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Perception of and Adaption Capacities to Climate Change Adaption Strategies by the Rice Farmers: A Case of Rajshahi District in Bangladesh

Bikash Chandra Ghosh[1*], Md. Ataul Gani Osmani[2], Md. Elias Hossain[3]

1. Lecturer, Department of Economics, Pabna University of Science & Technology, Pabna-6600, Bangladesh.
2. Research Student, Department of Economics, University of Rajshahi, Rajshahi-6205, Bangladesh.
3. Professor, Department of Economics, University of Rajshahi, Rajshahi-6205, Bangladesh.

*Email of the corresponding author: bikasheco_pust@ymail.com

Abstract

This paper evaluates rice farmers' perception and climatic variability using climate record. Adaptive capacities of rice farmers to climate change adaption strategies for the Rajshahi district were also identified. Forty two years of climate data on temperature and rainfall (1972-2013) from the Bangladesh Metrological Department (BMD) for Rajshahi weather station were collected and analyzed using non-parametric Mann-Kendall test. Questionnaire survey was conduct to understand farmers' perception and adaptations in response to changing climate and variability. The results revealed that an increase in annual temperature of +0.04º C form 1972 to 2013 has be recorded for the Rajshahi district, Bangladesh, whereas annual rainfall has not exhibited any trend but Sen's slope is negative for rainfall implies decreasing trend with time. The adaptive capacities of rice farmers were estimated quantitatively and categorized into high, moderate and low adaptive capacities. Result of adaptive capacities revealed that on the average the farmers' interviewed are moderately adaptive to climate change. As high adaptive farmers obtain higher amount of rice therefore, the more a farmer has the ability to adjust to climate change, the more the amount of rice he or she obtain. Rice farmers should be empowered through better extension services in order to attain high adaptive capacity status so as to help them obtain more rice output.

Keywords: Adaptive Capacities, Adaptive Strategies, Climate Change, Farmers' perceptions, Rajshahi District, Bangladesh.

1. Introduction

There is a consensus that over the coming decades, anthropogenic climate change will cause dramatic transformations in the biophysical systems that will affect human settlements, ecosystem services, water resources and food production; all of which are closely linked to human livelihoods (UNFCCC, 2005; IPCC, 2001, 2007; O'Brien & Leichenko, 2007; Mearns & Norton, 2010). These transformations are likely to have widespread implications for individuals, communities, regions and nations. In particular, poor, natural resource-dependent rural households will bear a disproportionate burden of the adverse impacts (Adger, 2001, 2003; Burton, Diringer & Smith 2006). Agriculture systems world over contribute substantially to the greenhouse gas emissions (Easterling et al., 2007). As a small country and also as a developing country, the contribution of Bangladesh for the global green house gas emissions is minimal, yet the vulnerability to the consequences of the climate change is high in Bangladesh. In developing countries there are many more areas other than the environment that are vulnerable to the direct and indirect effects of climate change (Baba, 2010). According South Asia Watch on Trade, Economics and Environment (SAWTEE, 2013), rice cultivated in most South Asian countries show a gradual stagnation in production levels mainly caused by the changes in temperature regimes. The assumption that increased greenhouse gas concentrations may lead to a rise in global temperatures first emerged in the 1960s (Peterson et al. 2008). The great majority of climate scientists now agree that the evidence for anthropogenic global warming is strong (Rosenberg et al. 2010). Predictions of average temperature changes and the economic costs of climate change are uncertain, but generally bleak: for increases of 5–6°C, which is a "Production as Usual" scenario, the predicted economic loss is 5–10% of global GDP (Stern 2007). In Earth's past there have been significant periods of global warming and cooling, with average global temperatures from some era higher than current temperatures (Zachos et al. 2001). Intergovernmental Panel on climate Change (IPCC) has reported in their fourth assessment report that global surface temperature increased 0.74 ± 0.18 °C during the 100 years ending in 2005 (IPCC 2007). It is also noted by IPCC (2007) that the rise of mean annual temperature will be 3.3 °C per century.

