Indian Journal of Extension Education
Vol. 55, No. 3, 2019 (49-55)

Adaptation Strategies to Climate Change among the Farming Community of the Indian Sundarbans

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ABSTRACT

Climate change is a world-wide event. The climate change of Indian Sundarbans reveal the changes in air temperature, surface water temperature, rainfall and monsoonal pattern, salinity regimes, cyclonic storms and depressions, sea level rise, erosion and accretion. To cope up with the adverse impact of climate change, farmers made adjustment in their farming practices. The present study was designed to determine the differential level of adoption of the prelisted adaptation strategies to climate change. A total 120 farmers who were growing crops, rearing livestock as well as involve in fish farming, simultaneously were selected from 5 blocks of the Indian Sundarbans. For assessing differential level of adoption, Cumulative square root frequency method was used to categories households into three categories namely lower level of adoption (low); medium level of adoption (medium); and higher level of adoption (high).The level of adoption of the adaptation strategy was measured under four components namely, crop cultivation, livestock rearing, fish farming and other farming activities. It was found that majority of the respondents had high level of adoption in crop cultivation practices, medium level of adoption for livestock rearing and other farm practices, while, they had low level of adoption in fish farming.

Keywords: Adoption, climate change, cumulative square root frequency method, livestock rearing.

INTRODUCTION

Climate change is the fluctuation in the average weather conditions including steady alteration in usual temperature (rise or fall), rainfall regime (pattern or intensity), wind, relative humidity and solar radiation overtime. Climate change poses serious threats to agricultural sustainability and poverty alleviation in the poorest and most vulnerable regions (Morton, 2007). Climate change impacts on agriculture include biological effect on cropyield, the resulting impact on prices, production, consumption and the impact on per capital calorie consumption and malnutrition (Vani and Kumar, 2016). Its impact affects the dependence on rain fed agriculture, results in increasing level of poverty, low level of human and physical capital development, inequitable land distribution and poor infrastructure development (Ikehi *et al.,* 2014). The most obvious manifestation of climate change is the rising of average worldwide temperature, popularly termed as global warming. Considering the present rate of temperature rise, thermal expansion of sea water and higher rainfall there is a strong probability that the sea level rise will be 50 cm by 2050.This implies higher coastal erosion and inundation, and a higher surge height duringcyclones (Hazra, 2012).

Coastal belts are more prone to devastating impact of climate change (IPCC, 2007).The Sundarbans, a delta of the rivers the Ganga, the Brahmaputra and the Meghna is located in West Bengal state of India and neighboring country of Bangladesh, is thelargest delta of the world.Sundarbans falls under the Complex-Diverse- Risk Prone (CDR) agro ecosystem. The climate of Sundarban is changing fast and the changes observed during the last two and ahalf decade (1976-2010) reveal decrease in dew deposition, increasing behavior of erraticnature of weather, reducing nature of winter span, faster rising

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trends of average daily minimum temperature, uncertainty of post monsoon weather and rising Incidences ofpartial break or mid-monsoon (Chand *et al.,* 2012). Based on various studies around the globe, it is now widely accepted among scientists that the values of the some of the basic climatic parameters, namely the air temperature, air pressure, relative humidity and precipitation, are changing at an alarming rate in the world-wide scale, especially since the last few decades (IPCC, 2013). Both temperature and precipitation is showing an increasing trend (Raha *et al.,* 2012; Pitchaikani *et al.,* 2017). The coastal region of Indian Sundarbans is traditionally backward and disadvantaged with low agricultural productivity and poor livelihood security of the farmers (Human Development Report, South 24 Paraganas, 2009). The ecosystem ofthe region is extremely fragile and vulnerable to degradation due to anthropogenicactivities. The farming community of this region is dominated by small and marginal and landless farmers, majority of whom belong to backward communities (Roy, 2010). The nature of farming is different in Sundarban as segments of land are not conjoined, which makes the fair distribution of water a problem. Paucity of sweet water in the regionposes a major problem for irrigation (Pakrashi, 2016). Thus the Sundarbans, a coastal, underdeveloped area, is one of the most sensitive victims of climate change in India. For the residents of Sundarbans, climate change is now a part of their daily battle for survival. Hence, they made adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, to moderates harmful or exploit beneficial opportunities. Adaptation strategies are the measures adopted and/or followed by the farming community to cope up with the adverse impact of climate change. As agriculture is climate sensitive sector it faces adverse impacts of climate change and climate variability, therefore it is imperative for farmers to deal with them through various adaptation strategies (Chunera and Amardeep, 2018). Adaptation is place and context specific. There is no single appropriate approach for reducing risks across all settings (Rakshitet al. 2016).Thus, the present study was conceptualized to determine the differential level of adoption of the climate change adaptation strategies taken by the farmers for crop farming, livestock rearing,fisheries and other allied farm practicesof the Indian Sundarbans.

