 1988	27	18.0
April, 1991	1	1
1996	7	4.7
19-22 November, 1998	23	15
15 November, 2007 (Sidr)	33	22
27 May, 2009 (Aila)	59	39.3
<i>Total</i>	<i>150</i>	<i>100.0</i>

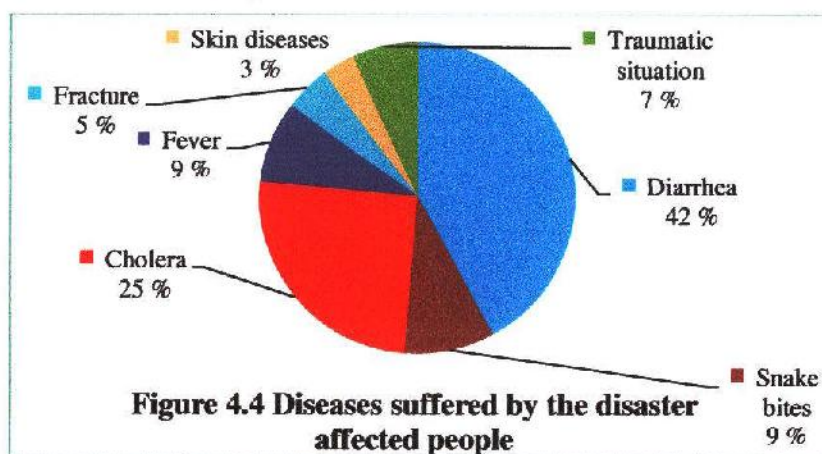
4.3. Damages of natural disasters

Resource dependent peoples had experienced many disasters and their damages. The damages are represented in Table 4.3 and Figure 4.3. The present study revealed that respondent experienced death of people (2 %), house damage and death of domestic animals (35.3 %), damage of crop (15.3 %), damages of fisheries (22.7 %), death of man, animal and house damage (12.7 %), and damage of fish and crops (12 %).



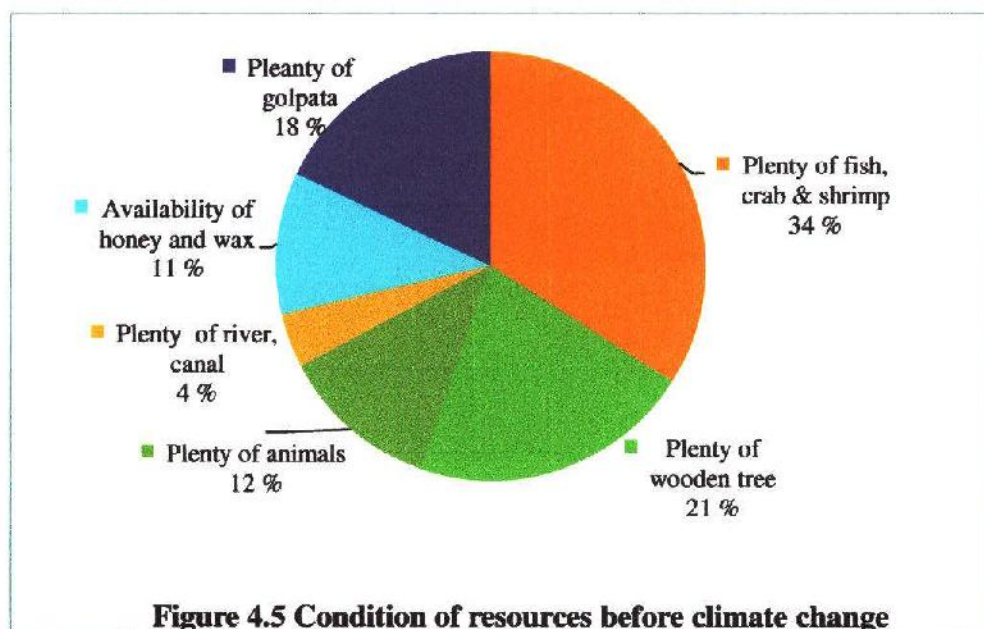
4.4. Condition of health

Disease outbreak is a common matter after a disaster had occurred. The condition of human health is showed in Table 4.4 and Figure 4.4. It is reported that 42 % suffered from diarrhea, 25 % cholera, and 3 % suffered by skin disease.



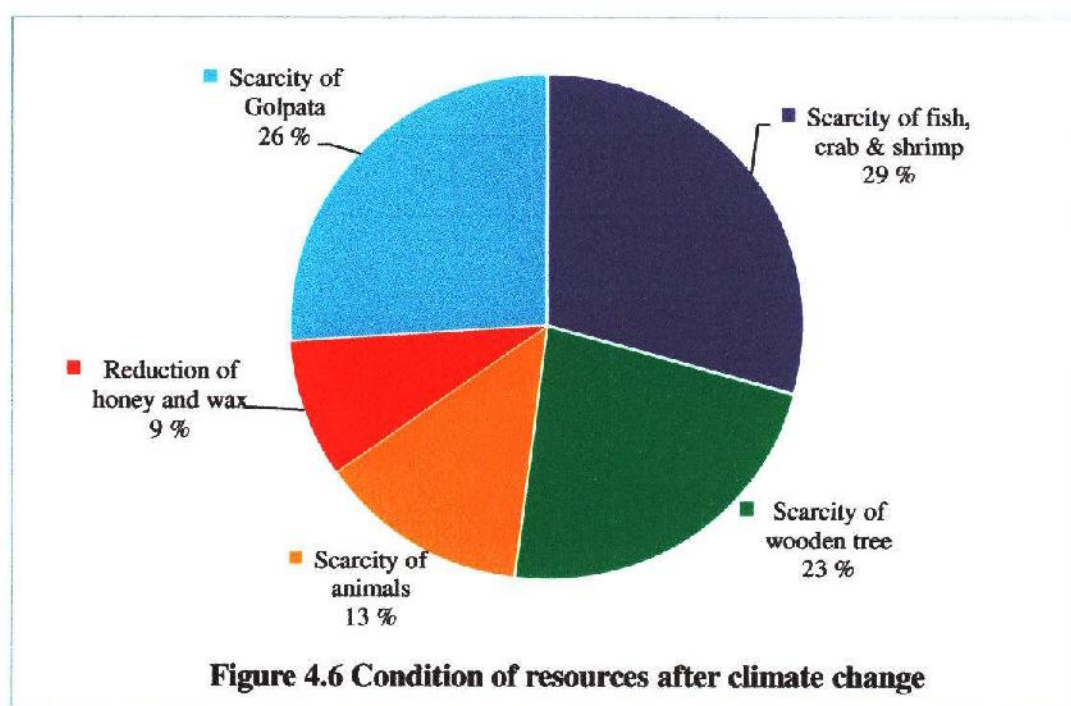
4.5. Resources of Sundarban before climate change

The conditions of resources of Sundarban before thirty years are given in Table 4.5 and Figure 4.5. In the study, it was found that 34 % resource users remarked plenty of fish, crab and shrimp, 21 % remarked plenty of wooden trees, and 4 % remarked plenty of river and canal.



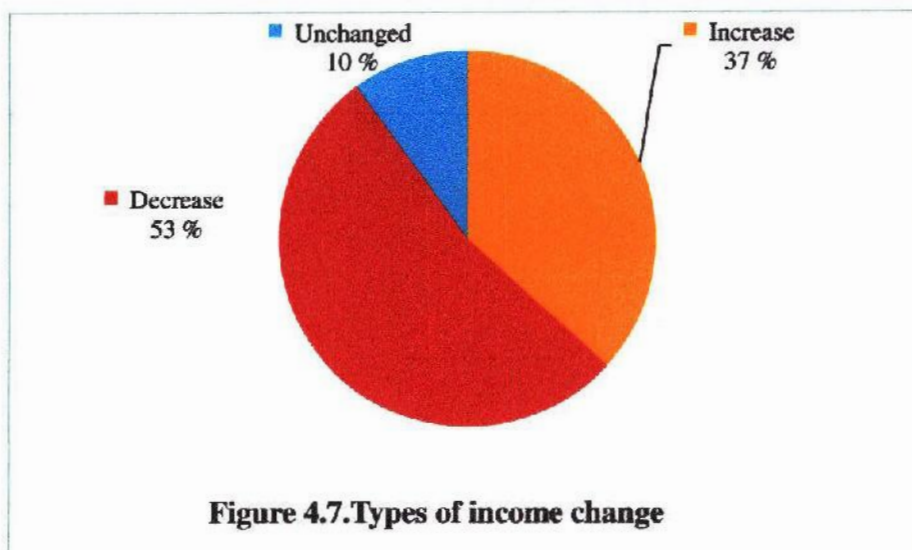
4.6. Resources of Sundarban after climate change

The condition of resources after climate change is represented in Table 4.6 and Figure 4.6. The resource users remarked that scarcity of fish, crab and shrimp (29 %), scarcity of golpata (26 %) and reduction of honey and wax (9 %).



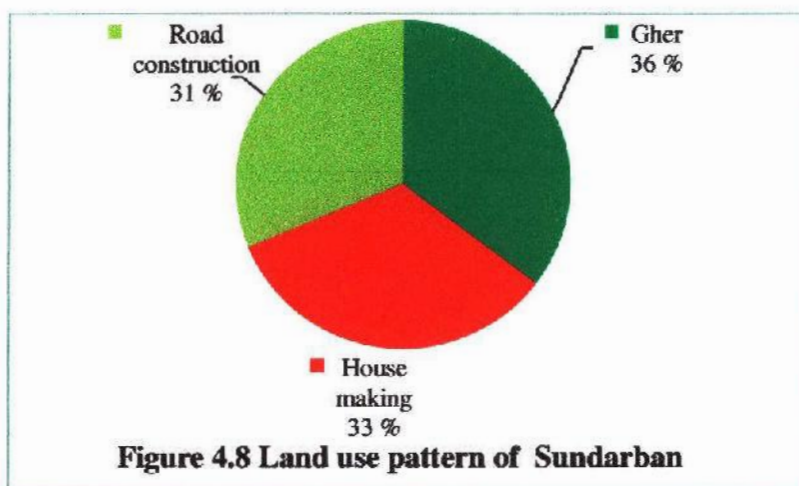
4.7. Types of income change

From the study, it was found that 53 % people's income was decreased, 37 % people's income was increased and 10 % people's income was unchanged (Table 4.7 and Figure 4.7).



