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Analysis

Influence of institutional access and social capital on adaptation decision: Empirical evidence from hazard-prone rural households in Bangladesh

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ABSTRACT

An understanding of the factors that shape resource-poor households' heterogeneity in adopting adaptation strategies is crucial in developing adaptation policies. This research examines the determinants of household adaptation choices and the barriers to adaptation. It also focuses on the influence of institutional access and social capital on adaptation choice as a way forward to support and sustain local adaptation process by using the survey data of 380 hazards-prone vulnerable households in Bangladesh. The results reveal that households are implementing adaptation strategies such as diversifying crops, tree plantation (adopted by large and medium farmers), and homestead gardening and migration (adopted by small and landless farmers). Barriers to adaptation are observed heterogeneously among the farming groups where access to credit and lack of information on appropriate adaptation strategies are among the important barriers to adaptation. The model results indicate that the choice of adaptation strategies is significantly influenced by social capital and access to institutions. To support adaptation locally and to enhance vulnerable households' resilience to better cope with riverbank erosion and other climatic change issues, interventions by the government through planned adaptation, such as access to institutions and credit facilities, and a package of technologies through agro-ecological based research are required.

1. Introduction

Bangladesh is most vulnerable to climate change (World Bank, 2013; IPCC, 2007). The extreme climatic hazards such as floods, sea level rise, cyclonic storm surges, riverbank erosion and drought pose major risks to the lives, livelihoods and food security of 64% of the rural population that depend on agriculture (GoB, 2011; IPCC, 2007). Especially, households in the riverine rural areas are more vulnerable to climate driven-hazards including riverbank erosion. A loss of productive land and other natural resources on which agricultural practices depend is a common phenomenon in the riparian areas. Elahi et al. (1991) asserted that some parts of 50 districts out of 64 in the country are subject to riverbank erosion. It causes the loss of land of about 8700 ha and the displacement of approximately 200,000 people along the estimated 150,000 km of riverbanks annually (CEGIS, 2012; GoB, 2010). These resource-poor households are also prone to other climatic hazards such as flooding and waterlogging due to their proximity to the river which also contributes to their increased vulnerability (Alam, 2016). Therefore, some argue that adaptation research should focus on the most vulnerable groups or those with the least adaptive capacity (Hulme et al., 2011; IPCC, 2007).

Adaptation is emerging as a key policy response for reducing the adverse effects of climate change, and to protect the livelihood and food security of poor farmers (IPCC, 2014; World Bank, 2013; Green and Raygorodetsky, 2010; Adger et al., 2009; Lobell et al., 2008). However, poor households' local adaptation strategies are often overlooked and not included when developing adaptation strategies (Nelson, 2011; Christoplos et al., 2009; Folke, 2006). Actions like government intervention are crucial in ensuring sustainability of farm-level adaptations of the poor farmers (Stringer et al., 2009; Smit and Pilifosova, 2001).

Farmers' adaptation strategies can be influenced by a range of factors, which are crucial for identifying appropriate options for enhancing adaptation. Moreover, there is a growing interest in the role of social capital (i.e., social connection) in enhancing vulnerable households' resilience (Jordan, 2015; Chen et al., 2014; Wolf et al., 2010; Brand, 2009; Adger et al., 2005; Pelling and High, 2005). Linking social networks — households' links with organizations — form an

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important part of support for disaster recovery (Carpenter, 2013). It facilitates access to broader source of information (Adler and Kwon, 1999). Studies argued that farmers' access to various institutions play crucial role in their adaptation decisions (Alam, 2015; Alauddin and Sarker, 2014; Deressa et al., 2009). This issue has particular importance for the resource-poor rural riverine communities in Bangladesh where the availability of institutional services and social connection among farmers are often limited due to the fragile infrastructure and low livelihood status (Alam, 2016; Jordan, 2015; GoB, 2010; Lein, 2010; Hutton and Haque, 2003). They are often deprived from many standard government services such as health services and education. They are among the poorest of the poor and are subject to persistent poverty and food insecurity (IFAD, 2013; GoB, 2010). In a situation like this, social capital can be used by the resource-poor households as a handy tool to tackle or overcome the critical situations. Therefore, this study particularly focuses on social capital and institutional access as a way forward to support and sustain local adaptation process of these vulnerable households.