The economy of Bangladesh is predominately agriculture. Since the birth of Bangladesh, the country has achieved an incredible growth in food production due to substantial cropping intensification, introduction of high yielding crop varieties, expansion of irrigated areas and increased use of chemical fertilizers. However

Bangladesh is presently facing a serious challenge in agriculture production to feed the growing population in the context of shrinking agricultural land and impact of climatic variability. Climate change impacts are already occurring, as measured by increasing temperatures, variable rainfall and an increase in climate-related extreme events such as floods, droughts, cyclone, sea level rise, salinity and soil erosion (Yu et al., 2010). These extreme climate events occur in Bangladesh almost every year, and sometimes more than once a year, affecting the crop agriculture sector adversely, particularly rice production (Yamin et al., 2005).

Rice is the dominant crop in Bangladesh and accounts for more than 60% of total crop agriculture value (Yamin et al., 2005). Almost 80% of the total cropped area is planted with rice, which accounts for over 90% of total cereal production (GOB, 2009). One particular worry is that overall rice production is forecast to decrease by 17% per annum due to climate change and climatic events (GOB, 2005). Because of the huge contribution of rice production to Bangladesh's economy and its high susceptibility to climate change and climate related extreme events, it is important to study perception of climate change and adaptation strategies to overcome the anticipated adverse impacts. Thus, this paper aims to improve our understanding of local farmer's perception of climate changes, explore the ways they are affected by them, and how well they are adapting to them. In order for policymakers to plan responses to climate change in Bangladesh, it is essential to understand how people understand and cope with these trends.

2. Methodology

2.1 Study Area and its Characteristics

Rajshahi is in the heart of the drought-prone northwestern region of Bangladesh. The district has an area of 2407 km^2 with a population of 2.4 million people (population density of 997/km2), making it the largest district of the Barind Tract (33% of the region). Because of its predominant dependence on crop agriculture, the district is referred to as the 'bread basket' of the country. This area was purposively selected for this study. The reasons behind this selection are: (i) it is characterized by high temperature and very low rainfall which make it severely drought-prone and (ii) rice farming is the major livelihood-supporting activity. Average annual rainfall across the district varies from 839 mm to 2,241mm. The average total rainfall for the period, 1964-2009, is 1,505 mm for the district compared to 2,408 mm for the whole country. The atmospheric temperature in the district is as high as 44^{o}C in May and as low as 6^{o}C in January. In terms of extreme climate events, the district is severely drought affected; however, almost free from cyclones and floods (Ahmed and Chowdhury, 2006; FAO, 2006). Rice is the principal crop and major livelihood activity in the study area. Among different varieties of rice, rain-fed transplanted Aman (popularly known as T. Aman) is the leading rice crop which occupies 56% of the total area under rice, followed by Boro (27%) and Aus (17%) (Sarker el al., 2013).

2.2 Data Sources

Both primary and secondary data were collected to complete the present study. Secondary data for different climatic variables (e.g. temperature and rainfall) was collected from Bangladesh Metrological Department, Dhaka for the Rajshahi weather station which covers the period 1972-2013. A cross-sectional survey to collect data from farming households in the Rajshahi District was also adopted for this study. Household data were collected from 4 randomly selected villages in the district during November to December, 2014. A multi-stage random sampling technique was employed to select the Upazillas (sub-districts), villages and households. At the first stage, random sampling was used to select two Upazillas (e.g. Godagari and Tanore). At the second stage, two villages were selected from each of the selected Upazillas, making a total of 4 villages (e.g. Deopara, Matikata, Saranjai and Badhair). As the number of farming households within each village varies considerably, a predetermined number of 10% households from each village were selected for the survey which gives a sample size of 200 for the 4 villages surveyed (50 from each village). This is considered to be sufficient: Bartlett et al. (2001) considered 5% to be adequate for cross-sectional household surveys. Furthermore, rural farming communities in the study area make up a mostly homogeneous group which also validates the use of a small sample (Blaikie, 2010). The unit of analysis was the rice farming households, and these were selected by simple random sampling using the list of rice farming households collected from the Sub-Assistant Agricultural Officers (SAAOs). Then, a structured questionnaire was administered in-person to elicit data regarding several aspects of adaptation strategies practiced by farming households and their socio-economic characteristics, institutional access, farm characteristics and perception of climate change.