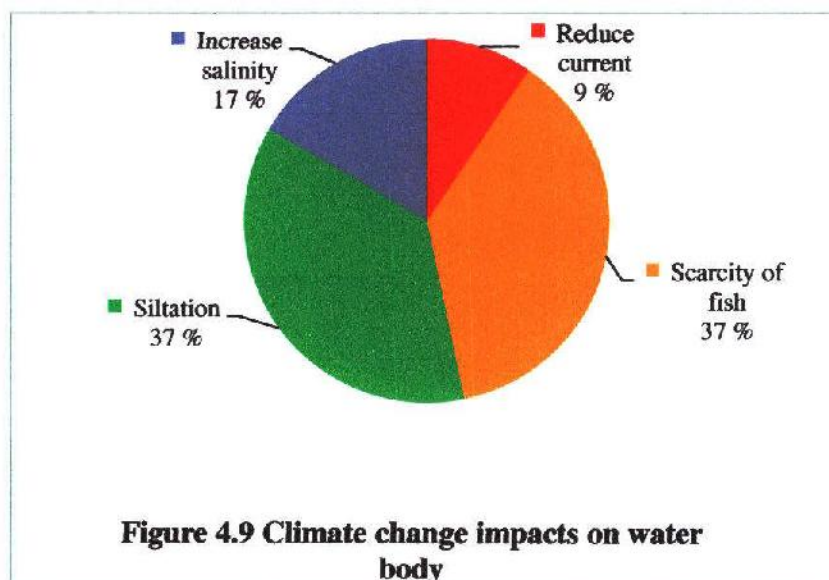
4.8. Change of land use pattern of Sundarban

The change of land using is presented in Table 4.8 and Figure 4.8. Land of Sundarban is using as gher was remarked by 36 %, house making was remarked by 33 % and road construction was remarked by 31 % of respondents.



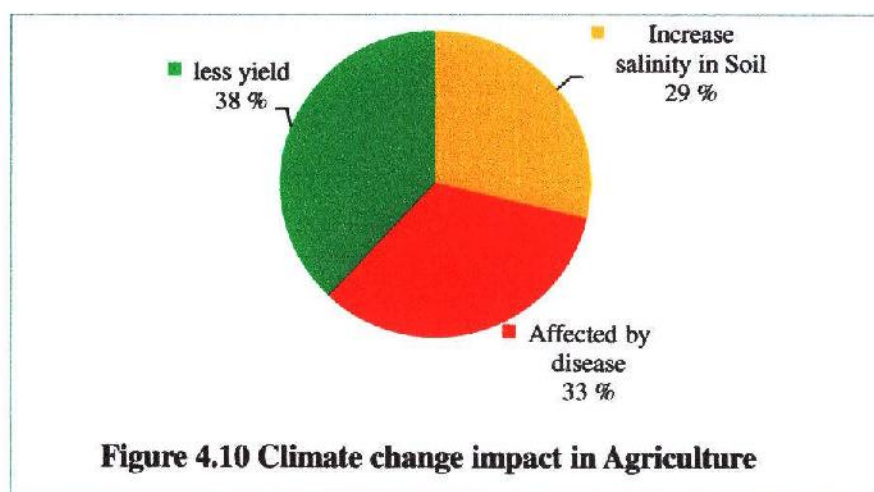
4.9. Impact of climate change on water body

Climate change impact on water body (canal, river, swamp) is represented in Table 4.9 and Figure 4.9. Most of the people (37.3 %) mentioned that scarcity of fish and siltation of water body and 9 % opined reduction of current as the climate change impact.



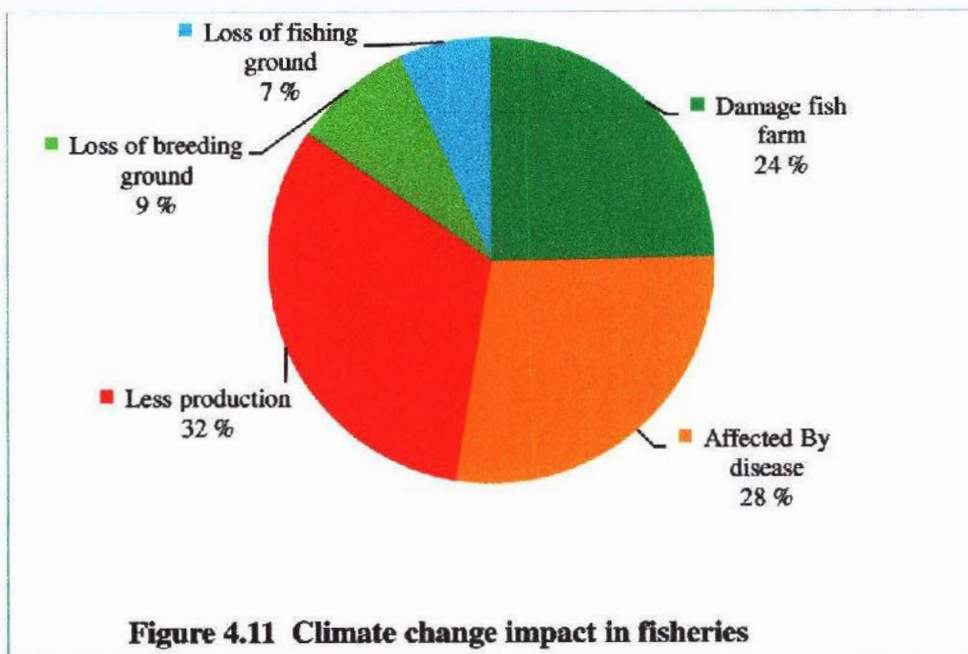
4.10. Climate change impact in Agriculture

The study revealed that 38 % people said reduce yield than before, 33.3 % people said that agricultural crops are more affected by disease and 28.7 % said that increase soil salinity (Table 4.10 and Figure 4.10)



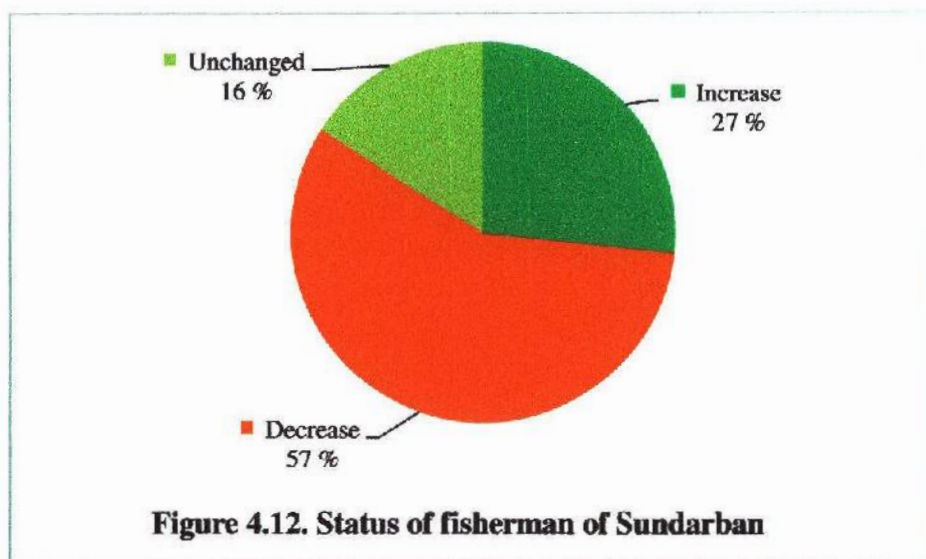
4.11. Climate change impact in fisheries

The present study mentioned that, 32 % people reported that less production, 28 % mentioned that affected by disease and 7 % loss of fishing ground (Table 4.11 and Figure 4.11)



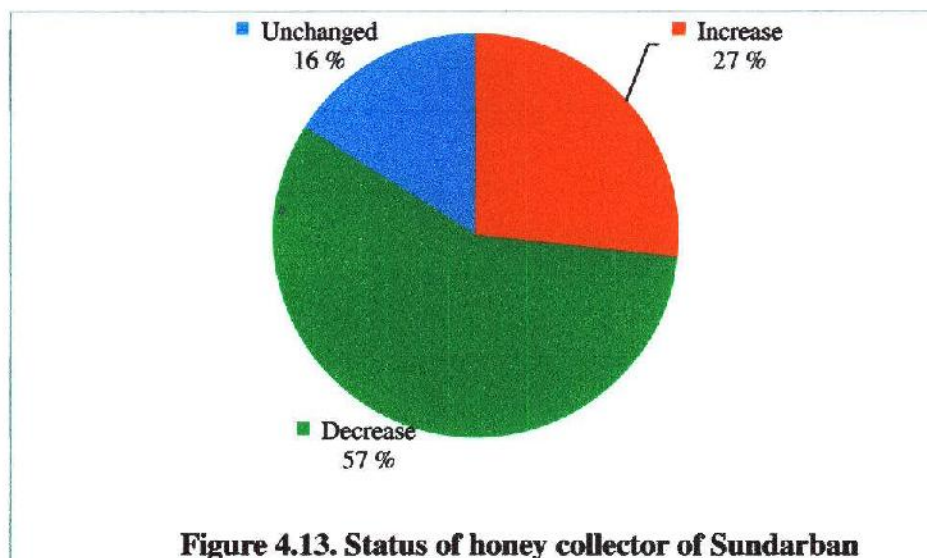
4.12. Status of fisherman of Sundarban

The Sundarban dependent fishermen are decreasing (57 %), some are newly added that counted as increase of fishermen (27 %) and a portion remain unchanged (16 %). This information is given in Table 4.12 and Figure 4.12.