However, despite increasing recognition of the need of adaptation to reduce rural households' vulnerability, limited research has been conducted on adaptation in Bangladesh (see Section 2). Hazard-prone resource-poor households' local adaptation strategies, the factors influencing adaptation and the barriers to adaptation have relatively unexplored. These are crucial to formulating and implementing an effective and sustainable adaptation policy in Bangladesh. This research using cross-sectional survey data from two most riverbank erosion-prone districts in Bangladesh provides information on resource-poor households' local adaptation strategies with new insights on the determinants of the households' choice of adaptation and the barriers to adaptation. The research questions posed to investigate this are: (i) what are the main adaptation strategies that the resource-poor households adopt?; (ii) what are the barriers to adaptation?; and (iii) what are the determinants influencing adaptation strategies, especially the influence of institutional access and social capital of resource-poor households in the study area?

The reminder of the paper is organized as follows: a review of relevant empirical evidence is presented in Section 2; Section 3 presents the background of the study area, the data collection procedure and a description of the model; the results are discussed in Section 4; and Section 5 provides a summary and some policy guidelines.

2. Review of Literature

This section provides a summary of the existing research on adaptation and the factors influencing adaptation. Adaptation to climate change and variability refers to the adjustments in the system of human-environment in response to actual and/or anticipated climatic conditions to avoid or to alleviate related risks or to realize potential opportunities (Wheeler et al., 2013; Smit et al., 2000; IPCC, 2001). The ability and capacity to adapt are influenced by system characteristics (e.g., agro-ecological) that are called the 'determinants of adaptation' (Smit et al., 2000). Understanding the determinants of adaptation is crucial to explaining the local adaptation process. This knowledge assists policy development by strengthening adaptation through investing in these factors (Yohe and Tol, 2002).

Empirical evidence from outside Bangladesh indicates that the most common adaptation strategies are using new crop varieties, diversifying crop varieties, adopting mixed crop and livestock farming systems, changing planting dates, planting trees, irrigation, soil conservation, and switching from farm to non-farm activities (Gebrehiwot and van der Veen, 2013; Deressa et al., 2011; Deressa et al., 2009; Molua, 2009; Kurukulasuriya and Mendelsohn, 2008; Nhemachena and Hassan, 2007). The determinants of adaptation choices can be broadly categorized as:

- Household and farm characteristics, including household head's age, gender, education and farming experience, household income, farm size and tenure status (Alam, 2016; Gebrehiwot and van der Veen, 2013; Bryan et al., 2009; Deressa et al., 2009; Hassan and Nhemachena, 2008; Seo and Mendelsohn, 2008).
- Social capital encompassing farmer-to-farmer extension and organizational involvement (Alam, 2016; Deressa et al., 2009).
- Institutional variables comprising access to climate information, extension services, credit facilities, markets, irrigation, and off-farm employment opportunities (Chen et al., 2014; Gebrehiwot and van der Veen, 2013; Bryan et al., 2009; Deressa et al., 2009; Kurukulasuriya and Mendelsohn, 2008).

Although the impacts of climate change in Bangladesh is not limited to the occurrence of droughts, most of the adaptation strategies are drought focused (see, for example, Alam, 2015; Alauddin and Sarker, 2014; Sarker et al., 2013; Habiba et al., 2012; Shahid and Behrawan, 2008; FAO, 2006). A few studies have focused on its low-lying and saline-prone areas (Islam and Walkerden, 2015; Islam et al., 2014; Anik and Khan, 2012; Rawlani and Sovacool, 2011; Ayers and Huq, 2008). Various determinants of adaptation strategies have been identified using a multinomial logit model. Alam (2015) indicated that farmers with more experience of farming, better schooling, and access to electricity and institutional facilities would have an increased likelihood of adopting alternative adaptation strategies in the drought-prone Rajshahi district. Alauddin and Sarker (2014) showed a household head's education level, farm size, access to climate information, electricity for irrigation, agricultural subsidies and severity of drought were significant factors underpinning the farmers' decision to adopt adaptation strategies in drought-prone areas in Bangladesh. Sarker et al. (2013) found that the household head's gender, age, education, household income, farm size, farmer-to-farmer extension, and access to credit, subsidy and electricity were the main determinants of an adaptation strategy in the Rajshahi district.

