Original Research Article

Agricultural adaptation options against adverse effect of climate change in Shyamnagar upazila of Satkhira district, Bangladesh

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Abstract:

Bangladesh is a developing country and its economy depends largely on agriculture but the economic sector is most vulnerable to climate change and variability. This survey study is intended to know the nature of hazards, identify and analyze the adaptation options due to climate change in Shyamnagar upazila of Satkhira district. Data were collected from the farmers of selected five villages (Ramjannagar, Padmapukur, Munshiganj, Kashimari and Koikhali) of Shyamnagar Upazila of Satkhira district during August, 2016 to December, 2016 by open questionnaire process. The sample size of the study was 100 farmers and drawn from a population size of 650 using proportionate random sampling technique. Data were processed and analyzed using excel-2007 and SPSS-16. The study revealed that the intensity of salinity has increased and 91% of the respondents observed that some crops damaged than that of past and some other hazards (flood, cyclone, rainfall etc.) are posing new threat by changing their nature. About 86% of the respondents perceived and adapted to climate change. In the study area there were different adaptation options viz. sorjan method, crop rotation, saline tolerant varieties, crop diversification, mini pond, adjusting planting time etc. introduced for agricultural activities and also enhancing agricultural production, improve soil health. In the study area farmers faced some problems those problems are ranked using Problem Confrontation Index (PCI), there "lack of available water" (PCI-291) ranked 1st "shortage of cultivable land" (PCI-287) 2nd and "unpredicted weather" (PCI-284) 3rd respectively. The adaptation options were measured by applying Adaptation Strategy Index (ASI) method, there "sorjan method"(ASI-287) ranked first, "Crop rotation"(ASI-242) 2nd and "saline tolerant varieties" (ASI-232) 3rd which are the attractive adaptation options in the study area. About 86% of the respondents followed Boro rice-Vegetables-T.aman cropping pattern in Shyamnagar upazila. There are some barriers of adaptation measures like lack of irrigation facilities (94%), lack of knowledge (90%) and poor soils (90%) on the top. For water harvesting adaptation options farmers benefited by digging mini-pond in crop field, water reserve in narrow canal in crop field. DAE, CDMP, FAO and different NGOs are doing the jobs. However, due to introduction of innovated adaptation tecniques the said threats have been mitigated to a greater extent. And, this has become possible only for the coordinated support from the government, development partner (NGOs, WB, FAO etc.) and local people.

Key Words: *Climate change, Agricultural adaptation, Adaptation Strategy Index (ASI), Problem Confrontation Index (PCI)*

I. Introduction

Climate is the longstanding average weather of an area. It characterizes a region's general weather patterns that happen over the course of many years. The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. The climate has already changed significantly over the last 30 years (Fisher *et al*., 2005) and (FAO, 2007). Crop farming is

extremely vulnerable to climate change and it has been predicted that climate change will impact negatively on agricultural yield in the 21st century through higher temperatures, more variable rainfall and extreme climate events such as floods, cyclones, droughts and rising sea levels (Alam *et al.,* 2017 and Molua, 2002). According to IPCC 5th Assessment Report, global climate change is likely to further aggravate the flooding and salinity situations of South-Asian countries including Bangladesh. Under a high emission scenario, total sea level rise may reach up to 98 cm by 2100 (CDKN 2014). Bangladesh is one of the most vulnerable country to climate change. The main reasons for its vulnerability are due to (i) its location in the tropics, (ii) the dominance of floodplains, (iii) low elevation from sea level and (iv) high population density. Extreme climate events like major floods, drought and cyclones occur almost every year, and sometimes more than once a year, affecting the crop agriculture sector adversely particularly rice production (MOEF, 2005; Yamin *et al*., 2005). The people of Bangladesh are reported to be among the most at risk worldwide from sea-level rise (World Bank, 2007). Even at current rates of sea-level rise, more than one million people could be directly affected by sea-level rise in 2050 (Ericson *et al.,* 2006).