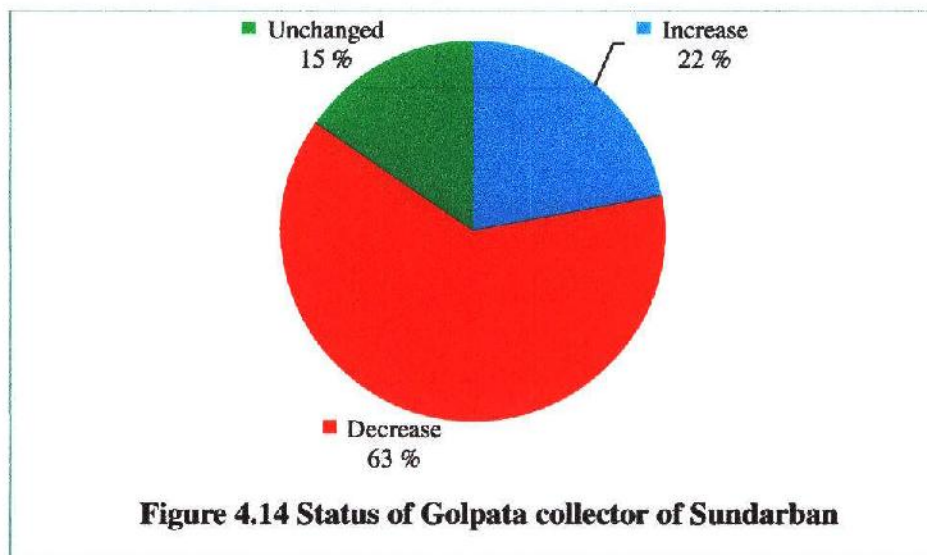
4.13. Status of honey collector of Sundarban

The Sundarban dependent honey collectors are decreasing (57 %), some are newly added that counted as increase of honey collector (27 %) and a portion remain unchanged (16 %). These results are given in Table 4.13 and Figure 4.13



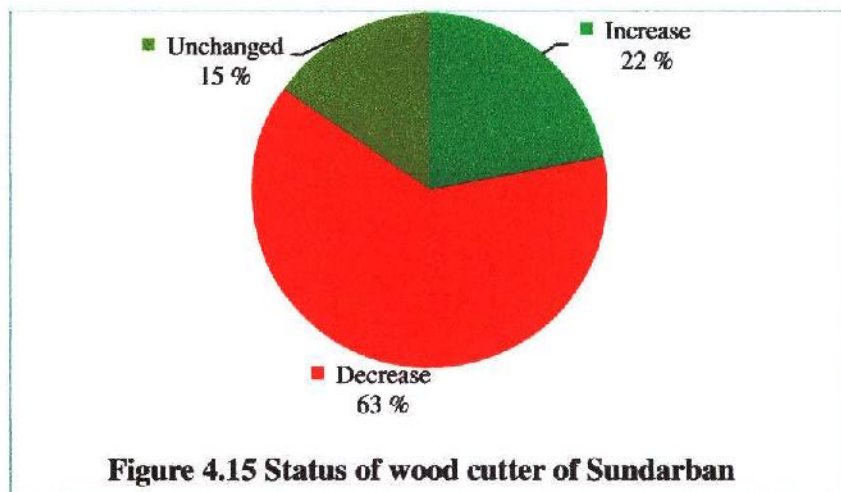
4.14. Status of Golpata collector of Sundarban

The Sundarban dependent golpata collectors are decreasing (63 %), some are newly added that counted as increase of golpata collector (22 %) and a portion remain unchanged (15 %). These results are given in Table 4.14 and Figure 4.14.



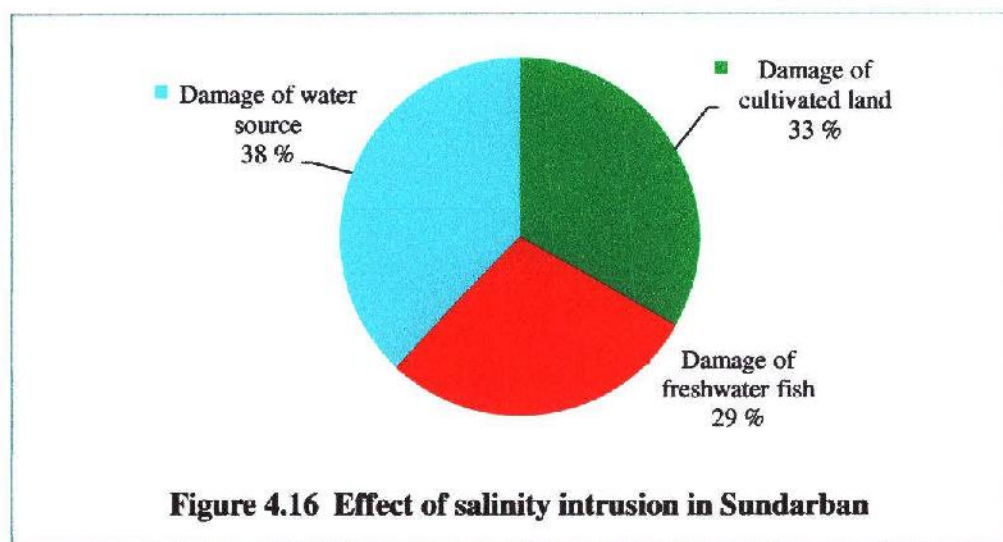
4.15. Status of wood cutter of Sundarban

The Sundarban dependent wood cutter are decreasing (63 %) , some are newly added that counted as increase of wood cutter (22 %) and a portion remain unchanged (15 %). These results are given in Table 4.15 and Figure 4.15.



4.16. Effect of salinity intrusion

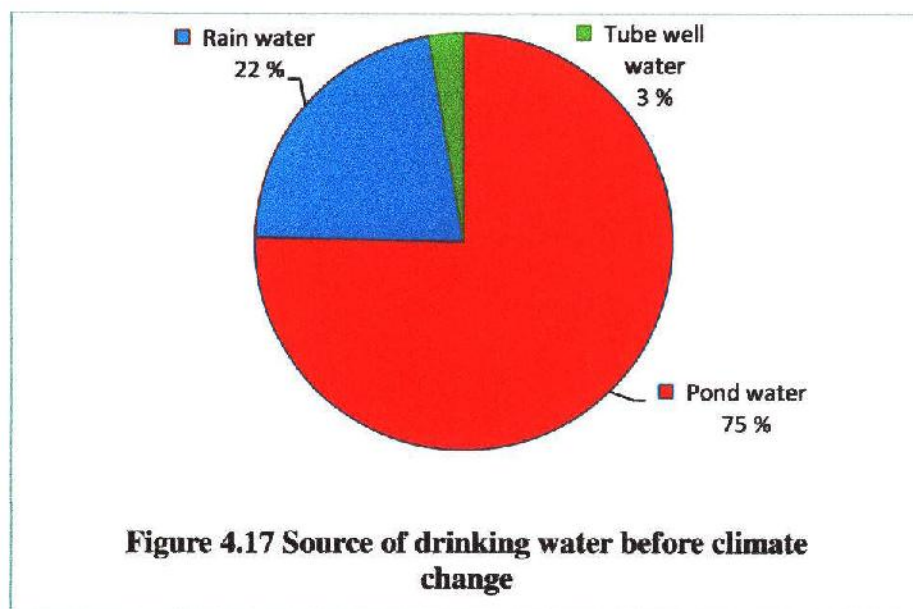
The effect of salinity intrusion is presented in Table 4.16 and Figure 4.16. Among the interviewed respondents 38 % said that damage of water source, 33 % said that damage of cultivated land and 29 % said that losses of freshwater fishes due to salinity intrusion.





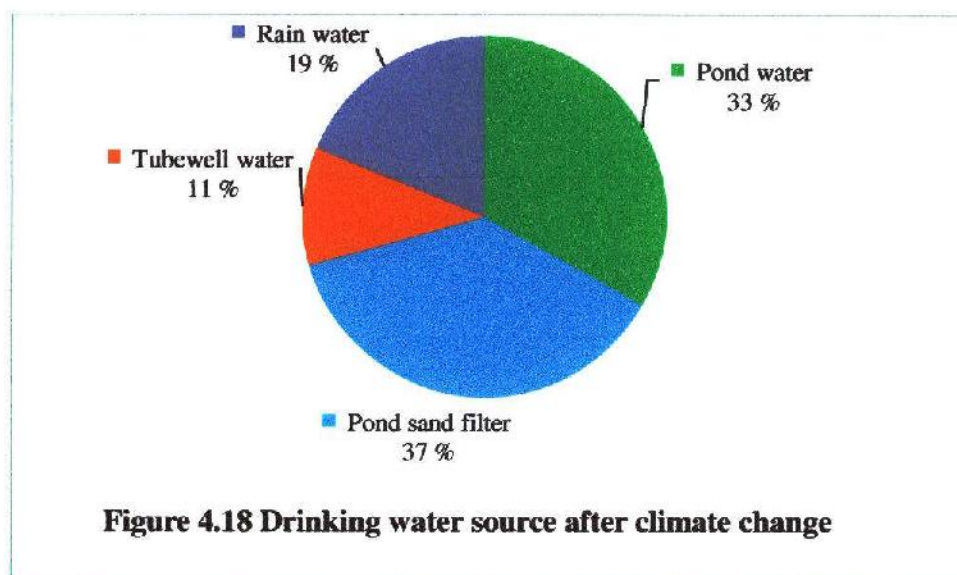
4.17. Source of drinking water before climate change

Safe Water is essential for human consumptions. Source of drinking water before climate change is represented in Table 4.17 and Figure 4.17. Among the respondents, 75 % drunk pond water, 22 % drunk rain water and 3 % drunk tube well water.



4.18. Source of drinking water after climate change

Source of drinking water after climate change is represented in Table 4.18 and Figure 4.18. Among the respondents, 37 % respondents drunk pond sand filter water, 33 % drunk pond water, 19 % drunk rain water and 11 % drunk tube well water after climate change.



4.19. Occupational changes of resource users

Occupational changes of resource users of Sundarban are presented in Table 4.19. and Figure 4.19. From the present study it was found that 14 fishermen changed their occupation and 30 fishermen remain unchanged, 6 honey collector changed their occupation and 21 remain unchanged, 15 PL collectors changed their occupation and 20 remain unchanged, 6 golpata collector changed their occupation and 13 remain unchanged, 3 wood cutters changed their occupation and 17 remain unchanged their occupation. Now 7 respondents changed to brick worker, 10 changed to day labor, 6 become motor cycle driver, 4 changed to construction worker, 4 become carpenter, 5 changed to petty business man, 5 become building maker, 3 become fish farmer, 5 become unemployed and 101 remain unchanged.