Empirical results suggest that riverbank erosion has catastrophic impacts on the lives and livelihood of riverine households in Bangladesh (Alam, 2016; Penning-Rowsell et al., 2013; Lein, 2010; Hutton and Haque, 2003; Zaman, 1991; Haque, 1997; Hossain, 1993). Research indicates that a significant portion of households are affected by riverbank erosion in many parts of the world including India, Sri Lanka, Cambodia, Laos, Thailand, Vietnam, Italy and Australia (Anthony et al., 2015; Das et al., 2014; Hall and Bouapao, 2010; Kummu et al., 2008; Rinaldi, 2003; Warner and Paterson, 2008). In terms of the magnitude of devastation of erosion, the Mississippi-Missouri River System of North America, Ganges and Brahmaputra of Bangladesh and India, Mekong River of Southeast Asia, Amazon River of South America, and River Nile of Africa are the most prominent (Das et al., 2014). Erosion of Danube River, the second longest river in Europe, creates severe problems for many European countries (Jones et al., 2007). Warner and Paterson (2008) asserted that flooding and riverbank erosion were the two major hazards for people living on or near flood plains of the coastal rivers of New South Wales, Australia. Hall and Bouapao (2010) argued that the Mekong riverbank's erosion had great impact on the livelihood and food security of the riverine people for Cambodia, Laos, Thailand and Vietnam.

So far there is no in-depth empirical research on adaptation and the factors influencing the adaptation strategies of hazard-prone resource-poor rural households. Particularly, the influence of institutional access and social capital that getting increasing attention for supporting and sustaining local adaptation process is lacking in the existing literature. Moreover, in recent years, place-based climate adaptation studies have received much theoretical discussion (Groulx et al., 2014; Fresque-Baxter and Armitage, 2012). Therefore, the factors that contribute to the adaptive capacity of households could allow government intervention to target the right groups of people and to formulate and implement an effective and sustainable adaptation policy in the country.

3. Methodology

3.1. Selection of Study Area

A multistage sampling technique was employed to collect data from riverbank erosion-prone areas in Bangladesh. The riverbank erosion affected districts, upazilas[1] and affected riverine villages were first selected purposively based on the degree of severity of erosion that was identified through a review of literature, reports in the newspapers and in consultation with experts. Respondents were selected randomly from each village. For the field survey, the Chauhali upazila of the Sirajgonj district and the Nagarpur upazila of the Tangail district were selected (Fig. 1). About 200 km north of Dhaka, the capital of Bangladesh, these areas represent one of the most erosion-prone riparian environments in the country. The Jamuna River which is reported to cause bank erosion of around 2000 ha per year (CEGIS, 2012) crosses the study area. Data were collected from six riverine villages – Kashpukuria, Moradpur, Kairat, Datpur, Kashkawalia and Atapara.

3.2. Sampling, Questionnaire and Data Collection

A complete list of riverine households in the selected villages was collected from the Department of Agricultural Extension. To make a representative sample size, 15% of households from each village were selected which gives a sample size of 380 households for the study. It is worth mentioning that a sample size of 350 is considered to be the optimal size for a structured interview in quantitative research (Perry, 1998). In addition, 5% of the population has been regarded as a sufficiently large sample size for survey research (Bartlett et al., 2001). To ensure the randomness in the sampling, a computer-generated random number table was applied to the list to select the 380 households. The unit of analysis was the rural household[2] and the household head (either male or female) was the survey participant for the data collection.

Data were collected using face-to-face interviews between January and May 2014. Before the final data collection commenced, a structured survey questionnaire was tested with 20 respondents to ensure the adequacy of the information obtained and to avoid any ambiguity of questions. Moreover, one focus group discussion was conducted in each village with a group of 10–12 household heads to obtain their views on various climatic and socio-economic variables. These opinions were used to cross-validate the information obtained from the survey and the key informants. In case of a non-response,[3] the interviewers proceed to the next household until the required number of respondents for a particular village was reached. Due to the smallness of the land holdings, the study households were categorized as: large farm household (38) (>2.5 acres), medium farm household (97) (1.5–2.49 acres), small farm household (125) (1.49–0.5 acres) and landless (120) (<0.5 acres).

3.3. Econometric Modelling

3.3.1. Theoretical and Empirical Model

The econometric analysis is based upon the random utility theory (Verbeek, 2004). The households' choice of adaptation strategies is discrete and mutually exclusive. The farmers in this study are assumed to select from a number of alternatives which have the highest utility (Alam, 2016; Alauddin and Sarker, 2014; Seo and Mendelsohn, 2008).