METHODOLOGY

Sampling plan

The purposively selected Indian Sundarbans comprises of 19 Community Development blocks of North and South 24-Parganas districts of West Bengal (Fig. 1). Out of 19 blocks, 5 blocks namely, Canning-I, Basanti, Kultali, Namkhana and Kakdwip were randomly selected. Subsequently, 2 villages from each block were selected randomly. Thus, the present study was confined to 10 villages. From each village 12 farmers who weremixed farmers involved in the activity of the growing of crops as well as the raising of livestock and fishing activities were selected, randomly, as respondents for this study. Hence, a total of 120 respondents were selected for the purpose of accomplishing the objective of the study. Data were collected in two phases during August 2017 to March 2018. In the first phase, list of adaptation strategies were prepared by focused group discussion and by applying observation method. Detail of adoption of each adaptation strategy was explored in the second phase of data collection by personal interview method at the door step of the farmersand/or grazing ground and/or their field of crop productionwith the help of pre-tested structured interview schedule.

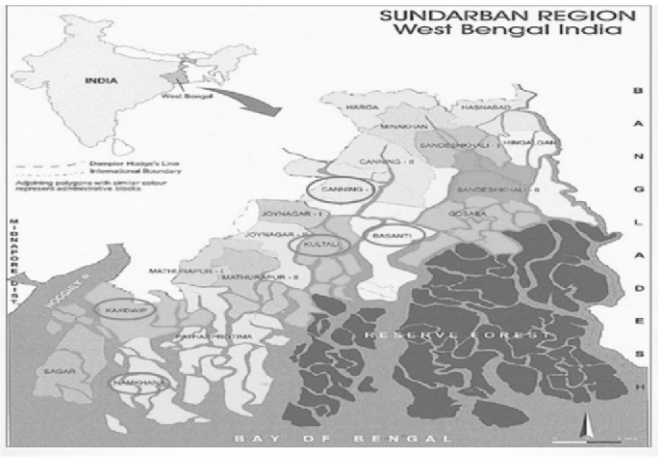

Fig 1: Locale of the study
(oval shape indicate the selected blocks)

Differential level of adoption among the sampled households

Adaptation refers to adjustment in ecological, social or economic systems in response to actual or expected climate stimuli and effects or impacts (IPCC 2001). Adaptation strategies were operationalized as the measures adopted and/or followed by the farming community to cope up with the adverse impact of climate change on their mixed farming. Lists of adaptation strategies followed in mixed farming were prepared during the pilot and first phase of the study, with expert consultation and review of literature which are presented in Box 1, Box 2, Box 3 and Box 4. In the present study, the level of adoption of the adaptation strategy was measured under four components namely; crop cultivation, livestock rearing, fish farming and other allied farming activities.