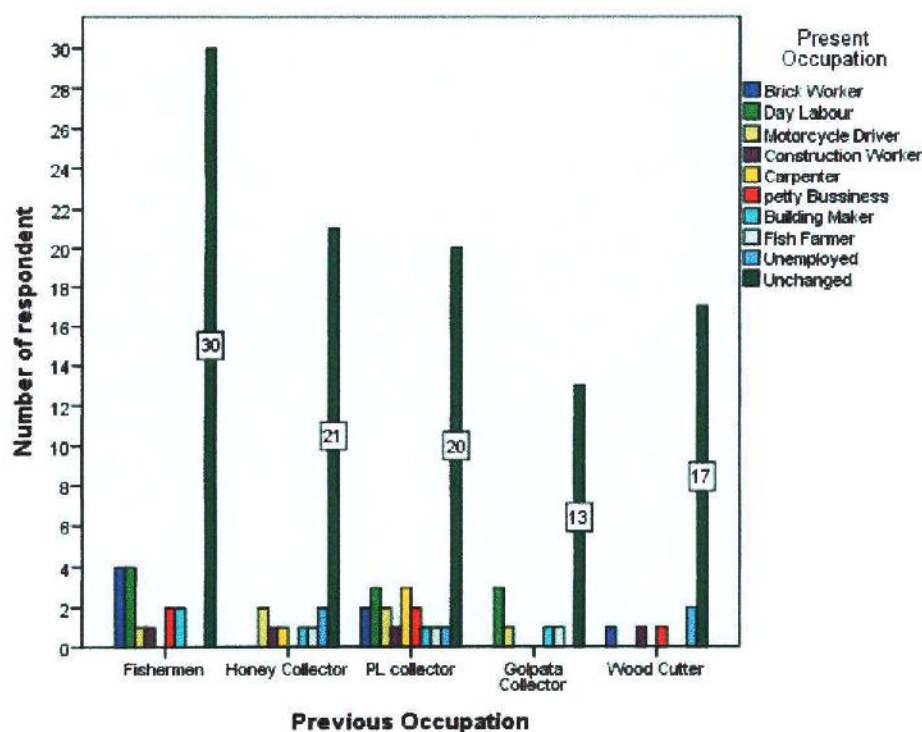


Figure 4.19 Occupational changes of resource users

4.20. Adaptation of Sundarban resource users

Sundarban dependent resource users adapt against climate change are presented in Table 4.20 and Figure 4.20. About 29.3 % people adapted by alternative occupation, 2.7 % people mentioned that their families members migrate towards town, 10 % people produce adaptive species of rice, fish and crops. About 10.7 % respondents are engaged in golpata collection, 8 %, 7.3 %, 6 % and 5.3 % respondent is engaged in PL collection, honey collection, shrimp culture and wood collection respectively. About 7.3 % Women are participated in work. homestead gardening (4 %) and salt cultivation (2.7 %).

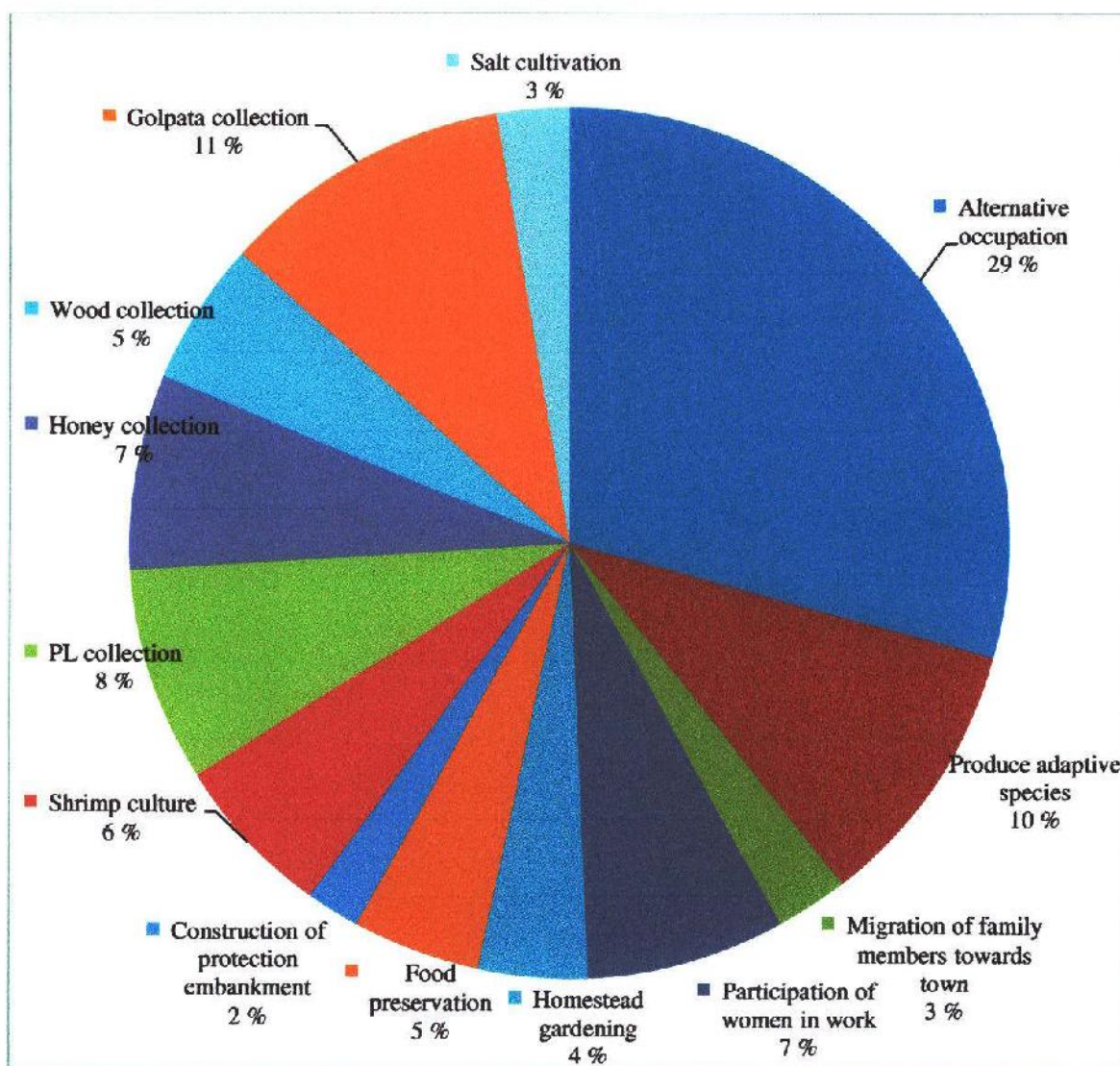


Figure 4.20 Adaptation mechanisms of resource users

4.21 Year basis adaptation of resource users

Adaptation of resource users on the basis of year are represented in Table 4.21 and Figure 4.21. The study revealed that 6.7 % peoples adapted from 1980-1990, 37.3 % peoples adapted from 1991-2000, 39.3 % peoples adapted from 2001-2010 and 16.7 % peoples adapted since 2011-recent.

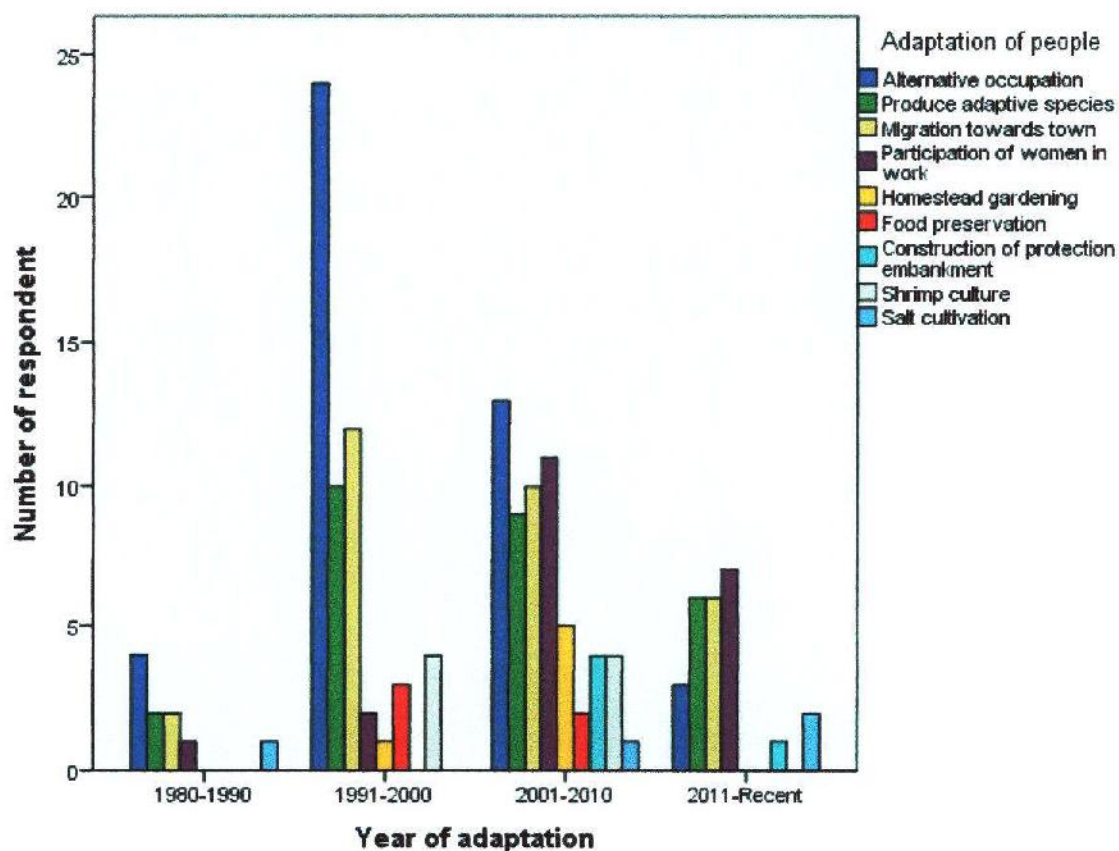


Figure 4.21 Year basis adaptation of resource users

4.22. Adaptation measures against climate change

Adaptation measures against climate change are presented in Table 4.22 and Figure 4.22. In the study it was found that 36 % peoples adapted to cyclone, 33.3 % to flood, 2 % to drought, 11.3 % to river erosion and 17.4 % to salinity intrusion