Climate change is one of the greatest challenges to the development process, and the adversity of climate change impacts is greater when they combine with factors such as increasing density of population, poverty, and reduced access to services, especially water supply and sanitation, energy, and health services (Rahman *et al*., 2007a). Recently, temperatures have been generally increasing in the monsoon period of June–August, with maximum and minimum temperatures increasing at the rate of 0.05℃ and 0.03℃ a year respectively (Rahman and Alam, 2003). Rainfall levels on average could become greater and more irregular overcoming decades, though winter rainfall levels may decrease. Annual rainfall rose at about 4 mm a year over the period 1978–2008 (MOEF, 2005). Coastal flooding and water logging due to excessive rainfall is frequent. The recent floods in 1998, 2004, and 2007 affected most of the coastal districts. Temperature and rainfall variations are already affecting both rice and non-rice crops in the coastal zone. The coastal areas of Bangladesh contain more than 30% of country's cultivable land. Tidal and estuarine floodplains cover 98% of this 30% of total area of the coastal belt (Haque *et al.,* 2006). Saltwater is already intruding into fresh water and increasing the level of salinity in many coastal districts in the southern part of the country, including Satkhira, Patuakhali, Pirojpur, Bhola, Khulna, Feni, and Noakhali (Islam, 2004). Salinity intrusion is affecting about 0.83 million hectares of land, resulting in reduction in crop yields (Rabbani *et al.,* 2010).

The storm damaged around 80% of the Sundarban area and destroyed crops over about 0.35 million hectares. Around a third of a million tons of rice (*Aus* and *Aman* variety) was damaged recently by excessive rainfall and flooding in Satkhira, one of the major rice-producing coastal districts of the country (BBS, 2010). Lack of water conservations technique and irrigation were other problem in Satkhira. (Rabbani *et al.,* 2010).

Different adaptation measures have been undertaken in the coastal areas of Bangladesh for decades in response to or in anticipation of the detrimental impacts of climate variability or climate change on

agriculture. Cultivation of different stress tolerant, hybrid and short duration crop varieties, improvement in agricultural management (crop rotation, sorjan method, crop diversification, mini pond etc.) infrastructural development, disaster preparedness and rehabilitation, awareness building, etc., have been mentioned as potential adaptation options in coastal Bangladesh. Some of these options have already been practiced in local level in a small scale which can be expanded with proper knowledge dissemination, community participation and coordination between different governmental and non-governmental organizations. A number of policy, framework and legislation have also been developed regarding agricultural adaptations in the coastal region of Bangladesh. But very few systematic studies have been performed on the evidence of adaptation practices in this country and their performance in successfully adapting to climate change (Karim *et al.,*1998). So the objectives of the research work were-

To study the characteristics of climatic hazards in the study area and

To study the perceived adaptability of different agricultural adaptation options against adverse effect of climate change in Shyamnagar Upazila.

II. Methods and Materials

The selected area was Shyamnagar upazila (Satkhira district) which under Khulna division of Bangladesh. It lies between 21º36' and 22º54' north latitudes and between 88º54' and 89º20' east longitudes. The total area of the district is 3817.29 sq. km. of which 1534.88 km is under reserve forest. The Main Rivers of the study area are Kobadak, Sonai, Kholpatua, Morischap, Raimangal, Hariabhanga, Ichamati, Betrabati, Kalindi, jamuna etc.

Data were collected from August, 2016 to December, 2016 and also collected from primary and secondary sources. Following information about socio-economic status were collected for conducting the research like as Name, Father's name, Gender, Occupation Educational qualification, Family size, Land size, Total family income of the respondent. Information about Climatic factors- Perception of long term temperature change, Support on climate change impact, Adaptation to climate change, Climate change impact on agricultural production, Distribution of responses to perceived changes in specific climatic events, Ranked order of the adaptation strategies to climate change, Adaptation options due to climate change, Type of hazards they face, Relative cost to practice the adaptation options. A total number of 650 farmers were listed. According to Yamane's (1967) formula, the sample size was determined as 100. In calculating sample size 9% precision level, 50% degree of variability and value of Z= 1.96 at 95% confidence level were chosen from the following formula: $n= Z^2P(1-P)N/Z^2P(1-P)+Ne^2$ Where; N= Population Size, n= Sample Size, e= The Level of Precision, Z= The value of standard normal variable at the chosen confidence level, P= The proportion or degree of variability. To fulfill of the objectives of the study structured questionnaires were prepared. The prepared questionnaire survey was done from the study area for primary data collection. Crop related data such as crop varieties, irrigation methods, cropping pattern, plantation etc. are collected from