2.3 Data Analysis

For statistical analysis, descriptive statistics, percentile and 5-point ordinal scale was employed to ascertain the farmers' perception of the climate change and adaption capacities to climate change adaptive strategies. However, the farmers perception were corroborated with the actual trend of the climatic variability using a Mann-Kendall trend test which is used to detect long-term trend of the metrological variables (e.g., temperature and rainfall) in the study area).

2.3.1 Mann-Kendall Test

By Mann-Kendall test, we want to test the null hypothesis H_0 of no trend, i.e., the observations x_i are randomly ordered in time, against the alternative hypothesis, H_1, where there is an increasing or decreasing monotonic trend. The data values are evaluated as an ordered time series. Each data value is compared with all subsequent data values. If a data value from a later time period is higher than a data value from an earlier time period, the statistic S is incremented by 1. On the other hand, if the data value from a later time period is lower than a data value sampled earlier, S is decremented by 1. The net result of all such increments and decrements yields the final value of S. The M-K test statistic S is calculated using the formula:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(x_j - x_k)$$

The application of trend test is done to a time series x_k that is ranked from k = 1, 2… n-1 and xj, which is ranked from j = k+1, 2 ….n. Each of the data point x_k is taken as a reference point which is compared with the rest of the data point's x_j so that,

$$Sgn(x_j - x_k) = \begin{cases} 1 & if \quad x_j - x_k > 0 \\ 0 & if \quad x_j - x_k = 0 \\ -1 & if \quad x_j - x_k < 0 \end{cases}$$

It has been documented that when n ≥ 8, the statistic S is approximately normally distributed with the mean. E(S) = 0. The variance statistic is given as

$$\text{VAR (S)} = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{q} t_p (t_p - 1)(2t_p + 5) \right]$$

Here q is the number of tied groups and t_p is the number of data values in the p^{th} group. The values of S and VAR(S) are used to compute the test statistic Z as follows

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{VAR(S)}} & if \quad S > 0 \\ 0 & if \quad S = 0 \\ \dfrac{S+1}{\sqrt{VAR(S)}} & if \quad S < 0 \end{cases}$$

Z here follows a standard normal distribution. A positive (negative) value of Z signifies an upward (downward) trend. To test for either an upward or downward monotone trend (a two tail test) at α level of significance, H_0 is rejected if the absolute value of Z is greater than $Z_{1-\alpha/2}$.

2.3.2 The Sen's Estimator of Slope

Some trends may not be evaluated as statistically significant even while they might have practical interest (Yue et al., 2002). Linear trend analysis, Sen's slope method is used in this study to estimate the magnitude of the trend. Here, the slope (Q_i) of all data pairs is computed as (Sen, 1968).

$$Q_i = \frac{x_j - x_k}{j-k} \quad \text{for i=1,2, ..., N.}$$

Where, x_j and x_k are considered as data values at time j and k (j>k) correspondingly. The median of these N values of Q_i is represented as Sen's estimator of slope which is given as:

$$Q_i = T_{[(N+1)/2]}, \quad \text{if N is odd}$$

$$Q_i = \frac{1}{2}(T_{[N/2]} + T_{[(N+2)/2]}), \text{ if N is even.}$$

Sen's estimator is computed as Qmed=$T_{(N+1)/2}$ if N appears odd, and it is considered as Qmed= $[T_{N/2+T\,(N+2)/2}]/2$ if N appears even. At the end, Qmed is computed by a two sided test at 100 (1-α) % confidence interval and then a true slope can be obtained by the non-parametric test. Positive value of Q_i indicates an upward or increasing trend and a negative value of Q_i gives a downward or decreasing trend in the time series.