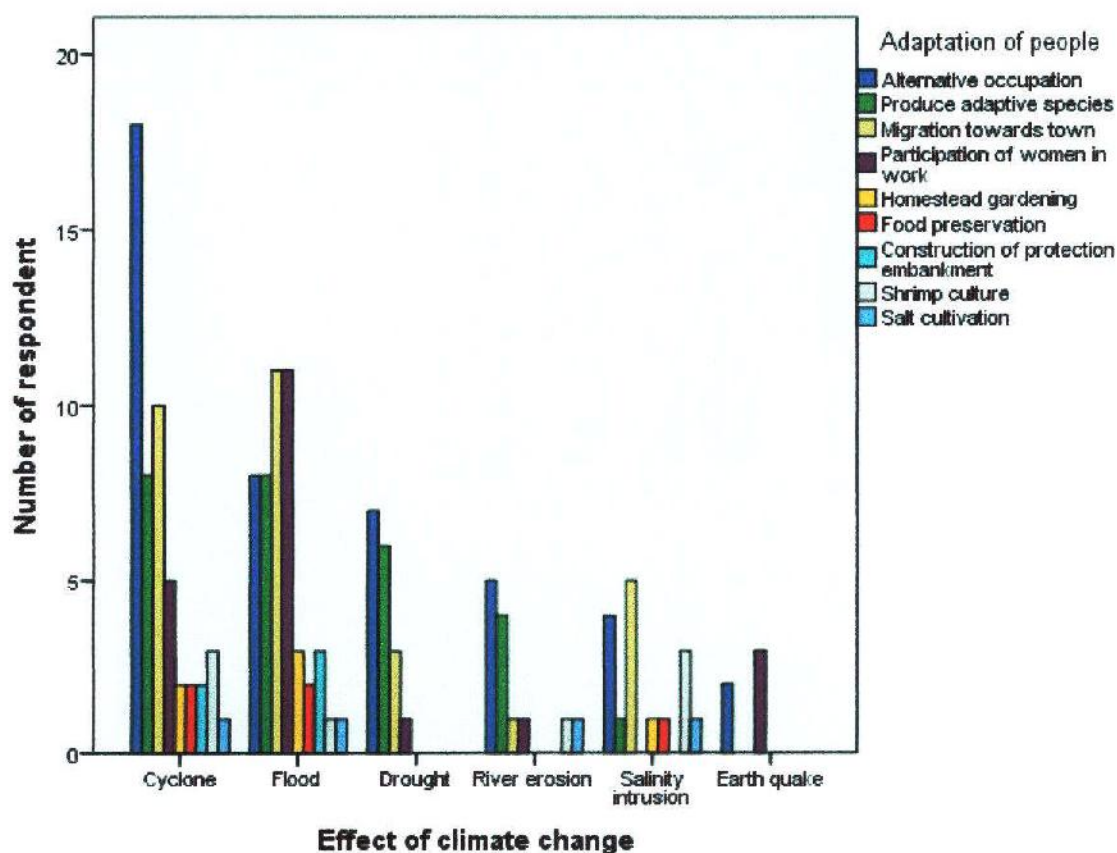


Figure 4.22 Adaptation measures against climate change

CHAPTER V
DISCUSSION

Discussion

5.1 Climate change hazard

The resource users of Sundarban mangrove forest cope with many climatic hazards. Majority of them had been faced cyclone, flood, salinity intrusion, drought, river erosion etc. Among the hazards, cyclone was faced by 34 % people, flood (6.7 %), salinity intrusion (4.7 %) and multiple hazards (such as cyclone, flood, salinity intrusion etc) were faced by 52 %. A study reveals that most of the respondents have faced tidal surge, flood and cyclone (91.67 %, 66.67 % and 50 %) respectively. River erosion, tsunami and excessive rainfall are the other disasters faced by the respondents. Natural disaster is the constant company of coastal population. They are faced more than one disaster every year (Islam, 2011). Disaster in Bangladesh is considered to be a great constraint for sustainable development. Cyclone, tidal surge, flood, river bank erosion are some of the worst types of disaster which is badly affecting the livelihood of our citizens especially in the coastal zone (Alam, 2005). Coastal areas put the coastal peoples at high risks as these areas are susceptible to a number of natural hazards, such as cyclones, tidal surges, salinity intrusion, riverbank erosion, shoreline recession, tsunami etc. (Haider *et al.*, 1992). The risks from tropical cyclones, storm surges, floods, and other climatic hazards are geographically concentrated in specific regions of Sundarban (Ahmed, 2012)

5.2. Dangerous natural disasters

People experienced a lot of natural disasters which damaged a lot, is known as dangerous disaster. The study observes that most of the respondents (39.3 %) reported that Aila was more dangerous, 22 % reported Sidr, 18 % reported cyclone of 1988, 15.3 % reported flood of 1998, 4.7 % reported cyclone of 1996 and 0.7 % reported cyclone of 1991 were very dangerous. Respondents mentioned that cyclone Aila was hitting at night; maximum people had no news about this disaster so it damages a lot, man, animals, birds were destroyed at a large scale. During 1991-2000, 93 major disasters were recorded in Bangladesh (Ahmed, 2012). The impacts of climate change effect community badly and the coastal community of Bangladesh first felt in 1970 and 1991, when two super cyclones hit the country and caused death of about 500,000 and 138,000 people respectively. In Bangladesh south west part of the country was affected by Category 4 Cyclone, Cyclone Sidr, in November 2007. Cyclone Aila began as a disturbance on 21 May in the Bay of Bengal, strengthened as Category 1 cyclone, causes death of about 200 people and left hundreds of thousands more homeless. (Barua, *et al.*, 2010.)

5.3. Damages of natural disasters

Natural disasters destroy houses, trees, roads, dams, cause death of man, animals, birds and damages fish farms, crop lands. The present study reported that respondent experienced death of people (2 %), house damage & death of domestic animals (35.3 %), damage of crop (15.3 %), damages of fisheries (22.7 %), death of man, animal and house damage (12.7 %), and damage of fish, crops (12 %). Koyra, Dacope and shymnagar upazila of southwest coastal belt of Bangladesh were hit the hardest by the cyclone Aila. Storm surge washed away all the houses, crops and agri-land, homestead garden and livestock and there by the area experienced huge toll damages to lives and livelihoods. Aila not only broke down the overall social harmonization but also resulted into a chaotic situation in those areas (Roy, *et al.*, 2009). One fourth of the Sundarbans forest area had been damaged by the cyclone Sidr (Bijoy, 2009). Eight to ten percent of the forest had been damaged completely, while fifteen percent has been partly damaged (The Daily Star, 2007).

5.4. Condition of health

Disease out break is a common matter after a disaster. It is reported that 42 % suffered from diarrhea, 25.3 % cholera, 9.3 % by snake bite, 8.7 % from fever, 6.7 % from traumatic situation, 4.7 % were fractured and 3.3 % suffered by skin disease. Some times people died of extreme diarrhea, cholera, and snake bites. They had insufficient medical facilities, it was reported by some peoples that they died of unknown disease which out breaks as epidemic. A study shows that 83.33 percent of the respondents suffer from traumatic situation during and after disaster and 16.67 percent does not suffer from any traumatic situation. From the table it is noticed that 50 percent of the respondents suffer from diarrhoea, 3.33 percent from snake bite, 18.33 percent from cholera, 38.33 percent from fever, 6.67 percent from fracture and 33.33 percent from skin diseases. Most of the respondents suffer from water borne diseases during and after disaster (Islam, 2011). Many people of Aila affected area are compelled to drink polluted water as they do not have any other option and consequently suffer from water borne diseases such as allergy, skin diseases, cholera and diarrhea. Currently, for curative measures affected peoples' medical cost has increased by 55 %. (Roy, *et al.*, 2009)

5.5. Resources of Sundarban before climate change

Sundarban was stock of natural resources. Mangrove forests serve as diverse habitat for many species, including fish, birds, reptiles, amphibians, mollusks, crustaceans and many other invertebrates. It was full of Sundari trees (*Heritiera fomes*). The leaves of golpata (*Nipa fruticans*) are harvested by local community for thatching purpose. Mangroves are a good source of wood, timber and housing materials, firewood, charcoal, and of poles for fish traps. Mangrove is a source of honey and wax, which has high economic value. The vegetated tidal lands of the Sundarbans also function as an essential habitat, produce nutrients and purify water. The forest also traps nutrient and sediment, acts as a storm barrier, shore stabilizer and energy storage unit. In the study, it was found that 34 % resource users remarked plenty of fish, crab and shrimp, 21.3 % remarked plenty of fruits, 12 % remarked plenty of live stock and wild animals, 4 % remarked plenty of river and canal, 10 % remarked availability of honey and wax , and 18 % remarked plenty of golpata. The Sundarban ecosystem supports rich fisheries diversity. This ecosystem support 27 families and 53 species of pelagic fish, 49 families 124 species of demersal fish, 5 families and 24 species of shrimps, 3 families and 7 species of crabs, 8 species of lobster. A total 334 plants, 165 algal, 13 special orchids, 17 fern, 87 monocotyledon and 230 dicotyledon belonging to 245 genera and 75 families from the sundarbans and adjacent area are found available. The principal tree species is Sundry (*Heritiera fomes*) which covers about 73% to total landmass and the second species is Gewa (*Excoecaria agallocha*) which covers about 16% of total forest area. The plant species include 35 legumes, 29 grasses, 19 sedges, and 18 euphorbias. Of the 50 true mangrove plant species recorded throughout the globe, the Sundarbans alone contain 35 species. The magnificent among the animals on land is Royal Bengal Tiger, Spotted deer, barking deer and wild boars are there in plenty. Besides those jungle cats, fishing cat, civet cat, monkey, bengal fox, jackle, water monitor, monitor lizard and snakes are important faunal spp. Moreover, abundant of the Sundarbans are purple heron, pond heron, cattle egret, little egret, open billed stork, smaller adjutant stork, brahmini kite, spotted dove, rose ringed parakeet, crow pheasant, wood pecker, bee eater, drongo, pide myna, jungle myna, bulbul, tailor bird, magpie robin, sparrow etc., Otherwise, recorded that wild Buffalo, 2 species of deer, javan rhinoceros extinct and presently 2 species of amphibians, 14 species of reptiles 25 species of birds and 5 species of mammals are considered as endangered species. This paper is to produce a new assessment of the mangroves ecology of Sundarbans (Rahaman and Asaduzzaman, 2010)