Assuming U_h and U_k are the utility of household i, who chooses between any two alternatives, the random utility model can be written as:

$$U_{ih} = V_{ih} + \varepsilon_{ih} \tag{i}$$

$$U_{ik} = V_{ik} + \varepsilon_{ik} \tag{ii}$$

where, U_{ih} and U_{ik} are an individual household's utility Eq. (i) of choosing option h and k, respectively, and V_{ih} and V_{ik} imply the deterministic (observable or explainable) or systematic component of utility. Whereas, ε_{ih} and ε_{ik} represent the stochastic (random or unexplainable) element that stands for unobservable influences on individual choices and measurement error, and are assumed to be independently and identically distributed (Greene, 2012). According to utility maximization behaviour, a household will only choose an option h if $U_{ih} > U_{ik}$ for all h ≠ k.

The deterministic components V_{ih} or V_{ik} represent an attribute vector x, i.e., $V_{ih} = x_{ih}\beta$ or $V_{ik} = x_{ik}\beta$. However, utility is not directly observable; rather, a households' choice of adaptation strategies can be observed. When there are many choices, the likelihood of alternative adaptations can be expressed as a probability:

$$\begin{aligned} Pr[Y_i &= [h|x|] = P\,[U_{ih} > U_{ik}] = Pr[x_i\beta_h + \varepsilon_{ih} - x_i\beta_k - \varepsilon_{ik} > 0|x|] \text{ and} \\ &= Pr[x_i[\beta_h - \beta_k] + \varepsilon_{ih} - \varepsilon_{ik} > 0|x|] = Pr[x_i\beta + \varepsilon > 0|x|] \end{aligned} \tag{iii}$$

where, β is a vector of unknown coefficients and x is the vector of the explanatory variables influencing the choice of adaptation and ε is a random error term. For a given x the probability that a household will choose an alternative h is given as follows:

$$\Pr(Y_i = h/x) = \frac{e^{\beta_h\, x_i}}{1 + \sum_{k=1}^{m} e^{\beta_k x_i}} \tag{iv}$$

Eq. (iv) can be estimated by choice models (Greene, 2012). To obtain unbiased and consistent parameters in the model, the assumption of Independence of Irrelevant Alternatives (IIA) must be fulfilled (Cameron and Trivedi, 2009). It indicates that the probability of adopting a particular adaptation strategy by a given farm household requires independence from the probability of selecting another adaptation strategy.

Different choice models – multinomial probit (MNP) or multinomial logit (MNL) – can be constructed based upon the assumed distribution of the random disturbance terms. MNL provides a more precise estimation than the MNP (Kropko, 2007). Moreover, estimation of MNL is simpler and interpretations of parameter estimates are easier (Cameron and Trivedi, 2009; Long, 1997). However, the estimated parameters of MNL only show the direction of the impact of the explanatory variables on the dependent variable and do not provide the extent of change or the probabilities. Marginal effects measure the impact on the probability of observing each of several outcomes rather than the impact on a single conditional mean and are more meaningful and interpretable (Cameron and Trivedi, 2009; Long, 1997). To compute the marginal effects of different exogenous variables, we differentiate Eq. (iv) with respect to N explanatory variables as follows:

$$\frac{\partial Pr_m}{\partial x_n} = Pr_h\left(\beta_{hn} - \sum_{h=1}^{H-1} Pr_h\beta_{hn}\right) \tag{v}$$

Marginal effects measure the likelihood of change in the probability of the adaptation of a particular choice with respect to a unit change in an explanatory variable (Greene, 2012). The MNL model can be regarded as simultaneously estimating binary logits for all possible comparisons among the outcomes. With Z outcomes, only Z-1 binary logits need to be estimated. Farmers can choose their most preferred option from a number of unordered and discrete adaptation strategies where one of these is the base category.

[1] Lower administrative unit of the government; below district level but above village level.

[2] A household (economic agent) is understood as a domestic unit and household heads have the power and decision-making authority over the household's resources (Ellis, 1988).

[3] Unavailability of respondents or refusal to answer questions were mainly in female-headed households (<2% of the actual sample).