2.3.3 Serial Correlation Effect

The Mann–Kendall test requires time series to be serially independent. The presence of serial correlation in the time series makes trend tests too liberal, i.e. the null hypothesis of no trend is rejected too frequently, specifically if there is a positive serial correlation (Kulkarni and von Storch, 1995; von Storch, 1995). For this, von Storch and Navarra (1995) suggest that the time series should be 'pre-whitened' to eliminate the effect of serial correlation before applying the Mann–Kendall test. This study incorporates this suggestion, and thus possible statistically significant trends in climatic observations (x_1, x_2,..., x_n) are examined using the following procedures:

(a) Compute the lag-1 serial correlation coefficient (designated by r_1).

(b) If the calculated $r_1$is not significant at the 5% level, then the Mann–Kendall test is applied to original values of the time series.

(c) If the calculated r_1 is significant, prior to application of the Mann–Kendall test, then the'pre-whitened' time series may be obtained as ($x_2–r_1 x_1$, $x_3–r_1x_2$,...,$x_n–r_1x_{n-1}$) (Partal and Kahya, 2006).

2.3.4 Measurement of Farmers' Adaptive Capacities to Adaption Strategies

According to Klein (2002), adaptive capacity to climate change is the ability of a system or an individual to adjust to climate change or climate variability so as to minimize the potential damages or cope with the consequences. Adaptive capacity varies from farmer to farmer based certain factors that are peculiar to each farmer. Asante et al. (2009), Nakuja et al. (2012) and Mabe et al. (2012) measured adaptive capacities of farmers by using five attributes such as knowledge, use, availability, accessibility and consultation. The adaption strategies considered in this research are the use of chemical/organic fertilizer, improved irrigation, farming near water bodies, early maturing rice varieties, drought tolerant rice varieties, mixed cropping, changing planting dates, integration of trees in rice farms, building of embankments, crop rotation and setup shallow tube well in pond. This study also follows the methodology of measuring farmers' adaptive capacities to adaption strategies by Asante et al. (2009), Nakuja et al. (2012) and Mabe et al. (2012).

In measuring the adaptive capacities quantitatively, farmers were asked to indicate their degree of attainment of each attribute. The highest degree of attainment of each of the attributes or factors affecting adaptive capacities was scored 1 where the lowest degree was given a score of 0.25. The score level for a farmer with higher degree of attainment of each attribute is 0.75. Lastly, the score level for high degree of each farmer's knowledge on each adaptation strategy was sought. In terms of knowledge, the higher the degree, the better knowledge the farmer has on a particular adaption strategy. Table 1 summarizes how each attribute was measured.

Table 1: Score Levels of Farmers' Achievement of Attributes

Degree	Scores	Knowledge	Use	Availability	Accessibility	Consultation
Highest Degree	1.00	Very well	Several	Very regular	Easily accessible	Several
Higher Degree	0.75	Well	Twice	Regular	Accessible	Twice
High Degree	0.50	Fairly well	Once	Occasionally	Not easily accessible	Once
Low Degree	0.25	Not well	Never	Never	Not accessible	Never

Source: Modified from Nakuja et al. (2012) and Mabe et al. (2012)

The adaptive capacity (AdapCap) of an ith farmer to jth adaption strategy is calculated as shown in equation (1) below:

$$AdapCap_{ij} = \frac{k_{ij} + U_{ij} + V_{ij} + A_{ij} + C_{ij}}{N_A} \quad \text{..............} (1)$$

Where $AdapCap_{ij}$ denotes the adaptive capacity of an ith farmer to a jth adaption strategy; K_{ij}, the knowledge of the ith farmer on jth adaption strategy; U_{ij}, the level of usage of jth adaption strategy by ith farmer; V_{ij}, the availability of innovations on jth adaption strategy to ith farmer; A_{ij}, accessibility of innovations on jth adaption strategy to ith farmer; C_{ij}, level of consultation on jth adaption strategies by ith farmer; N_A, the sum of applicable attributes.

