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FACTORS AFFECTING ADOPTION OF LOCAL ADAPTATION OPTIONS TO CLIMATE CHANGE VULNERABILITY

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ABSTRACT

The main objectives of the study were to understand the climate change vulnerability and factors responsible to the adoption of local adaptation options. Field level primary data was collected through interview and group discussion during May 2015 in the Teesta riverine area under Rangpur district of northern Bangladesh. The findings showed that the study area was vulnerable to flood and drought in the last three decades. Majority (56.25%) of the respondents perceived that flood was main reason while43.75% respondents stated that drought was the major reason for climate change and variability. Among seven demographic characteristics, five namely occupation, education, farm size, daily income and training received on disaster management of household head showed positive significant relationship with the adoption of local adaptation options. These characteristics were supposed to influence the household to a great extent in adopting different local climate change adaptation techniques. The step wise multiple regression analysis showed that predictor variables daily income (X_6) and training received on disaster management (X_7) of the household head had positive significant regression effect on the adoption of local adaptation techniques (Y). It meant that a unit changes in daily income of household had contributed 0.645 unit changes in the adoption level assuming other variables constant. Again, a unit change in 'training received' had contributed 0.329 unit changes of the adoption level when other variables remained constant. The top ranked local adaptation options implemented by the households were: i) household shifting, ii) dry food storage and iii) pure water storage. No weather related insurance scheme and cooperative market facilities were found in the study area.

Key words: Adoption, adaptations options, climate change, vulnerability

INTRODUCTION

Bangladesh has been frequently cited as one of the most climate change and disaster vulnerable countries in theworld (Ali 1999; Rahman 2011; Siddika 2013).It is located at the two geographical interfaces, the Himalayas to the north and the Bay of Bengal to the south. This peculiar geographical location has made the country most disaster-prone(Ali 1999). According to IPCC (2007) prediction, the world temperatures will rise between 1.8^{o}C and 4.0^{o}C by the last decade of 21st century. As a result, the melting of Himalayan glaciers may increase the flows of water in South Asia, especially affecting Nepal, India and Bangladesh (MOEF 2009). OECD (2003) has predicted that one meter rising sea level would inundate 18% of total landarea of Bangladesh (Rahman 2011). Climate-related natural events like cyclone, flood and drought had hit the country since 1974 to 2007 (Uddin 2012). Tropical cyclones attack almost every three years due to the sea surface temperature rising (MOEF 2009). About 90% of the rainfall has been occurring during the period of rainy season (June-September) which cause severe flood(Rahman2010). The north-western region of Bangladesh is most vulnerable to drought (NIRAPAD 2011) and moreover, around 41%–50% country area has been experiencing drought every year (Stocker *et al.* 2013; Uddin *et al.*2014). According to IPCC (2007) prediction, rice production in the country could fall by 8% and wheat by 32% by 2050 due to water stress that could lead to future food shortage(MOEF 2009).

Teesta is one of the trans-boundary rivers of Bangladesh originated from the Himalayas. This river passes 269 km Indian upstream region before entering to Bangladesh. Then it flows about 124 km of northern Bangladesh before merging into Brahmaputra river and width varies up to 300 to 550 m(Islam *et al.* 2003). About 8 million people live in the upstream India followed by 21 million in the downstream region of Bangladesh(Islam and Higano 2001; Rahman 2013).Agro-climatic

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variation e.g. rainfall, temperature, humidity, evaporation, evapotranspiration etc(Sarker *et al.*2011)has led temporal distribution of water resources into two extremes such as dry season from December to May and wet season from June to October (Rahman 2013). In the environmental view, during dry season the Teesta catchment faces severe water stress due to low rainfall, high temperature and high rate of evaporation. During pre-monsoon of winter, particularly in November, land and surface water sources start to dry up and land becomes cracked in March-April due to ground water drop down significantly(Islam 2003).According to IPCC (2007), rainfall in this region has fallen in the past 100 years and future projection shows that rainfall in dry season will decrease slightly within the 21st century (Rahman, 2013). The river floodplain area situation becomes quite opposite to the scenario observed during the rainy season. This is because of heavy rainfall in the upper catchments of rivers create overflow of water during therainy season. In addition, the current trend of glacial melting of Himalayas due to rising global temperature has increased the risk of flash flood. Both precipitation in rainy season and glacial melts would generate additional volume of water runoff causing rever bank erosion (NIRAPAD 2011). Teesta riverine char(river bank) land areas are very unstable due to weak and poor infrastructure. Productivity of charland is very low due to sandy and unfertile soil. People living in char community are more vulnerable to climate hazards like flood, drought and riverbank erosion(NIRAPAD 2011). The Teesta riverine area consequently encountered a wide range of challenges during the last two decades. The purpose of the present study was to determine the specific demographic characteristics, climate change vulnerabilities that the household face and find out possible adaptation strategies which will create an influx in combating climate risk.