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local people of the selected locations who have first-hand knowledge about the issues concerned. Secondary data were collected from different sources. These are Google Earth, Bangladesh Bureau of Statistics (BBS) and Agricultural statistics information's were collected from Shyamnagar Upazila Agricultural Office. Data were processed and analyzed from August, 2016 to December, 2016. The primary and secondary data were processed and analyzed with the help of Microsoft excel 2007 and statistical package SPSS-16.

In this study the relative importance of adaptation strategies to climate change was calculated based on the following index formula: ASI= ASn×0+ ASl×1+ASm×2+ASh×3 ----------(1) Where, ASI= Adaptation Strategy Index, ASn= Frequency of farmers rating adaptation Strategy as having no importance, ASl= Frequency of farmers rating adaptation Strategy as having low importance, ASm= Frequency of farmers rating adaptation Strategy as having moderate importance, ASh = Frequency of farmers rating adaptation Strategy as having high importance and problem confrontation was calculated based on the following index formula: PCI = Pn×0+Pl×1+Pm×2+Ph×3----------(2) Where, PCI = Problem Confrontation Index, Pn = Frequency of the farmers who rated the problem as not encountered, Pl = Frequency of the farmers who rated the problem as low, Pm = Frequency of the farmers who rated the problem as moderate, Ph = Frequency of the farmers who rated the problem as high. Uddin et al., (2014).

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III. Results and Discussions

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Survey was conducted to examine the hazards and analyze the adaptation strategies due to climate change on agriculture in Shyamnagar Upazila of Satkhira District. It is tried to know the adaptation options through the analyzing socio-economic status, present hazards and Agricultural adaptation strategies of the respondents. The major findings of the study are presented and discussed in this chapter.

3.1 Socio-economic condition of the respondents: Different categorize of socio-economic condition of the respondents were represents in Table 1. Gender had divided into 2 categories such as male and female, about 80% respondents were male and the rest 20% respondents were female in the study area. Respondent's age had classified into six categories (Table 1). From survey analysis it observed that, highest 27% respondent's ages were below 30 years and lowest 4% respondent's age were above 70 years. Marital Status had divided into 2 categories like, married and unmarried. Table 1 represents that, 94% percent of the respondents were married and 6% percent of the respondents were unmarried. Passed classes of the respondents were divided into different categories. Majority of the respondents were passed in secondary education level and it was 34% percent. 29% of the respondents were Illiterate. 27% of the respondents were passed in below Secondary education level. From Table 1, Family Members of the respondents was divided into 3 categories here, 71% respondents had family member below 4 and 26% respondent family members were 5-9. Earning members of the respondents were divided into 5 categories where, 82% of the respondents told that

his/her family earning members were only 1. About 12% of the respondent told that his/her family earning members were 2 and 4 percent told that family earning members were 3 (Table 1). Occupations of the respondents were divided into 10 categories (Table 1). From survey analysis it was found that, 10%t of the respondents were unemployed. 35% were related to agriculture, 17% were related to fishing and 14% were related to small business. Income per Month of the respondents was divided into 5 categories. From survey data, 8% respondents were below 2000 Tk. 18% of the respondent earned 2000-4000 Tk. 38% of the respondent earned 4000-6000 Tk. 26% of the respondent earned 6000-10000 Tk. 10% of the respondent earned above 10000 Tk.