The average adaptive capacity of farmers to jth adaption strategy, $AveAdapCap_j$ is calculated using the equation (2) below

$$AveAdapCap_j = \frac{\sum AdapCap_{ij}}{N} \text{................} (2)$$

Where, N is the number of Observations.

Table 2: Degree of Adaptive Capacities of Farmers

Degree of Adaptive Capacities	Ranges of Indices for $AdapCap_{ij}$	Ranges of Indices for $AveAdapCap_j$
Low Adaptive Capacity	$0< AdapCap_{ij}<0.33$	$0< AveAdapCap_j <0.33$
Moderate Adaptive Capacity	$0.33\leq AdapCap_{ij}<0.66$	$0.33\leq AveAdapCap_j <0.66$
High Adaptive Capacity	$0.66\leq AdapCap_{ij}\leq1.00$	$0.66\leq AveAdapCap_j \leq1.00$

Source: Modified from Nakuja et al. (2012) and Mabe et al. (2012)

Based on the adaptive capacities of the attributes, three indices were established. Table 2 shows the categories of adaptive capacities (low, moderate and high) to which each farmer falls within. It also shows the categories of average adaptive capacities (low, moderate and high) of each adaption technology. Farmer i is lowly adaptive to adaptation strategy j if the adaptive capacity calculated falls in the range of $0< AdapCap_{ij}<0.33$. The range for moderate and high adaptive capacities are $0.33\leq AdapCap_{ij}<0.66$ and $0.66\leq AdapCap_{ij}\leq1.00$ respectively.

3. Result and Discussion

3.1 Trend of Climatic Variability

Annual temperature displays significant changes, with an upward trend identified for the Rajshahi district. The average trend calculated for the study area has a Sen slope of +0.04, implying that an increase in annual temperature of +0.04º C form 1972 to 2013 has be recorded for the Rajshahi district which is consistent with Chowdhury and Debsharma (1992) and Mia (2003) pointed out that temperature has been changed by using historical data of some selected meteorological station. Parathasarathy et al. (1987) and Divya and Mehritra (1995) reported mean annual temperature of Bangladesh has increased during the period of 1895-1980 at 0.31^0C over the past two decades. Karmakar and Shrestha (2000) using the 1961-1990 data for Bangladesh projected that annual mean maximum temperature will increase to 0.4^0C and 0.73 ^{0}C by the year of 2050 and 2100 respectively.

Table 3: Trend of Annual Temperature and Rainfall for Rajshahi District, 1972-2013

Statistics	Temperature	Rainfall
Mann-Kendall Statistic	185.00	-167.000
Kendall's Tau	0.025	-0.194
Sen's Slope	0.04	-0.67
P-value (Two Tail)	0.046	0.072
Alpha	0.05	0.05
Test Interpretation	Reject H_0	Accept H_0

Note: H_0: There is no trend in the series, H_A: There is a trend in the series

For annual rainfall, no significant trend was observed in case of Rajshahi District, which is consistent with the study of Ali (2013), he did not observe any significant trend for annual rainfall in the study area. Rainfall for Rajshahi district had negative values for Kendall's tau, implying a decrease in that parameter with time as the situation going on it may trigger to form desertification in this region. So, climate of this region may change significantly. This decreasing trend of total rainfall may have the relationship to the decrease of water in rivers of this region, less evaporation as well as its consequences.

3.2 Farmers Perception of Climate Change

As Ban and Hawkins (2000) define 'perception' it is the process by which we receive information or stimuli from our environment and transform it into psychological awareness. It is interesting to see that people infer about a certain situation or phenomenon differently using the same or different sets of information. Knowledge, interest, culture and many other social processes that shape the behavior of an actor who uses the information and tries to influence that particular situation or phenomenon (RECOFTC 2001; Banjade, 2003). Saarinen (1976) talks about perception as an extremely complex concept and confines 'social perception' which is concerned with the effects of social and cultural factors on cognitive structuring of our physical and structural environment. This varies with the individual's past experiences and present sets or attitudes acting through values, needs, memories, moods, social circumstances, and expectations (Saarinen, 1976; Banjade, 2003).