MATERIALS AND METHODS

Locale of the study and sampling: The research study was carried out in LaxmitariUnion of GangacharaUpazila under Rangpur district of northern Bangladesh. One village "West Ichli" was selected out of the 9 villages of the Laxmitariunion. This village is closed to geographically situated on the bank of Teesta River and very remote and vulnerable to climate change and disaster. The total household of West Ichli was 485 containing of 1939 people(Anonymous, 2015). The sampling units (household) were sampled through probability sampling called stratified random sampling. In stratified sampling technique, at first village community was divided into4homogenous segments or strata consisting of 100-120 households. Then, about 80 households were randomly selected from each segment in order to cover the whole community of the village. The demographic characteristics sex, occupation of household head, age, education, farm size, daily income, and training received on disaster management were considered independent variables and adoption of local adaptation options was measured as dependent variable of the study. The demographic attributes were measured by following appropriate measurement scale, score and techniques. The respondents were interviewed on order to ascertain the adaptations practices or strategies followed by their household against natural disaster. Adaptation practices were categorized and discussed according to the Agrawal and Perrin (2008) community based adaptation categories such as mobility, storage, diversification, communal pooling, and exchange. Respondents were asked to give their Yes/No response against the indicators of each category. Adoption of local adaptation options score were measured by counting the total of 'Yes' responses against the thirteen adaptation options. It means that score 1 indicated very low adoption and 13 indicated very high adaption score of the individual household respondents on implementing local adaptation options.

Data collection and analysis: Data were collected from the sampled units through maintaining personal interview and focus group discussion during the month May 2015. The SPSS (Statistical Package for Social Sciences) was used to determine mean, range and percentage and standard deviation. Correlation and step-wise multiple regression analysis was done to determine influence household characteristics on adopting the local adaptation options. In this study, at least five percent (0.05) level of probability was used to reject the null hypothesis. In multiple linear regressions, a linear model was developed between the mean of a dependent variable (Y_i) and more independent variables (Xi). Each independent variable (Xi) has a partial regression coefficient (β_i). The partial regression coefficient determines the influence of the concerning independent variable on dependent variables while the influence other independent variables are kept constant. The regression model (Thas 2013) has given as follows:

$Y_i=\mu+\beta_1X_{1i}+\beta_2X_{2i}+\epsilon_i \qquad i=1,\ldots\ldots,n,$

Where,

$\epsilon_i \sim N(0, \sigma^2)$ is the error term

Y_i= Dependent variable

X_{1i} and X_{2i} are the two regressors

μ is the intercept parameter

β is the regression coefficient or slope parameter

$Y_i=\mu+\beta_1X_{1i}+\beta_2X_{2i}$, is the regression line

The assumptions were fulfilled to develop the regression model such as a) Normality of the error

terms was checked whether the residuals (errors) are approximately normally distributed or not. This was assessed by means of a normal P-P plot of the residuals; b) Linearity of the covariate effect was assessed by means of a scatter plot in order to assume a linear association between an independent variable and a dependent variable (Thas 2013) c) The 3rd assumption was multicollinearity in order to assess how two or more independent variables are highly correlated with each other. This produces big standard deviations of the regression coefficients and decreases the model validity (Gujarati and Porter, 1999). It was done with correlation matrix or collinearity statistics and when the correlations $|r| \geq 0.9$, then one or both independent variables assume to leave out of the model (Ottoy *et al.* 2013); and d) Independence of observations or independence of residuals was checked by Durbin-Watson statistic to assess how the effect of independent variables significantly correlated with the outcome variable. The determination coefficient ($R^{2)}$ indicates how much variances in the dependent variable can be explained by independent variables. If the p-value ($P<0.05$), the regression model is significant rejecting the null hypothesis. It means that there is a significant linear association between dependent variable and one or more independent variables (Ottoy*et al.* 2013).