Table 1. Socio-economic condition of the respondents

Characteristics	Measuring Units	Percentage (%)	Cumulative Frequency
Gender	Male	80	80
	Female	20	100
Age	Below 30 years	27	27
	31-40 years	25	52
	41-50 years	24	76
	51-60 years	12	88
	61-70 years	8	96
	Above 70 years	4	100
Marital Status	Married	94	94
	Unmarried	6	100
Passed Class	Illiterate	29	29
	Below Secondary	27	56
	Secondary (VI-X)	34	90
	Higher Secondary (XI-XII)	5	95
	Bachelor	3	98
	Masters	2	100
Family Members	Below 4 members	71	71
	5-9 members	26	97
	Above 10 members	3	100
Earning Members	1 members	82	82
	2 members	12	94
	3 members	4	98
	4 members	1	99
	5 members	1	100
Occupation	Unemployed	10	10
	Farmer	35	45
	Van Puller	5	50
	Fishing	17	67
	Small Business	14	81
	Handicraft	5	86
	NGO Worker	1	87
	Honey and Wood Collector	8	95
	Shrimp Firm Worker	3	98
	Driver	2	100
Income per Month	below 2000 Tk	8	8
	2000-4000 Tk	18	26
	4000-6000 Tk	38	64
	6000-10000 Tk	26	90
	Above 10000 Tk	10	100

3.2 Information about climate change and Agricultural Adaptation Strategies

3.2.1 Informed of climate change: Eighty three percent of the respondent's opinion was yes and seventeen percent of the respondent's opinion was no.

3.2.2 Informed of climate change sources: Most of the respondent's informed of climate change from television and it was 56 percent. Eighteen percent of the respondents heard from radio, 11 percent heard from newspaper and 10 percent heard from NGO.

3.2.3 Farmers perceptions on experiencing climate change: All of the respondents were asked a dichotomous ("yes/no" response) question about whether or not they had experienced changes to regional climate within the previous years. Table 2 reports their responses for individual climatic events. Here, all respondents indicated that they had experienced increases in Temperature, Cyclones and Salinity. Across all events, at least 80% or more reported having experienced climatic shifts which are likely to have a negative impact on agricultural activity. While it is clear that these are perceptions of farmers, such information provides an important background of the respond group.

Table 2. Distribution of responses to perceived changes in specific climatic events

Climatic events	% of respondents indicating to what level they have experienced the climatic events			
	Increased	No change	Decreased	Don't know
Temperature	100	-	-	-
Rainfall	-	18	82	-
Salinity level	100	-	-	-
Occurrence of flood	82	7	11	-
Occurrence of cyclones	100	-	-	-
Short winter season	89	4	-	7
Long Summer season	85	5	-	10
Changes of monsoon season	80	2	-	18

3.2.4 Constraints to adapting coping strategies faced by farmers: The problem identified by farmers which can hinder or constrain adaptation of the climate change coping strategies identified and investigated in this report and this section discusses the related results (Table 3). Similar to previous sections, a ranking of the problems was completed using a Problem Confrontation Index (PCI) value as estimated by using the formula (2). Survey respondents were asked to rate their perception of each constraint on a four-point Likert scale ranging from 'not encountered' to 'high'.

Based on the results of the formula, the problems were listed in rank-order also presented in (Table 3). The results indicate that "Lack of available water (both irrigation and drinking)" ranked first and seems to be the most severe problem of the farmers in the region studied in terms of adaptation of climatic change adaptation strategies. Land use policy is also one of the most important issues enabling this decrease in cultivable land.

Table 3. Rank of the problems faced by the farmers

Problems	Degree of problems				CI	
	High (3)	Medium (2)	Low (1)	t All(0)		
vailable water gation and drinking)	92	7	1	-	**91**	1
of cultivable land	89	9	2	-	87	2
ted weather	85	14	1	-	84	3
redit/money	69	9	-	22	25	4
	57	14	22	-	21	5
gging	46	19	13	22	89	6
nformation	45	52	-	3	87	7
narket access	42	17	20	21	80	8
fertility	42	10	32	16	78	9

3.2.5 Agricultural effects due to climate change: Increase in salinity was the top problem (78%) in the study area and the respondents were told that salinity intrusion increase day by day (Figure 1). Around 72% and 67% of the respondents were said that flood intensity and hampering of food security were increased respectively in study area. 76% and 77% of the respondents told that crop yield and soil fertility is drastically reduce but they also said that after flood aggregate silt and improve soil fertility.