Box-1	Box-2
Adaptation Strategies for crop cultivation	**Adaptation Strategiesfor livestock rearing**
Use of traditional/indigenous crop varieties	Cultivation of fodder crops on raised land
Land shaping	Shifting from large ruminants to small ruminants
Change from mono -cropping system to multi-cropping system	Use of indigenous knowledge to combat with livestock disease
Ail Cultivation	Housing with cross ventilation for keeping livestock
Use of indigenous technological knowledge	Providing extra concentrates and mineral supplements to livestock
On farm production of microbial biopesticide	Providing adequate clean and fresh drinking water
Management of acid sulphate soil by liming	Rearing of Garole sheep
Using of shallow tubewell for withdrawal of ground water during rabi season	Breeding of animals by natural mating
Box-3	**Box-4**
Adaptation Strategiesfor fish farming	**Adaptation Strategiesfor other allied farm practices**
Practicing Brackish Aquaculture	
Cultivation of stress tolerant monosex tilapia	Ornamental bird rearing
Ornamental fish rearing	Rearing of stress tolerant poultry bird
Paddy cum Fish Farming	Practicing Vermicomposting
Practicing Composite Fish Culture	Practicing Bee-keeping
	Practicing of Integrated Farming System

Farmers who recognized the changing climatic scenario during last 30 years were directly asked whether they adopt any adaptation strategy to cope up with the climate change on the binary response 'YES' or 'NO'. Those who responded 'YES', were again requested to put their response on a three point continuum viz. continued the adoption, discontinued the adoption and never followed/adopted with the score of 2, 1, and 0 on the identified adaptation strategies. The entire sampled households were categorized into three differential level of adoption of adaptation strategies on the basis of obtained adaption score by the respective house holds. Cumulative square root frequency method was used to categories households into three categories (Table 1).

Table 1: Criteria of categorization of differential adaptation strategies

Category	Score for differential level of adoption			
	Crop cultivation	Livestock rearing	Fish farming	Other farming practices
Lower level of adoption (Low)	12.00-19.33	2.00-6.45	2.00-3.40	2.00-6.03
Medium level of adoption (Medium)	19.34-23.93	6.46-10.53	3.41-5.43	6.04-8.50
Higher level of adoption (High)	23.94-29.00	10.54-16.00	5.44-10.00	8.51-13.00

RESULTS AND DISCUSSION

Climate change adaptation among the farming community of the Indian Sundarbans

Extreme climate events include unexpected, unusual, unpredictable severe orunseasonal weathercondition. It is evident from Table 2 that all the respondents of the studied area had experienced extreme climatic events during last 10 years. Also Table 3 shows that all the respondents had witnessed storm and cyclone.

Table 2: Distribution of respondents according to extreme climate events experienced

Extreme climate events experienced	Frequency	Percentage
Experiencedextreme climate events	120	100
Not experienced extreme climate events	-	-

Table 3: Distribution of respondents according to different types of climate events experienced

Different types of climate events experienced	Frequency	Percentage
Extremely heavy rainfall only	48	40
Flood	72	60
Storm	120	100
Cyclone	120	100
High Temperature (heat wave)	36	30

Adoption of adaptation strategiesto cope up with climate change

State of adoption of the adaptation strategies followed for crop cultivation

Table 4 vividly describes the state of adoption of the 8 adaptations trategies among the crop cultivars of the studied area. It was found that the 100 per cent of the crop cultivars continues grow indigenous/traditional crop varieties. About 98.33 per cent respondents followed and continued to use indigenous technological knowledge for growing crops, remaining 1.67 per cent never followed it. Shifting from monocropping to multi-cropping system was followed and continued by 74.17 per cent of farmers. More than two-third of the crop growers followed and continued Ail cultivation (70.83%) and land shaping (65%).

It was observed more than half of the respondents (56.67 %)followed using of shallow tube well for withdrawal of ground water during rabi season while 43.33 per cent never adopt it. On farm production of microbial bio pesticide and management of acid sulphate soil by liming were practiced by 47.5 per cent and 40 per cent respectively remaining others never followed at all.