5.6. Resources of Sundarban after climate change

The resource users remarked that inadequacy of fish, crab and shrimp (29.3 %), Scarcity of wooden tree (22.7 %), scarcity of animals (13.3 %), reduction of honey and wax (8.7 %), and scarcity of golpata (26 %). Climate change reduces the stock of resources. Saline water increases with the sea level rising, as a result freshwater fishes losses their habitat. One calculation showed that a 25 cm sea level rise would result in a 40 % mangrove loss (Smith et al., 1998). Local community remarked that excessive heat reduces water retention capacity of land, trees are died lack of water. Rain does not come in timely so animals, fishes can not breed, as result fishes are decreasing day by day. Tree can not survive lack of rain fall, excess of salinity, heat so honey is decreasing day by day. Besides that some peoples cutting trees randomly as result Sundarban fallen into danger. River, canals are full of due to siltation, as a result breeding and feeding ground are lost. Prevalence of higher poverty of these areas might also be connected to poor livelihood patterns alongside higher environmental adversity. Livelihoods in these areas are mainly based on local resources (e.g. forest) and its extraction (e.g. agriculture, fishing) (Baten and Khan, 2008).

5.7. Change of land use pattern of Sundarban

In the study it was found that land of Sundarban is using as gher was remarked by 35.3 % respondents, house making was remarked by 33.3 % and road construction was remarked by 31.3 % respondents. Maximum land is now used as shrimp gher. Forest is deforested randomly. Due to the various man-made and also for some natural reasons different species in the Sundarbans are reducing at a significant level and land cover is changing day to day. Homestead (houses accompanied by evergreen broadleaf type vegetation), agricultural land (standing crop and fallow), water (rivers, ponds, shrimp farms), mangrove vegetation, etc. patterns are some of the main changed in the Sundarban mangrove forest area. Although the Sundarban mangrove ecosystems have tremendous value for south-west coastal communities and associated species, they are being destroyed at alarming rates. Human threats to the mangroves include the overexploitation of forest resources by local communities, conversion into large scale development such as agriculture, forestry, salt extraction, urban development and infrastructure and diversion of freshwater for irrigation. The greatest human threat to the mangroves is the establishment of shrimp aquaculture ponds. Because the mangroves are often viewed as wastelands, many developing countries are replacing these forests with agricultural land or shrimp aquaculture production. Shrimp aquaculture accounts for the loss of 20 to 50 percent of mangrove in the world (Rahman and Begum, 2011).

5.8. Impact of climate change on water body

Climate change affects largely on water body (canal, river, swamp). Most of the people (37.3 %) cited that scarcity of fish, 36.7 % opined siltation, 16.6 % mentioned increase of salinity and 9.4 % reported reduce of current as the climate change impact. Rivers, canals, swamps lost their flow and day by day fish and other aquatic animals reduces significantly. Saline water entered into the freshwater canals. Siltation is a great problem for rivers, canals, swamps which causes flood during rainy season. Flowing water in the rivers, canals etc. through and around the sundarbans flush out saline water intrusion from the sea. Increase in salinity intrusion due to anticipated sea level rise is one of the major threats to the sundari trees, which are already under threat due to increased salinity levels (Haq, 2010)

5.9. Climate change impact in Agriculture

The study revealed that 38 % people said reduce yield than before, 33.3 % people said that agricultural crops are more affected by disease and 28.7 % opined that increase soil salinity. At present, salinity in river water has exacerbated the inundation problems from Cyclone Aila. The tidal surge during the cyclone rushed over or broke rivers' embankments and covered farmland in saline water. This means that even after the water has subsided and the land is dry, salinity will continue to harm crop cultivation, grazing, tree growth etc. for years (Lonnqvist, 2010). Agricultural crops are attacked by disease, pesticide & insecticide used at high doses to prevent disease, these chemicals mixed with water and polluted the water body.

5.10. Climate change impact in fisheries

The present study mentioned that, 32 % people mentioned that less production, 28 % cited that affected by disease, 24.7 % told damage of fish farm, 8.7% said that loss of breeding ground and 6.7 % loss of fishing ground. Climate change can affect the productivity or distribution of fishery resources of marine waters in a variety of way; Changes in water temperature and precipitation affect the dynamics of ocean currents, the flow of rivers and the area covered by wetlands. This will have effects on ecosystem structure and function and on the distribution and production of fish stocks. Increased incidence of extreme events such as floods, droughts and storms will affect the safety and efficiency of fishing operations and increase damage and disruption to coastal and riparian homes, services and infrastructure (Allison, 2005). Increased water temperature may likely to advance the sexual maturation and

the process of and timing of spawning of adult hilsha population, this may upset timing of spawning migration into the fresh water rivers and estuarine areas (Haque, 2009).

5.11. Status of fisherman of Sundarban

The Sundarban dependent fishermen are decreasing (54.7 %), some are newly added that are counted as increase of fishermen (26 %) and a portion remain unchanged (19.3 %). Fish reduces significantly due to climate change as a result fishermen was decreasing day by day. On the other hand some fishermen engaged in fishing because they have no alternative livelihood option. A study depicts that 85% of the women in coastal area are engaged in various works of shrimp farming. Most of the women are engaged with the collection of shrimp larvae from nearby coastal rivers and marshes. Increasing salinity of river water threatens the traditional way of living in such communities (Chowdhury, 2007)

5.12. Status of honey collector of Sundarban

The Sundarban dependent honey collectors are decreasing (57.3 %), some are newly added that are counted as increase of honey collector (26.7 %) and a portion remain unchanged (16 %). Honey producing bees were reduced, flower did not come timely and flower taste sour or sometimes bitter. So honey collector lost interest. Due to disaster a lot of trees destroyed and uprooted and many animals and insect become food and shelter less. All facts keep an effect on honey collection profession of the Mowals. For example, in 2007 cyclone 'Sidr' made many Mowals jobless as this was one of the severe cyclones in their lifetime. (Sohela, 2013)

4.13. Effect of salinity intrusion

A total of 150 respondents were interviewed, among them 38 % given statement that damage of water source, 33.3 % opined that damage of cultivated land and 28.7 % said that damage of freshwater fishes due to salinity intrusion. Sea level rise will also have adverse impacts on the forest, directly through enhanced inundation and indirectly by enhancing saline intrusion in river systems. Reduced freshwater flows coupled with sea-level rise would consequently further enhance the dry season salinity levels in the Sundarbans. The effects of climate change on the Sundarbans would be considerably more critical during the dry season that extends from November to April. (Agrawala, *et al.*, 2003)

5.14. Source of drinking water after climate change

The study reviewed that the respondents, 37.3 % respondents drunk pond sand filter water, 33.3 % drunk pond water, 18.7 % drunk rain water and 10.7 % drunk tube well water after climate change. After climate change drinking water is a problematic issue for Sundarban dwellers. Pond water became saline. People could not drink pond water. They didn't have sufficient tube well. During the rainy season they preserved rain water. About 3-4 months they were drunken rain water. The people of the study area received the highest amount of sufferings from drinking water shortage and destruction of sanitation facilities soon after Aila attack. However, still the affected people are suffering from shortage of pure drinking water, which is evident from all respondents' response and physical visit to the area. In the study area water supply and sanitation coverage was about 50-60 % before Aila. However, Aila devastated all the drinking water sources (ponds and tube wells). During Aila, high tidal surges contaminated all fresh water sources with polluted saline water (Roy, *et al.*, 2009)

5.15. Livelihood of Sundarban resource users

For the coastal dwellers of mangrove ecosystem area, the value of mangrove is not surprising. Local community has long recognized the socioeconomic values of mangrove ecosystems for their lives and livelihoods. These resources help to eliminate poverty. The local people are depending largely on the natural resources of mangrove forest for their living. Major activities in mangrove forest area are shrimp farming, salt production, collection of fuel wood, fry collection, cattle grazing and human settlement. Mollusk shells are collected from mangrove by fishermen for lime preparation. Mangrove twigs are used as firewood to the local people due to the high caloric value. The mangrove wood with high content of tannin is used as timber for its durability. The pneumatophores of mangrove trees are used by local fishermen for stopper and float making. (Kathiresan, 2000). About 18 percent households of the Sundarban impact zone are dependent on Sundarban resources (shrimp fry collectors, honey collectors, golpata collectors, shell/crab collectors and medicinal plant collectors. Around 0.5 million household's (family members 2.7 million) primary income source is fishing (losing working days because of rough weather in the Bay). Over 160,000 coastal fishermen and estimated 185,000 shrimp fry collector are involved in marine fisheries. (Ahmed, 2012). The Sundarban mangrove reserve has a great economic importance for Bangladesh and provides livelihood options for 300,000 people. (Barua, *et al.*, 2010).

5.16. Occupational changes of resource users

From the present study it was found that 14 fishermen changed their occupation and 30 fishermen remain unchanged, 6 honey collector changed their occupation and 21 remain unchanged, 15 PL collectors changed their occupation and 20 remain unchanged, 6 golpata collector changed their occupation and 13 remain unchanged, 3 wood cutters changed their occupation and 17 remain unchanged their occupation. Now 7 respondents changed to brick worker, 10 changed to day labor, 6 become motor cycle driver, 4 changed to construction worker, 4 become carpenter, 5 changed to patty business man, 5 become building maker, 3 become fish farmer, 5 become unemployed and 101 remain unchanged.