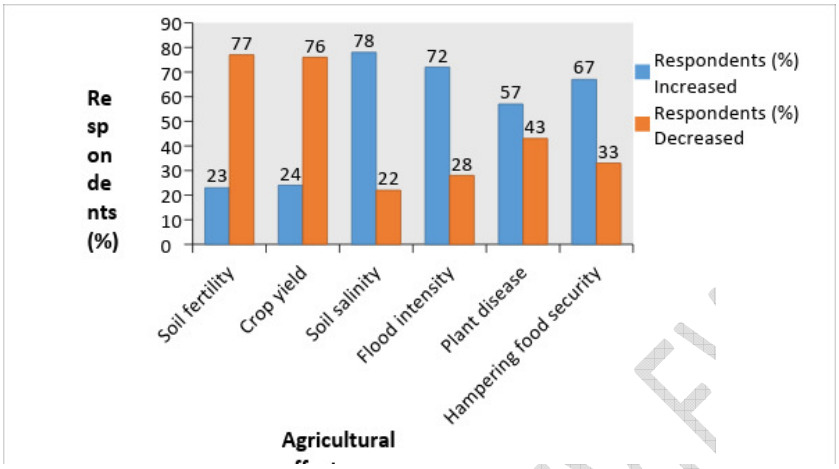

Figure 1. Agricultural effects due to climate change

3.2.6 Effect of salinity on agriculture: Most of the respondents (91%) referred that some crops damaged in their crop field due to salinity factors in the study area (figure 2). Lack of fresh water in the study area 62 percent of the respondents cited that irrigation cost increasing for fulfill the demand of fresh water as well as increase fallow land (42%) and reducing cropping intensity (40%) due to salinity. Some respondents (13%) mentioned that crops totally damaged option increased day by day due to climate change

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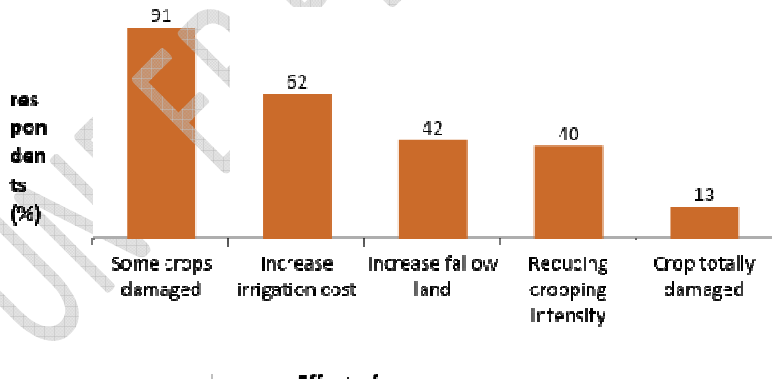

Figure 2. Effect of salinity on agriculture

3.2.7 Farmers Adaptation Strategies to Climate Change: An overwhelming majority 86% of respondent farmers indicated that they had employed at least one of the identified adaptive strategies, with only 14% indicating no adoption of any of the adaptive strategies included in this study (figure 3).