RESULTS AND DISCUSSION

Demographic information: Sex was considered individual characteristics of the respondents provided information during interview. Findings showed that respondents were dominated by the female. The reason behind that the data collection was done in off-season of farming caused male household head seasonal migration to nearby town or capital city for their livelihood earnings. Agricultural farming was the main occupation of the family head in the study area. About 45% of the households earning source was agriculture farm followed by 16.3 % daily wage labour and 21.2% households was depended on both farming and daily wage labor. Very few households (17.5%) relied on others occupation such as fishing, small business, shops, rickshaw pulling or easy bike driving for their livelihoods (Table 1).

Table 1. Demographic information of the respondents

Demographics features	Description in Categories	Frequency	Percentage	Mean	SD
Sex of respondent	Male	26	32.5	-	-
	Female	54	67.5		
Occupation of household head	Farming	36	45.0	-	-
	Wage labour	13	16.3		
	Both farming and wage labour	17	21.2		
	Small business or others	14	17.5		
Age of household head (year)	Young (< 30)	15	18.8	38.74	9.13
	Middle aged (31-45)	51	63.7		
	Old (>45)	14	17.5		
Education of household head (year of schooling)	Illiterate (0)	13	16.3	3.12	3.82
	Can sign only (0.5)	32	40.0		
	Primary (1-5)	18	22.5		
	Secondary (6-10)	8	10.0		
	Above secondary (>10)	9	11.2		
Farm size of household (Ha)	Landless (≥ 0.02)	11	13.8	0.19	0.20
	Marginal (0.021-0.2)	42	52.5		
	Small (0.021-1)	27	33.7		
Daily income (in $)	Faced poverty (≤ 1.25)	48	60.0	1.33	0.76
	Out of poverty (> 1.25)	32	40.0		
Training received on disaster management (day of attendance)	No training	41	51.3	1.18	1.52
	Training received	39	48.7		

Majorities (63.7%) of the household head were middle aged, and highest portion (40%) of them could sign only. In this study, household farm size is the total farming area including homestead, contract or share land. Farm size was categorized into five such as landless (≥0.02 ha), marginal (0.021–0.2 ha), small (0.21–1 ha), medium (1–3 ha) and large (above 3 ha) farmers following the

farm categorization system of DAE (1999). The average household farm size was 0.19 ha and there was no medium and large farm household found in the study area. Daily income was counted by following World Bank commonly used international poverty line (Norton et al., 2015). The households were categorized into, poverty line (daily income below or equal to US$ 1.25 in 2005 purchasing power parity) and out of poverty line (daily income above US$ 1.25). About 60% households in the study area lived in below poverty line. The reason was that farm size was comparatively lower causing dependent on wage labor. Another reason, the community was more flood and erosion vulnerable because of nearby stands on the Teesta river bank. Near about half (48.7%) of household head received training on climate change and adaptation technologies provided by different Non-government organizations.

Perception of the climate change vulnerability: During focus group discussion, all household respondents agreed that flood and drought were the major environmental disasters in their community and in addition, they often occasionally faced storms, winter cold, summer hot and earth quake in some extent. Riverbank erosion is second hand impact of the recurrent flood. When they were asked to mention only one major natural risk name, majority (56.25%) indicted that flood was their main natural disaster, while 43.75% indicted that drought was most harmful for them (Figure 1).

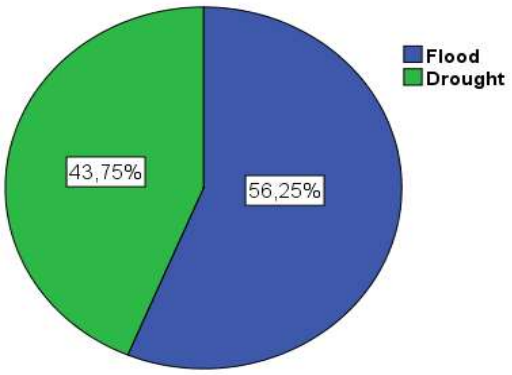

Figure 1. Perceived impact of climate change and variability as per respondents

Most of the respondents mentioned that they often affected by severe floods in rainy season (June-September) due to heavy rainfall or sudden flash water. They claimed that flash flood was controlled by upstream Gojaldoba barrage of India and Dalia barrage of Bangladesh, and was more dangerous to loss human property and lives than rain flood. The reason behind that flash flood was occurred suddenly and rapidly in the Teesta riverine area. When they did not able to receive early information in respect to flash flood, especially at night, it seemed to very difficult to move safe shelter with households materials as well as children, disorder or old people. Drought was seen as problem in dry season occurred in every year in the month of November to April. They included that that loss of drought was more harmful than floods due to affecting the region for a long duration causing crop productivity loss. Sometimes, farm household did not able to harvest minimum yield of production cost due to the negative effect of water scarcity.