Mangrove resource users changed their occupations at a large scale. Some were remain unchanged. Besides these, some were newly added. The mangrove forests have been shown to sustain more than 70 direct human activities, ranging from fuel-wood collection to fisheries.(Barua, *et al.*, 2010)

5.17. Adaptation mechanism of Sundarban resource users

The abilities of communities to adapt to climate change is determined by their access to resources, indigenous ecological knowledge, practice and technical capacity, depending on cultural features, social capital, socioeconomic context etc. About 29.3 % people adapted by alternative occupation, 2.7 % people mentioned that their family members migrate towards town, 10 % people produce saline tolerant rice (BARI dhan 40,41, BINA Dhan 7), fish (Tilapia), carrot, sugar beat etc. About 10.7 % respondents are engaged in golpata collection, 8 %, 7.3 %, 6 % and 5.3 % respondent is engaged in PL collection, honey collection, shrimp culture and wood collection respectively. About 7.3 % Women are participated in work homestead gardening (4 %) and salt cultivation (2.7 %). Traditional lifestyles were in fact reasonably well adapted to these unique characteristics of the Sundarbans. Human dwellings were built on raised platforms, and farmers cultivated salinity and flood tolerant rice during the monsoon in land protected by temporary dykes when the abundance of freshwater had greatly reduced salinity levels. The dykes were dismantled post-harvest, opening the land to tidal movements. Meanwhile fishing of salt tolerant varieties was the principal source of livelihood during the dry season when salinity levels were high (Firoze, undated). People also cultivating betel leaf as their cash crop and it is profitable. But the betel vines are very much vulnerable to flood and storm. Due to climate change betel leafs are affected by diseases and pests. So farmers fall in to dangers and be looser. Farmers use fertilizer viz. TSP, Potas, Gypsum etc to reduce salinity in land. Women are aware of the fact that a certain species

grow well in saline conditions. They plant palm, betel nut, sofada etc. sapling which provide little cash for family. In doing so, they actually utilize condition which otherwise poses threat to their betterment of life. Due to the close proximity of gher fisheries, women find it easier to raise ducks. Women also engage themselves in handicraft, based on their individual skill.

4.18. Adaptation measures against climate change

In the study it was found that 36 % peoples adapted against cyclone, 33.3 % adapted against flood, 2 % adapted against drought, 11.3 % adapted against river erosion and 17.4 % adapted against salinity intrusion. Flood resilient housing, raising plinth of the house was done by the flood prone people to adapt against flood. Farmers produce saline tolerant rice such as BARI dhan 40,41, BINA Dhan 7. Chilis, Carrot, Sugar beet, Barley were also cultivated by the resource users as alternative cultivation (Ahmed, 2012).

CHAPTER VI
RECOMMENDATION

Recommendation

6. Recommendation

The following recommendations play an important role in improvement of adaptation of resource users of Sundarban mangrove forest.

- Awareness about climate change should be increased among the resource users.
- Expansion of indigenous knowledge on adaptation should be enhanced.
- Participation of GO and NGOs in disaster prone area should be extended.
- Social security of people must be strengthening.
- Sustainable harvest of resources should be ensured.
- More cyclone shelter, medical center, embankment should be constructed for local people.
- More trees should be planted to prevent green house effect as well as sea level rising.
- Ban of PI collection and alternative livelihood should be opened for them.

CHAPTER VII

CONCLUSION

Conclusion

Sundarbans is one of the largest mangrove forests in the world. It is full of many natural resources viz. fish, crustaceans, shrimp, honey, fuel wood, timber, medicinal plant, golpata etc. The Sundarban mangrove reserve has a great economic importance for Bangladesh and provides livelihood options for 300,000 people. A total of 80% people who uses the resources facing many dangers like attacks of tiger, robber as well as climatic hazards affect their livelihood options. Now a day, cyclone, storm, flood, tsunami, salinity intrusion are major problems in coastal regions of Bangladesh. These results the damage of houses, death of man, animals, destroy fish farm, crop lands, alter the habitat of birds, alter the fishing ground and breeding ground of many fishes. Day by day sea level rises gradually and salinity increases rapidly, as a result cropping pattern, methods of cultivation and variety are changed. Water becomes more saline, destroy the drinking water sources. Farmers cultivate saline tolerant fish and crops. Due to climate change rain does not comes timely, delay of summer season, increasing ambient temperature. For this breeding of fish, birds, animals are hampered and mortality rate becomes high. So fish, bees, trees, river, canals, are going to be lost forever. The resource users of Sundarban become jobless, their livelihood is in danger. They change their occupations, search of alternative drinking water; more women are engaged in garments, brick industries. All information may play important role for development of adaptation measures of mangrove resource users and may also helpful for future studies.

CHAPTER VIII
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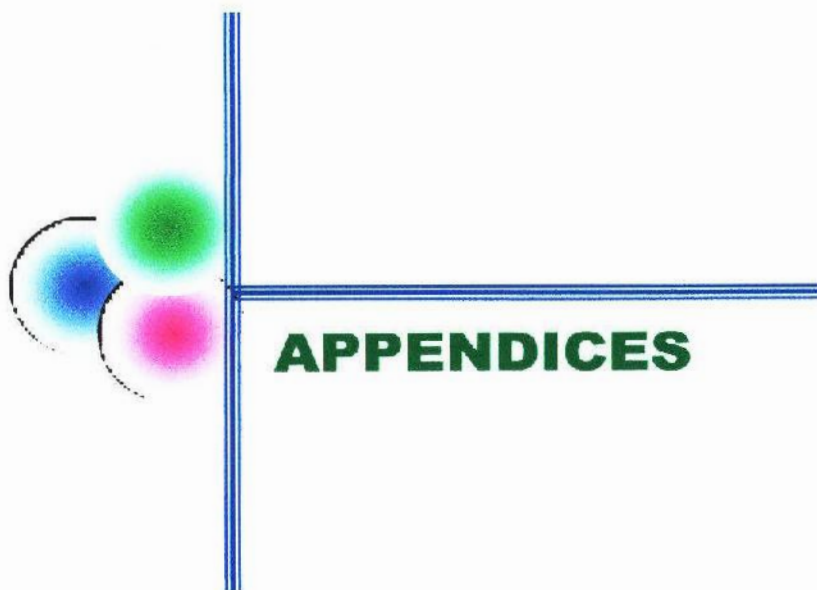
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APPENDICES

APPENDICES

Appendix I. Questionnaire on Sundarban mangrove forest resource users adaptation measurement under changing climate.

Sl.no:

Date:

1. Name of the respondent:

2. Age: ☐ 20-30 yrs. ☐ 31-50 yrs. ☐ 51-80 yrs. ☐ Above 81 yrs.

3. Sex: ☐ Male ☐ Female

4. Religion: ☐ Muslim ☐ Hindu ☐ Christian ☐ Buddhist

5. What is your present occupation?

☐ Brick worker ☐ Day labor ☐ Motorcycle driver

☐ Construction worker ☐ Carpenter ☐ Petty business

☐ Building maker ☐ Fish farmer ☐ Garments worker

☐ Fishermen ☐ Unemployed ☐ Unchanged

6. What was your previous occupation?

☐ Fishermen ☐ Honey collector ☐ PL collector

☐ Golpata collector ☐ Wood cutter

7. When you change your occupation?

☐ 1980-1990 ☐ 1991-2000 ☐ 2001-2010 ☐ 2011- Recent

8. What is your monthly income?

☐ < 3000 Tk. ☐ 3001-5000 Tk. ☐ 5001-7000 Tk. ☐ 7001-9000 Tk

☐ >9000 Tk.

9. What types of disaster(s)/climatic hazards you faced?

☐ Cyclone ☐ Flood ☐ Drought ☐ River erosion

☐ Salinity intrusion ☐ Earth quake ☐ Multiple



19. What types of changes are noticed in land use pattern?

☐ Road construction ☐ House making ☐ Gher

20. What is the climate changing effect on water bodies?

☐ Reduce current ☐ Scarcity of fish ☐ Siltation ☐ Increase salinity

21. What is the effect of climate change in agricultural sector?

☐ Increase salinity ☐ Affected by disease ☐ Less yield

22. What is the effect of climate change in fisheries sector?

☐ Damage fish farm ☐ Affected by disease ☐ Less production

☐ Loss of breeding ground ☐ Loss of fishing ground

23. What is the status of fishermen in Sundarban?

☐ Increase ☐ Decrease ☐ Unchanged

24. What is the status of honey collector in Sundarban?

☐ Increase ☐ Decrease ☐ Unchanged

25. What is the status of wood cutter in Sundarban?

☐ Increase ☐ Decrease ☐ Unchanged

26. What is the status of golpata collector in Sundarban?

☐ Increase ☐ Decrease ☐ Unchanged

27. What is the impact of salinity in this region?

☐ Damage of cultivated land ☐ Damage of freshwater fishes

☐ Damage of drinking water resources

28. What were the sources of drinking water before climate change?

☐ Pond water ☐ Rain water ☐ Tube well water

29. What are the sources of drinking water after climate change?

☐ Pond water ☐ Rain water ☐ Tube well water

☐ Pond sand filter

30. How the people of this area are adapted with climate change and its impacts?

- | | |
|---|--|
| ☐ Alternative occupation | ☐ Produce saline & flood tolerant crops |
| ☐ Migration towards town | ☐ Participation of women in work |
| ☐ Homestead gardening | ☐ Construction of protection embankment |
| ☐ Shrimp culture | ☐ Salt cultivation |

31. What is the year of adaptation?

- | | | |
|---------------------------------------|------------------------------------|------------------------------------|
| ☐ 1980-1990 | ☐ 1991-2000 | ☐ 2001-2010 |
| ☐ 2011- Recent | | |

Appendix II. Tables

Table 4.1. Climate change hazards of Sundarban

Climate change hazard	No. of respondent	Respondent (%)
Cyclone	51	34.0
Flood	10	6.7
Drought	1	0.7
River erosion	3	2.0
Salinity intrusion	7	4.7
Multiple(Cyclone, Flood, salinity intrusion)	78	52.0
Total	150	100.0