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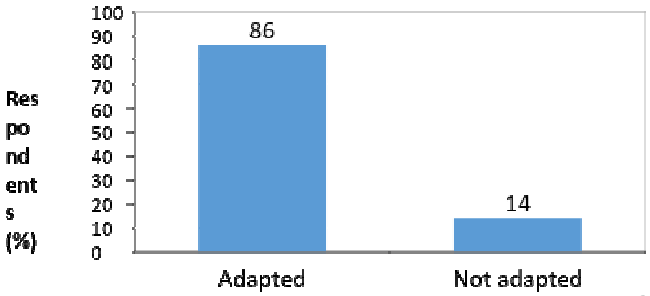

Figure 3. Proportion of respondents by adaptation classification

3.2.8 Adaptation Strategy Index: To identify those adaptive strategies which held related importance over others an adaptation index procedure was implemented, as measured by the formula (1). Farmers were asked to assess different adaptation strategies by using the same four-point rating scale. The relative importance of adaptation strategies to climate change was calculated based on the index formula (1).The ranking of different adaptation strategies to climate change, as identified by the surveyed farmers are presented in (Table 4).

3.2.9 Adaptation Strategies: Practices in Shyamnagar Upazila, Out of 13 adaptation strategies, Practicing "Sorjan method" (ASI-287) was ranked first (Table 4) and thus most important, among farmers' adaptive strategies to climate change. Practicing "crop rotation" (ASI-242), "use of salinity tolerant varieties" (ASI-232), "crop diversification" (ASI-221), Mini pond (ASI-218), "Adjusting planting time" (ASI-195) ware identified as the 2nd, 3rd, 4th, 5th ,6th ranked in adaptation strategy (Table 4).

In the face of changing climates with higher uncertainty of rainfall, late varieties of Aman rice have been the viable adaptation option for such climate stressors. Moved to non-farm activities, Integrated farming system, increased use of irrigation, Agroforestry, Soil conservation techniques were ranked 7th, 8th, 9th, 10th, and 11th respectively (Table 4). Crop insurance (ASI-79) was ranked as the least important adaptation strategy. This is most likely due to (1) a significant lack of good management of finance institutions in the country underwriting agriculture and offering farm-based insurance products (2) Poor deployment of technical assistance and low-levels of farmer awareness about the use of agricultural insurance (3) Only a very recent abatement of governmental regulations and policies which placed prohibitive restrictions on insurances provision entities and (4) an overall lack of capacity (financial, infrastructure and human) among in-country financial institutions to float insurance programs.

Table 4. Ranked order of the adaptation strategies to climate change

ɔtation strategies	Importance of your farm				SI	ank
	High (3)	Medium (2)	Low (1)	t all(0)		
g Sorjan method	90	7	3	-	67	1
g Crop rotation	58	30	8	4	42	2
alinity tolerant verities	56	32	12	-	32	3
g Crop diversification	45	37	12	6	21	4
d	60	14	10	16	8	5
g planting time	33	47	2	18	05	6
ɔ non-farm activities	38	32	9	21	87	7
d farming system	45	13	14	28	75	8
d use of irrigation	36	12	25	27	57	9
stry	22	12	30	36	20	10
servation techniques	14	13	27	16	5	11
urance	9	11	28	52	9	12

3.2.10 Major cropping pattern at present: In the present time there were many types of cropping pattern prevail in the study area (Table 5). Now a day, farmers are conscious about their farming. Different types of adaptation options have already been adapted by DAE, CDMP, FAO and NGOs in the study area.

Table 5. Major cropping pattern

Sl. No.	Major cropping pattern	Farmers opinion	
		No. of respondents	Percent (%)
1	Boro rice- Vegetables –T. aman	86	86
2	Vegetable-Fallow-T. aman	62	62
3	Vegetable-Vegetable-Vegetable	56	56
4	Boro rice-Fallow-T. aman	48	48
5	Boro rice-Fish-Fish	42	42

From the table 5 we can see that Boro rice- Vegetables –T. aman (86%) cropping pattern existing of that area but vegetable- vegetable-vegetable cropping pattern are increasing (56%). Because, farmers are using homestead or small scale land for vegetable cultivation and also adapt different type of

techniques for year round vegetable cultivation. Water melon, aus, potato, and boro rice also cultivate in Shyamnagar Upazila.