Table 4: Adoption of adaptation strategies followed by the farming community of Indian Sunderban for crop cultivation

n=120

Adaptation strategies adopted for crop cultivation	Adopted (%)	Not adopted (%)
Use of traditional/indigenous crop varieties	100	-
Land shaping	65	35
Change from mono-cropping system to multi-cropping system	74.17	25.83
Ail Cultivation	70.83	29.17
Use of indigenous technological knowledge	98.33	1.67
On farm production of microbial biopesticide	59.17	40.83
Management of acid sulphate soil by liming	69.17	30.83
Using of shallow tubewell for withdrawal of ground water during rabi season	56.67	43.33

State of adoption of the adaptation strategies followed for livestock rearing

Table 5 highlights the state of adoption of the documented 8 adaptation strategies among the livestock rearers of the studied area. It was found that the 100percent of the livestock-rearer continued practicing indigenous knowledge to combat with livestock disease. Less than half of the respondents (45.83%) were shifting from rearing of large ruminants to small ruminants while remaining (54.17%) never followed. 23.33 per cent livestock-rearers continues to provide extra concentrates and mineral supplements to their livestock while remaining 76.67 per cent never followed at all. 90 per cent livestock rearers support housing with cross ventilation for keeping their livestock while only 10 per cent did not followed. More than half of the livestock rearer (58.33%) continues to supply more drinking water to their herd. Garole rearing was practiced by 60.83 per cent of livestock rearers. Only 6.67 per cent livestock rearers cultivate fodder crops on raised land, 2.5 per cent discontinued it while remaining 93.33 pe cent did not adapt it. Breedingo f animals by natural mating was followed and continued by 58.33 per cent of livestock rearers.

Table 5: Adoption of adaptation strategies followed by the farming community of Indian Sunderban for Livestock rearing

n=120

Adaptation Strategies adopted for livestock rearing	Adopted (%)	Not adopted (%)
Cultivation of fodder crops on raised land	6.67	93.33
Shifting from large ruminants to small ruminants	45.83	54.17
Use of indigenous knowledge to combat with livestock disease	100	-
Housing with cross ventilation for keeping livestock	90	10
Providing extra concentrates and mineral supplements to livestock	23.33	76.67
Providing adequate clean and fresh drinking water	61.66	38.33
Rearing of Garole sheep	60.83	39.17
Breeding of animals by natural mating	58.33	41.67

State of adoption of the adaptation strategies followed for fisheries

Table 6 describes the state of adoption of the observed 5 adaptation strategies among the fish farmer of the studied area. It was found that the majority (77.5 %) of the respondents followed and continues composite fish culture while remaining (22.5%) never followed it. Paddy cum fish farming were followed and continued by 38.33 per cent of the respondent while others did not follow it. Brackish aquaculture and Cultivation of stress tolerant mono sex tilapiawere followed 30 per cent of the respondent while others did not follow it. Ornamental fish rearing was least followed (7.5%) adaptation strategies.

Table 6: Adoption of adaptation strategies followed by the farming community of Indian Sunderban for fish farming

n=120

Adaptation Strategies adopted for fish farming	Adopted (%)	Not adopted (%)
Practicing Brackish Aquaculture	30	70
Cultivation of stress tolerant monosex tilapia	30	70
Ornamental fish rearing	7.50	92.5
Paddy cum Fish Farming	38.33	61.67
Practicing Composite Fish Culture	77.5	22.5

State of adoption of the adaptation strategies followed for other farming practices

Table 7 depicts the state of adoption of the cited 5 adaptation strategies among the farmers of the studied area. It was found that the all the respondents were practicing integrated farming system (100%) followed by vermi composting (79.17%). About two-third (70%) of the farmers were farming stress tolerant poultry bird while remaining never followed. Bee keeping and Ornamental bird rearing were followed and continued by 61.67 and 8.33 per cent respectively.