Table 4.3. Damages experienced by the people

Damages	No. of respondent	Respondent (%)
Death of People	3	2.0
House damage & domestic animal's death	53	35.3
Crop damage	23	15.3
Fisheries damage	34	22.7
Man, animal death and house damage	19	12.7
Fish and crop damage	18	12.0
Total	150	100.0

Table 4.4. The health condition of disaster prone people

Disorder	No. of respondent	Respondent (%)
Diarrhea	63	42.0
Snake bites	14	9.3
Cholera	38	25.3
Fever	13	8.7
Fracture	7	4.7
Skin diseases	5	3.3
Traumatic situation	10	6.7
Total	150	100.0

Table 4.5.Resources of the Sundarban before climate change

Resource	No. of respondent	Respondent (%)
Plenty of fish, crab & shrimp	51	34.0
Plenty of fruits	32	21.3
Plenty of live stock and wild animals	18	12.0
Plenty of river, canal	6	4.0
Availability of honey and wax	16	10.7
Plenty of Golpata	27	18.0
<i>Total</i>	<i>150</i>	<i>100.0</i>

Table 4.6.Resources of the Sundarban after climate change

Resource	No. of respondent	Respondent (%)
Scarcity of fish, crab & shrimp	44	29.3
Scarcity of wooden tree	34	22.7
Scarcity of animals	20	13.3
Reduction of honey and wax	13	8.7
Scarcity of Golpata	39	26
<i>Total</i>	<i>150</i>	<i>100.0</i>

Table 4.7.Types of income change

Status	No. of respondent	Respondent (%)
Increase	55	36.7
Decrease	80	53.3
Unchanged	15	10.0
<i>Total</i>	<i>150</i>	<i>100.0</i>

Table 4.8.Land use pattern of Sundarban

Pattern of use	No. of respondent	Respondent (%)
Gher	53	35.3
House making	50	33.3
Road construction	47	31.3
<i>Total</i>	<i>150</i>	<i>100.0</i>

Table 4.9.Impact of climate change on water body

Impact	No. of respondent	Respondent (%)
Reduce current	14	9.4
Scarcity of fish	56	37.3
Siltation	55	36.7
Increase salinity	25	16.6
Total	150	100.0

Table 4.10.Impact of climate change in agricultural sector

Impact	No. of respondent	Respondent (%)
Increase salinity in Soil	43	28.7
Affected by disease	50	33.3
less yield	57	38.0
Total	150	100.0

Table 4.11.Impact of climate change in fisheries

Impact	No. of respondent	Respondent (%)
Damage fish farm	37	24.7
Affected By disease	42	28.0
Less production	48	32.0
Loss of breeding ground	13	8.7
Loss of fishing ground	10	6.7
Total	150	100.0

Table 4.12.Status of Sudarban dependent fishermen

Status	No. of respondent	Respondent (%)
Increase	39	26.0
Decrease	82	54.7
Unchanged	29	19.3
Total	150	100.0

Table 4.13. Status of Sudarban dependent honey collector

Status	No. of respondent	Respondent (%)
Increase	40	26.7
Decrease	86	57.3
Unchanged	24	16.0
Total	150	100.0

Table 4.14. Status of golpata collector of Sudarban

Status	No. of respondent	Respondent (%)
Increase	26	17.3
Decrease	102	68.0
Unchanged	2	14.7
Total	150	100.0

Table 4.15. Status of Sudarban dependent wood cutter

Status	No. of respondent	Respondent (%)
Increase	33	22.0
Decrease	94	62.7
Unchanged	23	15.3
Total	150	100.0

Table 4.16. Effects of salinity intrusion

Effect of salinity	No. of respondent	Respondent (%)
Damage of cultivated land	50	33.3
Damage of freshwater fish	43	28.7
Damage of water source	57	38.0
Total	150	100.0

Table 4.17.Drinking water sources of people before climate change

Source of water	No. of respondent	Respondent (%)
Pond water	113	75.3
Rain water	33	22.0
Tubewell water	4	2.7
Total	150	100.0

Table 4.18.Drinking water sources of people after climate change

Source of water	No. of respondent	Respondent (%)
Pond water	50	33.3
Pond sand filter	56	37.3
Tubewell water	16	10.7
Rain water	28	18.7
Total	150	100.0

Table 4.19. Professional changes of Sundarban resource users

Previous occupation	Present Occupation											Grand Total
	Brick Worker	Day Labour	Motorcycle Driver	Construction Worker	Carpenter	Petty Business	Building Maker	Fish Farmer	Unemployed	Occupation Changed	Unchanged	
Fishermen	4	4	1	1	0	2	2	0	0	14 (9.3%)	30 (20.0%)	44 (29.3%)
Honey Collector	0	0	2	1	1	0	1	1	2	6 (4.0%)	21 (14.0%)	29 (19.3%)
PL collector	2	3	2	1	3	2	1	1	1	15 (10.0%)	20 (13.3%)	36 (24%)
Golpata Collector	0	3	1	0	0	0	1	1	0	6 (4.0%)	13 (8.7%)	19 (12.7%)
Wood Cutter	1	0	0	1	0	1	0	0	2	3 (2.0%)	17 (11.3%)	22 (14.7%)
Total	7 (4.7%)	10 (6.7%)	6 (4.0%)	4 (2.7%)	4 (2.7%)	5 (3.3%)	5 (3.3%)	3 (2.0%)	5 (3.3%)	44 (29.3%)	101 (67.3%)	150 (100%)

Table 4.20. Adaptation mechanism of resource users of Sundarban

Adaptation of people	No. of respondent	Respondent (%)
Alternative occupation	44	29.3
Produce adaptive species	15	10.0
Migration of family members towards town	4	2.7
Participation of women in work	11	7.3
Homestead gardening	6	4.0
Food preservation	7	4.7
Construction of protection embankment	3	2.0
Shrimp culture	9	6.0
PL collection	12	8.0
Honey collection	11	7.3
Wood collection	8	5.3
Golpata collection	16	10.7
Salt cultivation	4	2.7
Total	150	100.0

Table 4.21. Year basis adaptation of resource users

Year of adaptation	Adaptation of people									Total
	Alternative occupation	Produce adaptive species	Migration towards town	Participation of women in work	Homestead gardening	Food preservation	Construction of protection embankment	Shrimp culture	Salt cultivation	
1980-1990	4	2	2	1	0	0	0	0	1	10 (6.7%)
1991-2000	24	10	12	2	1	3	0	4	0	56 (37.3%)
2001-2010	13	9	10	11	5	2	4	4	1	59 (39.3%)
2011-Recent	3	6	6	7	0	0	1	0	2	25 (16.7%)
Total	44 (29.3%)	27 (18%)	30 (20%)	21 (14%)	6 (4%)	5 (3.3%)	5 (3.3%)	8 (5.3%)	4 (2.7%)	150 (100%)



Table 4.22. Adaptation measures against climate change

Effect of climate change	Adaptation of people									Total
	Alternative occupation	Produce adaptive species	Migration towards town	Participation of women in work	Homestead gardening	Food preservation	Construction of protection embankment	Shrimp culture	Salt cultivation	
Cyclone	18	8	10	8	2	2	2	3	1	54 (36%)
Flood	10	8	11	11	3	2	3	1	1	50 (33.3%)
Drought	2	1	0	0	0	0	0	0	0	3 (2.0%)
River erosion	5	4	4	2	0	0	0	1	1	17 (11.3%)
Salinity intrusion	9	6	5	0	1	1	0	3	1	26 (17.4%)
Total	44 (29.3%)	27 (18%)	30 (20%)	21 (14%)	6 (4%)	5 (3.3%)	5 (3.3%)	8 (5.3%)	4 (2.7%)	150 (100%)

Appendix III. Photo gallery



Plate 1. An interview was made by the author



Plate 2. FGD in Burigoalini



Plate 3. Kewra and Bain trees of Sundarban



Plate 4. Boats used for fishing



Plate 5. A fish drying center

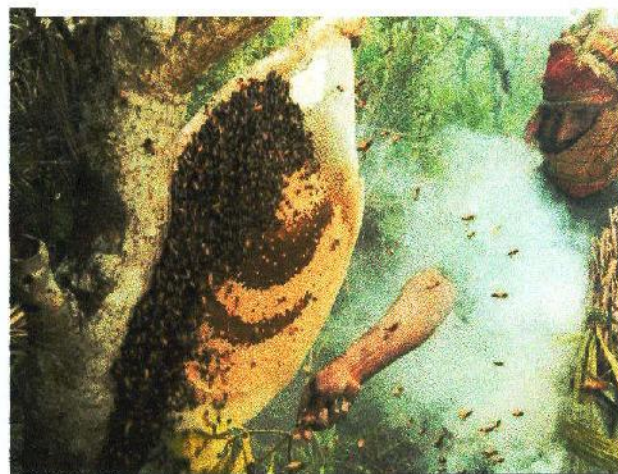


Plate 6. Honey collection



Plate 7. Shrimp PL collection



Plate 8. Shrimp PL selling in a market

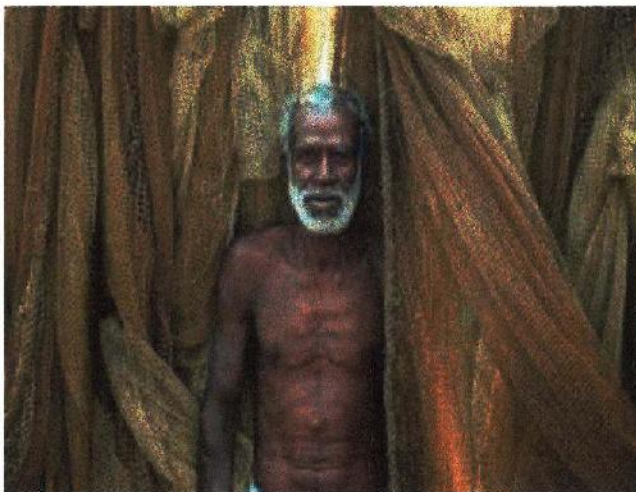


Plate 9. A Fisherman standing beside his net



Plate 10. Golpata of Sundarban