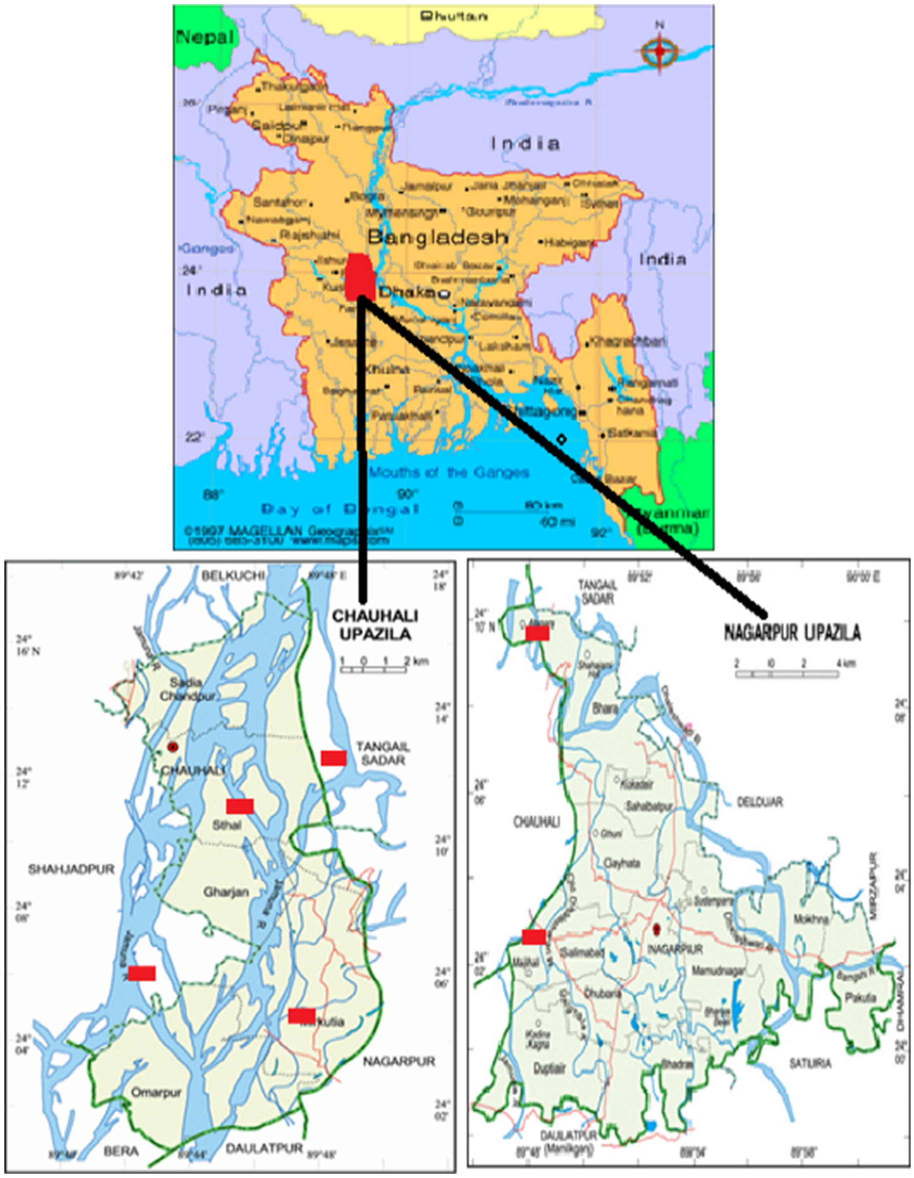

Fig. 1. The study area: the Chauhali and Nagrapur Upazilas in Bangladesh.

3.3.2. Specification of Variables

The selection of explanatory variables is based on the review of the literature, the focus group discussions and field experience. We assumed household adaptation strategies are a function of a household's socio-economic and farm characteristics such as the age, gender and education of the household head, household income and farm size. We also hypothesized that access to various institutions facilities and social capital are associated with increased adaptation.

Therefore, indexes of social capital and access to various institutional facilities were constructed. The components of the institutional access index are: (i) access to market (input and output), (ii) financial institution for credit, (iii) agricultural extension services, (iv) information on climate and weather conditions, and (v) off-farm employment opportunities. The social capital[4] index includes farmer-to-farmer extension, help receive from relatives in case of need, organizational involvement of the household heads and women members. The respondents replied 'yes' or 'no' to the questions on these components and the score was provided to make the index.[5] The index was then scaled into high and low. High refers to access to (at least) more than three institutional facilities and low otherwise. High social capital represents households' connection with (at least) more than two entries and low otherwise. The higher (lower) the index value the higher (lower) the likelihood of the adoption of that particular adaptation strategy. The variables and summary statistics are presented in Table 1.

An initial 15 adaptation strategies were identified through the focus group discussions. However, these failed to generate statistically significant parameters in the logit estimation. Therefore, following Alam (2015), Alauddin and Sarker (2014), Chen et al. (2014), Sarker et al. (2013) and Seo and Mendelsohn (2008) the adaptation strategies were reorganized by grouping closely related choices into the same category based on the best practices in the field and expert opinions for the model estimation. Thus, diversifying crops and varieties included the cultivation of pulses, spices and oil seed, and the cultivation of wheat and HYV rice varieties (e.g., BRRI-28, BRRI-29). Adjusting planting time and techniques included the cultivation of *aman* and *aus* rice,

[4] Social capital includes bonding networks (with family members), bridging networks (with neighbours and friends), and linking networks (with organizations) (Woolcock and Narayan, 2000).