Table 7: Adoption of adaptation strategies followed by the farming community of Indian Sunderban for other farming practices

n=120

Adaptation Strategies	Adopted (%)	Not Adopted (%)
Ornamental bird rearing	8.33	91.67
Rearing of stress tolerant poultry bird	70	30
Practicing Vermicomposting	79.17	20.83
Practicing Bee-keeping	61.67	38.33
Practicing of Integrated Farming System	100	-

Differential level of adoption of adaptation strategies among the farming community of the Indian Sundarbans

All the sampled households of the Indian Sundarbans who recognized the changing climatic scenario and adopted at least one adaptation strategy were categorized into three differential level of adoption of adaptation strategies *i.e.* low, medium, and high on the basis of obtained index score by the respective households. Cumulative square root frequency method was used to categories households into three categories *viz.* low, medium and high,under four components namely; crop cultivation, livestock rearing, fish farming and other allied farming activities.

Distribution of respondents according their differential level of adoption of adaptation strategies followed for crop cultivation

All the respondents of Indian Sundarbans were categorized into three differential level of adoption *i.e.* low, medium and high on the basis of obtained index score by the respective farmers. Cumulative square root frequency method was used to categories into low,

medium and high level of adoption. Figure 2clearly shows that 40.83 per cent respondents were having higher level of adoption followed by 34.17 per cent and 25 per cent were having medium and low level of adoption, respectively in case of adoption of adaptation strategies related to crop cultivation.The reasonthat majority (40.83%) of the respondents shows higher level of adoptions that 53.96 per cent of their average income was earned from crop cultivation as calculated during field survey.

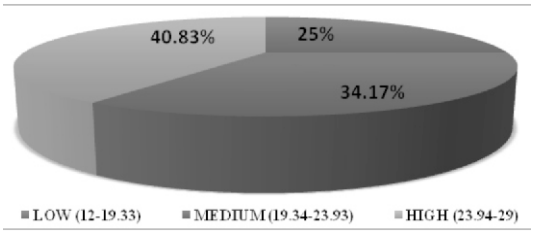

Fig 2: Distribution of respondents according their differential level of adoption of adaptation strategies followed for crop cultivation

Distribution of respondents according their differential level of adoption of adaptation strategies followed for livestock-rearing

In case of adoption of the adaptation strategies followed for livestock rearing, all the respondents were categorized into three differential level of adoption of adaptation strategies *i.e.* low, medium and high on the basis of obtained index score by the respective farmers. Cumulative square root frequency method was used to categories into low, medium and high level of adoption. Figure 3 clearly shows that 24.17 per cent of the farmers were having higher level of adoption followed by 45 per cent and 30.83 per cent were having medium and low level of adoption, respectively in this category.The livestock composed of cattle (both indigenous and cross bred), sheep and goat. The breed present in the herd composition was mostly indigenous nondescript cattle and some were upgraded with Gir and Sahiwal. The productivity of both indigenous and cross bred was very low. Moreover, the average holding of the herd of the small and marginal farmers was very low. Thus, majority (45%) farmers were showing medium level of adoption in following the adaptation strategies to livestock rearing.

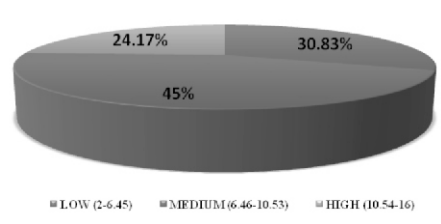

Fig3: Distribution of respondents according their differential level of adoption of adaptation strategies followed for livestock rearing

Distribution of respondents according their differential level of adoption of adaptation strategies followed for fish farming

Regarding adaptation strategies followed for fish farming, all the respondents of the study area were categorized into three differential level of adoption of adaptation strategies *i.e.* low, medium and high on the basis of obtained index score by the respective farmers. Cumulative square root frequency method was used to categories into low, medium and high level of adoption.Figure 4clearly shows that 15.83 per cent of the farmers were having higher level of adoption followed by 35.83 per cent and 48.33 per cent were having medium and low level of adoption, respectively for the adaptation strategies followed for fish farming.Majority of the respondents shows low rate of adoption of the adaptation strategies because oflack of information about major insect and pest attack, poor fisheries extension services, feed adulteration and low water quality.