3.2.11 Adaptation Measures: Figure 4 shows that various existing adaptation measures. They take major steps for adaptation. Most of the respondent's opinions were yes about change crop varieties, Reduction in number of livestock, reduction in cultivated land, use of irrigation, use of shades and shelters. 62% respondents changed crop varieties because they cultivated saline tolerant crop varieties. About 96% respondents said that cultivated land has been reduced due to construction of new houses in cultivated land. About 84% respondent's opinion is yes about reduction in number of livestock. Major cause of this problem is domestic animals like cow and goat were loss their survival for Climate change. 80% farmers used irrigation for agriculture practices because the salinity water was major cause of agriculture. About 82% respondents used of shade and shelters against climate change. Smaller percentage of respondent opinion was not about those options. Most of the respondents opinion was no for change of planting dates, movement to different sites, switching from livestock to crops, use of water conservation techniques, use soil conservation techniques, rural urban migration, search off farming jobs and change use of chemical fertilizers. Smaller percentages of respondent's opinion were yes about of those options.

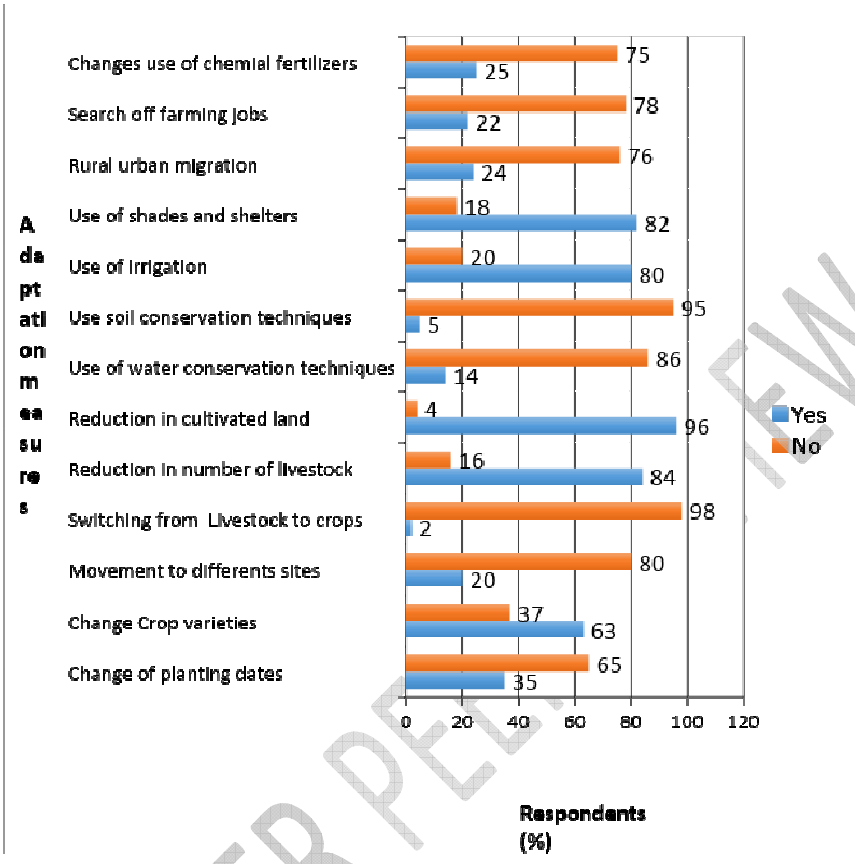

Figure 4. Different Adaptation measures

3.2.12 Barriers of adaptation measures: From figure 5 it was found that respondents had given some opinions about adaptations barriers.64% respondents opinions' were yes and 36% opinions were no about lack of information's. 94% respondents were said that, their major barriers are lack of irrigations facility. About 90% respondents gave opinions about lack of knowledge. Respondents give opinion yes for other adaptations barriers such as lack of money, lack of own land, poverty, lack of storage facilities, poor soils and low level of technology. 54% respondents opinion yes for lack of money, 36%for lack of own land, 81% for poverty, 30% for lack of storage facilities, 90% for poor soils and 5% for low level of technology respectively.