Farmers should perceive first that there is climate change in order to take necessary adaptive strategies (Bryan et al. 2009). The surveyed households were asked for any observed changes in temperature, rainfall, drought, availability of ground water and availability of surface water over the past 20 years in order to ascertain their level of perception. Perceptions on climatic components were divided into four categories: increased, decreased, not changed and don't know. Farmers' perceptions on each climatic parameter are presented below (Table 3).

Table 3: Farmers Perceptions of Various Climatic Parameters over Last 20 Years

Farmers' Perception	Temperature (%)	Rainfall (%)	Drought (%)	Availability of Ground Water (%)	Availability of Surface Water (%)
Increased	95.2	0	98.21	0	0
Decreased	5.1	96.91	0	99.24	98.70
Not Changed	1.7	2.36	0	0.76	1.30
Don't Know	0	0.73	1.79	0	0

Source: Computation from field data (2014)

Table 3 indicate that 95.2% of the surveyed farmers have observed increasing temperature while only an insignificant 5.1% noticed a decreased in temperature, and for 1.7% of the respondent it remain unchanged. In case of rainfall 96.91% household heads observed a decline in yearly rainfall. No household heads perceived an increase in rainfall while rainfall remain the same to 2.36% and don't know to 0.73% of households, respectively. Almost 98.21% households noticed that frequency of drought has increased over the last 20 years while 1.79% households had no idea about the drought. In case of availability of ground water and availability of surface water almost 100% of the household heads perceived that availability of ground and surface water has decreased.

3.2 Degree of Adaptive Capacities of Farmers to Adaption Strategies

The degree of adaptive capacities of rice farmers to the various adaption strategies is presented in Table 4. The respondents interviewed were highly adaptive to changing planting dates, early maturing rice varieties and drought tolerant rice varieties. This is because their adaptive capacities are within the range of $0.66 \leq AdapCap_{ij} \leq 1.00$. Among these adaption strategies with high adaptive capacities, changing planting dates and drought tolerant rice varieties recorded the highest and the lowest adaptive capacities of 0.81 and 0.74 respectively. The adaptive capacities calculated for drought tolerant rice varieties is equal in value (0.76).

Table 4: Degree of Adaptive Capacities of Farmers

Adaption Strategies	Adaptive Capacities ($AdapCap_j$)	Rank	Degree of Adaptive Capacities
Changing planting dates	0.81	1	High adaptive capacity
Early maturing rice varieties	0.76	2	High adaptive capacity
Drought tolerant rice varieties	0.74	3	High adaptive capacity
Use of chemical/organic fertilizers	0.65	4	Moderate adaptive capacity
Farming near water bodies	0.64	5	Moderate adaptive capacity
Mixed cropping	0.58	6	Moderate adaptive capacity
Improved irrigation	0.36	7	Moderate adaptive capacity
Set up shallow tube well in pond	0.33	8	Moderate adaptive capacity
Building of embankments	0.31	9	Low adaptive capacity
Integration of trees in rice farms	0.28	10	Low adaptive capacity
Crop rotation	0.28	10	Low adaptive capacity
Average	**0.52**	**-**	**Moderate adaptive capacity**

Source: Computation from field data (2014)