Factors affecting in the adoption of local adaptations options

Adoption score of local climate change adaptation options was considered as dependent variable and other variables namely sex of respondents($X_{1)}$, occupation of household head ($X_{2)}$, age of household head ($X_{3)}$, education of household head ($X_{4)}$, farm size of household ($X_{5)}$, daily income of household ($X_{6)}$,and training received on disaster management ($X_{7)}$were taken as independent variables in this study. The coefficient of correlation (r) between the demographic characteristics of the household heads and their adoption of local adaptation options score has been presented in Table 2. Among seven demographic characteristics, five namely occupation, education, farm size, daily family income and training received of household head showed positive significant relationship with their adoption of local adaptation options. It could be said that these characteristics influenced the household head to a great extent in adopting different local climate change adaptation techniques. The characteristics such as sex of respondents and age of household head had no influence on the implementing of local adaptation options.

Step wise multiple regression

The general concept behind the stepwise regression analysis is that building the regression model from a set of candidate variables by entering and removing predictors-in a stepwise manner. From Table 4, it was found that the independent variables (predictor) daily income of household (X_6) and training received on disaster management (X_7)has been retained after eliminating the other rest variables in the preceding steps. Possible assumptions were fulfilled in order to run the step wise multiple regression analysis. The normal P-P plot showed that there was no significant deviation from the straight line and could be said that the error terms or residuals were normally distributed.

Table 2. Correlation Co-efficient between the adoption score (Y) and Independent variables (Xi)

Variables	'r' value (Pearson)
Sex of respondents($X_{1)}$	.215
Occupation of household head ($X_{2)}$	.258*
Age of household head ($X_{3)}$	.009
Education of Household head ($X_{4)}$	.396**
Farm size of Household ($X_{5)}$	.431**
Daily income of Household ($X_{6)}$	.412**
Training received on disaster management ($X_{7)}$	.417**

**, ** Correlation is significant at 5% and 1% level of significance, respectively*

Table 3. Analysis of variance (ANOVA)

	Sum of Squares	df	Mean Square	F	Sig.	Durbin-Watson
Regression	46,629	2	23,314	15,245	,000[b]	1.542
Residual	117,759	77	1,529			
Total	164,388	79				

Table 4. Stepwise multiple regression analysis of the adoption of local adaptation practices (Y) with the independent variables (X)

Variables	Unstandardized Co-efficient		Standardized Co-efficient			
	B	Standard Error	Beta (β)	't'	Sig.	VIF
Adoption (Y) Constant	6.039	0.287		21.029	0.000	
Daily income of household (X_6)	0.645	0.188	0.339	3.440**	0.001	1.046
Training received on disaster management (X_7)	0.329	0.094	0.346	3.504**	0.001	1.046

**, ** significant at 5% and 1% level of significance, respectively, R^2 =0.265*

As the observations (80>30), normality of residuals could be fulfilled based on Central Limit Theorem (CLT). It could be assumed from the scatter plot that there was linear association between at least one independent variable and the dependent variable. Durbin-Watson value (1.542) was proved the independence of observations or independence of residuals that means the effect of independent variables are significantly and positively correlated with the outcome variable (Table 3). The VIF (Variance Influence Factor) were less than 10 which indicated that independent variables did not show multicollinearity or they were not highly correlated (Table 4). The Pearson correlation values of the independent variables were less than 0.9 that indicated no multicollinearity (Table 2).

From the linear model summary, the value of R2 (R Square) is 0.265. It means that 26.5% of the variance of adopting local adaptation options could be explained by its relation to the predictors or independent variables. The F-statistics of ANOVA indicated that the model was highly significant (P <0.05) that indicated the regression model significantly predicted the outcome or dependent variable (Table 3).

In the table 4, the P value of intercept was 0.00 (<0.05) which meant the intercept was significant and the dependent variable (adoption of local adaptation options) was affected by at least one of the independent variables. The predictor variables daily income of household (X_6) and training received on disaster management (X_7) of the household head' significantly had positive regression effect on the adoption score. The variable 'daily income of household' had positive effect on adopting climate change adaptation techniques exhibiting the β value 0.339. It meant that a unit changes in daily income of household had contributed 0.645 unit changes in the adoption level assuming other variables constant. Again, a unit changed in 'training received on disaster management' had contributed 0.329unit changes of the adoption level when other variables remained constant.