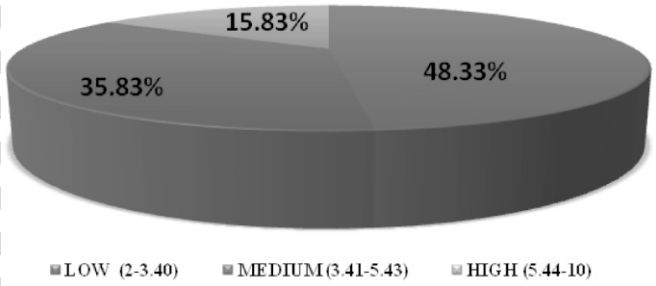

Fig 4: Distribution of respondents according their differential level of adoption of adaptation strategies followed for fish farming

Distribution of respondents according their differential level of adoption of adaptation strategies for other allied farming practices

Other farming practices were operationalized as all farming activities except crop cultivation, livestock-rearing and fish farming.All the sampled farmers of Indian Sundarbans were categorized into three differential level of adoption of adaptation strategies *i.e.* low, medium and high on the basis of obtained index score by the respective farmers. Cumulative square root frequency method was used to categories into low, medium and high level of adoption. Figure 5 clearly shows that 25.83 per cent farmers were having higher level of adoption followed by 44.17 per cent and 30 per cent were having medium and low level of adoption, respectively, with respect to other farming practices. Thus, majority (44.17%) shows medium level of adoption due to lack of knowledge and technical guidance, current marketing know-how and facilities.

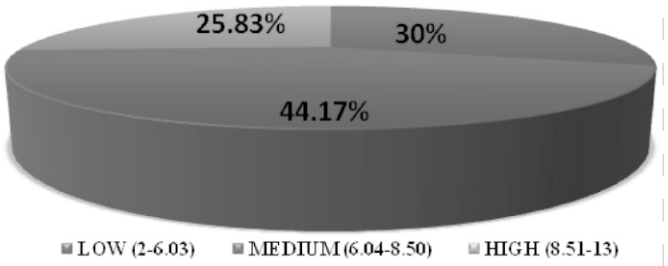

Figure 5: Distribution of respondents according their differential level of adoption of adaptation strategies followed for other farming practices

CONCLUSION

In this study, it was found that, farmers of the Indian Sundarbans is dependent upon climate-sensitive sectors such as agriculture, forests, animal husbandry and fisheries along with its high physical exposure to climate-related disasters. They were highly experienced towards climatic disaster and followed adaptation strategies to cope up with it. The main goals of climate change adaptation are to reduce vulnerability and build resilience to the impacts brought by climate change (Brooks and Adger, 2005). A total of 26 adaptation strategies to cope up with climate change were documented, out of which 8 adaptation strategies followed in crop cultivation, 8 in livestock rearing, 5 in fish farming and 5 in other allied farm practices. It was found that majority of the respondent had high level of adoption in crop cultivation practices, medium level of adoption for livestock rearing and other allied farm practices, while, they had low level of adoption in fish farming. To increase the level of adoption for livestock rearing, cultivation of fodder should be enhanced along with the upgradation of the indigenous livestock breed. For increasing the level of adoption for other allied farm practices promotion of Integrated Farming System models should be done.For enhancing the level of adoption in fish farming, a dedicated team of fishery extensionistsmust be trained or promoted to teach the farmers in different aspects of climate change including scientific adaptation strategies in fish farming.Thus, the present study provides an insight into the differential level of adoption of the climate change adaptation strategies by the farming community. This study also serve as guide line for the extension workers to intensify their effort in promoting integrated farming systems for enhancing farmers' income and nutritional security in changing climatic scenario.

Paper received on : December 19, 2018
Accepted on : January 22, 2019

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