The adaption strategies with moderate adaptive capacities are the use of chemical/organic fertilizers, farming near water bodies, mixed cropping, improved irrigation and setup shallow tube well in pond. Out of the 11 adaption strategies used, farmers are moderately adaptive to 5 of them. Among adaption strategies which farmers are moderately adaptive, the use of chemical/organic fertilizers had the highest adaptive capacity value of 0.65 whiles the set up shallow tube well in pond recorded the lowest of 0.33. The adaptive capacities calculated for farming near water bodies, mixed cropping and improved irrigation are equal with the value of 0.64, 0.58 and 0.36 respectively. The respondents in the area have low adaptive capacity to the building of embankments, the integration of trees in rice farms and crop rotation. Building of embankments to keep water on the rice field has the adaptive capacity value of 0.31. The adaptive capacity value quantified for integration of trees in rice farms and crop rotation is equal with a value of 0.28. Generally, the average adaptive capacity of the respondents is 0.52. This implies that farmers in the study area are moderate adapters to climate change.

Table 5 represents the percentage of the degree of adaptive capacities of respondents. Table 5 indicates that 45.0% out of 200 farmers interviewed are low adapter to the climate change adaption strategies. Also, 38.5% of the respondents are moderate adapters. On the other hand, only 16.5% of the respondents interviewed are high adapters. Though, majority (45.0%) of rice farmers is low adapters to climate change; on the average, the farmers interviewed are moderate adapters. This is because, the mean adaptive capacity calculated is 0.51 which falls within the range of moderate adapters ($0.33 \leq AveAdapCap_j < 0.66$). This implies, averagely the farmers in the area do not have all necessary resources to aid them adapt highly and effectively to climate change.

Table 5: Percentage of the Degree of Adaptive Capacities of Respondents

Adaptive Capacity	Mean Adaptive Capacity	Frequency	Percentage
High Adapters	0.69	33	16.5
Moderate Adapters	0.53	77	38.5
Low Adapters	0.32	90	45.0
Average	**0.51**	**200**	**100.0**

Source: Computation from field data (2014)

4. Conclusion

The main objective of this paper was to study perceptions of and adaption capacities to climate change adaption strategies by the rice farmers in corroboration with the actual trend of the climatic variability for Rajshahi District in Bangladesh. For this purpose Mann-Kendall trend test was used to detect long-term trend of the metrological variables (e.g. temperature and rainfall). The result of the study revealed that an increase in annual temperature of + +0.04º C from 1972 to 2013 has been recorded for the study area where as annual rainfall has not exhibited any trend but Sen's slope is negative which means decrease in rainfall in the study area. In our study, we use a semi-structured questionnaire to explore farmer's perception of climate change. Evidence from official data has revealed that temperatures have risen and rainfall has decreased in the Rajshahi district over almost last 50 years. The findings of our study revealed that farmers' perceptions of climate change are also consistent with official records and other studies (Noorunnahar and Rahman, 2013; Alam, 2015). The study also determined the adaptive capacities as well as the degree of adaptive capacities of rice farmers to each climate change adaption strategy. This was done by asking farmers to indicate the degree of achieving each of the following attributes: knowledge, use, accessibility, availability and consultation. The adaptive capacities of farmers estimated were categorized into high, moderate and low adaptive capacities. The result of this study revealed that farmers are highly adaptive to the changing planting dates, early maturing rice varieties and drought tolerant rice varieties where as farmers are moderately adaptive to the use of chemical/organic fertilizer, farming near water bodies, mixed cropping, improved irrigation and set up shallow tube well in pond. They are lowly adaptive to building of embankments, integration of trees in rice farms and crop rotation. Generally, farmers are moderately adaptive to climate change adaption strategies as this was justified by the average adaptive capacity value 0.52, but it was found that only 16.5% farmers has high adaptive capacities where as 45.0% farmers has low adaptive capacities for this study area.

Based on the findings and field level surveyed experiences we can say that farmers with high adaptive capacities get higher rice output, rice farmers should be empowered in order to attain high adaptive capacity status. Policy makers should design policies to train farmers on the use of the adaption strategies to help them adapt well to the changing climatic conditions in the study area. This could be done through effective extension education on adaption strategies available for use by rice farmers. If this is done, farmers would be able to attain high adaptive capacity status which will help them get higher rice output.

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