Table 5. Distribution of the respondents according to adoption of local adaptations options

Sl. No.	Adaptation items	Responses (%)		Adoption index (AI)	Rank order
		Yes	No		
	Mobility				
1.	Household shifting	93.7	6.3	93.7	1
2.	Migration to city	63.8	36.2	63.8	7
	Storage				
3.	Pure water storage	81.2	18.8	81.2	3
4.	Dry food storage	88.7	11.3	88.7	2
5.	Asset savings	33.7	66.3	33.7	11
	Diversification				
6.	Diverse crop technology	65.0	35.0	65.0	6
7.	Employment opportunities	36.3	63.7	36.3	10
8.	Skill by training	42.5	57.5	42.5	9
	Communal pooling				
9.	Infrastructure	68.8	31.2	68.8	5
10.	Information sharing	72.5	27.5	72.5	4
	Exchange				
11.	Insurance scheme	0.0	100	0.0	13
12.	Credit received	52.5	47.5	52.5	8
13.	Market access	17.5	82.5	17.5	12

Implementing local adaptations options by the household

Mobility: Majority (93.7%) household respondents had experienced at least three times of shifting of household in the last three decades due to homestead loss by flood and river erosion. They often temporally moved to take shelter in the nearby high land, roads, neighbors or relative houses or school building during flooding. About 63.8% of respondents indicated that male household members had migrated to nearby town or capital city for their livelihood earning (Table 5). Migration happened mainly for two reasons; i) during lean period or off-season when they had no any farming activities or employment opportunities, and ii) when they had lost their household, standing crops and cultivable land due to flood and erosion, or lower yield due to water scarcity.

Storage: About more than two-third households preserved pure water and dry foods for unwanted flood condition as indigenous knowledge and experience learning from their family ancestor or society. Only 33.7% households were seen to follow the other storage indicator like asset savings (Table 5). Non-adopted households claimed that it was difficult to save money or other assets because of their poverty.

Diversification: About 65% household respondents mentioned that they adopted flood tolerant variety in crop cultivation. They received flood tolerance BRRI dhan 51 and BRRI dhan 56 seed at free cost from the NGO-RDRS and most of them found to get good harvest from cultivating these rice varieties. They cultivated short duration pumpkin in unfertile fallow sandy land using vermicompost. Technological diversification of tolerant rice and vegetables cultivation was highly motivated by the different activities of NGOs sector. Non-adopted respondents claimed that tolerant rice seed was unavailable in the local market. Only 36.3%of respondents agreed that crop diversification increased their employment

opportunities. Less than (42.5%) respondents believed that their adaptive capacity has increased because of receiving training from different NGOs (Table 5).

Communal pooling: Around 68.8% respondents revealed that every year they provided possible effort to make their homestead above the flood level with the support of community based adaptation program. Non-adopted respondents claimed that they had no economic ability to make house above flood level, although they wanted to raise houses. They collectively often tried to protect river bank erosion with the support of piled sand bag, but there was still lacking of government initiatives of establishing stable embankment. Another indicator of communal polling was information sharing, more than two-third (72.5%) respondents agreed that they shared information as early forecasting. They were able to get information and early warning from their neighbors and Water Development Board (WDB) official agents (Table 5).

Exchange: More than half of respondents (52.5%) mentioned that they received credit from neighbors, relatives, friends or NGOs for the recovery of property loss due to natural disasters. All the respondents agreed that there was no any weather related insurance scheme in the study area. Majority (82.5%) of the respondents revealed that they had no cooperative market access or facilities to sell their farm products, especially the vegetables like pumpkin (Table 5).

CONCLUSION

There was no doubt that the adoption local adaptation practice varied by individual and household characteristics of respondents such as household income and training received. It is necessary to take appropriate steps to diversify the both farm and nonfarm activities in the study. More than half of the respondents had received no training on climate change impact and adaptation measures especially flood or drought tolerance crop production, whereas training opportunities should be helpful for increasing adoption rate and adaptive capacity. It was claimed that market price of vegetables like pumpkin was very low due to the remote location. So, agro-company based cooperative could be helpful for getting good price of vegetables. Crop or life insurance scheme had been working in many developed countries, but in the study area there was lack of insurance system. The government agency or private company should ensure weather insurance system in the study area. It is also necessary further arrangement and strong coordination among policy makers, local government, NGOs and local communities. There was difficult to predict the long term impact of the adaptation practices to climate change. So, the research related to socio-economic impact analysis of the adaptation option could be undertaken in future.

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