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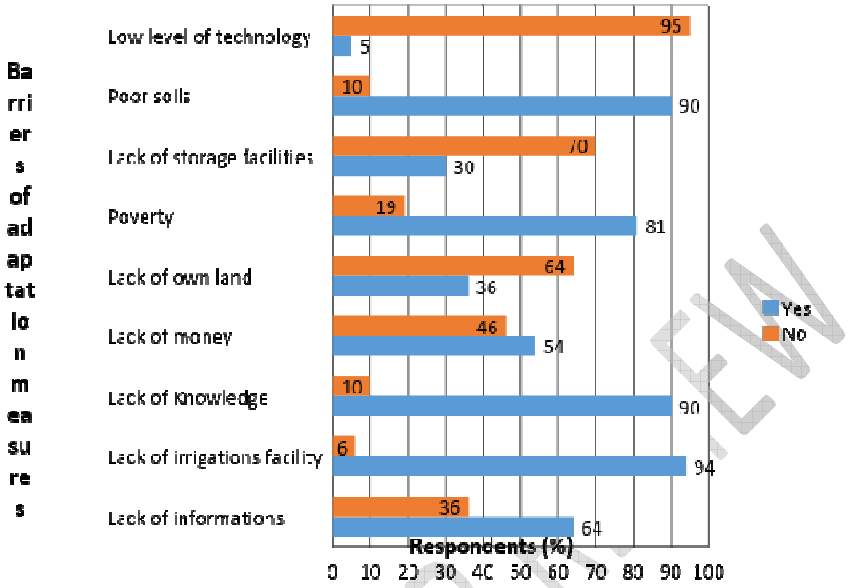

Figure 5. Some barriers of adaptations measures

3.3.1 Future Adaptation Measures: Adapting to rising salinity levels in the future will require an extension of the coping measures currently employed – primarily the use of canal and of saline-resistant varieties. For example, 95% of all respondents agreed that canal need to be dug in order to irrigate freshwater for crop cultivation. A lack of canal and/or a lack of freshwater sources were a commonly-cited barrier to adopting saline-resistant varieties. Other adaptation measures include:

- Draining out of saline water by using power pumps
- Using underground water through deep and shallow tube wells
- Building dykes and embankments to resist saline water intrusion
- Using additional fertilizer/chemicals
- Using green manure

In order to overcome the barriers that obstruct the uptake of saline-resistant varieties, 65% of the households studied excavate canals, set up shallow tube-wells and manage drainage systems. 50% of the study population also feels that the development of saline-resistant crops, improving the quality of seeds, and facilitating seed distribution are necessary to reach the adaptation benchmarks. Several respondents also indicated for the smoothly supply of fertilizer and pesticides. Furthermore, 12.7 per cent of the households feel that building embankments is key to overcoming obstacles to adaptation.

Training has also been mentioned by a quarter of the households surveyed as a method of overcoming the barriers to adaptation. Some expert and Stakeholders at different levels in Satkhira district gives some opinion for overcome from this barriers. The required actions can be classified as:

- Developing saline-resistant varieties
- Disseminating saline-resistant varieties
- Adopting saline-resistant varieties

IV. Conclusion

Climate change awareness through observation and copious media attention could help a farmer to plan easily for future mitigation strategies and enable policy makers to implement and facilitate adaptation strategies. This study conducted to local level agricultural adaptation strategies in relation to hazard-prone resource-poor rural households' perception of climate change and climatic hazards using survey data. From the survey study it might be concluded that different climatic hazards like salinity, flood, cyclone, water logging, erratic rainfall and insect-pest infestation were occurred in Shyamnagar Upazila. But salinity was the devastating hazards in that area. To minimize those climatic hazards farmers were practicing different adaptation strategies like Sorjan method (ASI-287), crop rotation (ASI-242), saline tolerant varieties (ASI-232), crop diversification (221), mini pond (ASI-218), integrated farming system (ASI-175), Agroforestry (ASI-120), crop insurance (ASI-79) etc.

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