[5] No weighting was used to treat the facilities equally as Wheeler et al. (2013) stated weighting can be inherently biased.

Table 1
Summary statistics.

Explanatory variables	Description	Mean	Std
Age	Years	45.12	14.43
Education	Years of schooling	3.17	4.63
Gender	Dummy, 1 = male, 0 = female	0.95	0.22
Average household income	Bangladeshi Taka	35,000	38,456
Large farmer (N = 38)	Dummy, (1 = large farmer, 0 = otherwise)	0.23	0.56
Medium farmer (N = 97)	Dummy, (1 = medium farmer, 0 = otherwise)	0.37	0.43
Small farmer (N = 125)	Dummy, (1 = small farmer, 0 = otherwise)	0.63	0.39
Landless (N = 120)	Dummy, (1 = small farmer, 0 = otherwise)	0.36	0.48
High institutional access	= 1 if high institutional access; 0 otherwise	0.64	0.89
Low institutional access	= 1 if low institutional access; 0 otherwise	0.22	0.42
High social capital	= 1 if high social capital; 0 otherwise	0.31	0.45
Low social capital	= 1 if low social capital; 0 otherwise	0.12	0.29

and vegetables. Diversifying income sources included livestock, poultry and duck rearing, small business and off-farm employment.

3.3.3. Model Diagnosis

The problems of multicollinearity, heteroskedasticity and the effect of outliers in the variables are usually associated with cross-sectional survey data. We examined collinearity using the correlation matrix with all the explanatory variables. The correlations are found to be relatively low (<0.39) in all cases. In order to explore the potential multicollinearity in the model which can lead to imprecise parameter estimates (Gujarati, 2003), we calculated the Variance Inflation Factor (VIF) for each of the explanatory variables. The VIFs range from 1.07 to 1.53 which does not reach to the conventional thresholds of 10 or higher used in regression diagnosis. The robust standard errors were used to tackle the problem of heteroskedasticity. The Ramsey-RESET test was also performed to test the accuracy of the models. The result rejected the null hypothesis of incorrect functional form that indicates relevant variables have not been omitted.

Endogeneity can also be a problem as its presence in the model creates bias estimates and limits the ability to make inferences about the characteristics (Wooldridge, 2006). The education variable in the model could be argued to be a potential endogenous variable due to the influences of some external confounding factors, namely the Compulsory Primary Education Policy of the government of Bangladesh (Alam, 2015). The endogeneity problem of the education variable in the model is examined by employing an augmented Durbin–Wu–Hausman test. Using the total educated numbers in the family as a proxy for the government policy intervention, the test result rejects the null hypothesis that the education variable is endogenous (F value 1, 1.05; Prob > 0.2).

4. Results and Discussions

4.1. Socio-demographic Characteristics

Table 1 provides details of the socio-demographic characteristics of the households. In summary, the results are:

- About 29% of the household heads' had no schooling. The average education level was below primary level (3.17 years). As well, 17% households did not send their children to school due to lack of education facilities. More than 46% of the households had more than five members and the average family size was 5.21 which is slightly higher than the national average of 5 (BBS, 2012).
- The average household income is estimated at Tk 35,000 per year.[6] The standard deviation of household income is fairly large indicating a wide range of variability among the households.
- The average land holding of the households was 0.56 acres (small farms are common in Bangladesh). About 32% of the households were landless.
- The respondents had limited access to institutions for credit. About 69% of the households reported no access to government financial institutions and 64% had no access to non-government organizations (NGOs).
- The social network, the key to social capital, was found to be limited. About 67% of the households had no contact with the extension service providers from whom they can obtain advice related to agriculture and rural development. They also had less farmer-to-farmer contact (43%) and less involvement with different organizations, including membership of cooperative societies (29%), from whom they can receive information and assistance.

4.2. Households' Adaptation Strategies

All of the households responded positively to undertaking adaptation measures based on their long-term knowledge, experience and perceptions to address the adverse effects of riverbank erosion hazard and other climate change issues. Households adopted at least one form of adaptation from the various adaptation options to sustain their farming and livelihood. After grouping closely related choices into the relevant category, the adaptation strategies of the households resulted in six main outcomes (Fig. 2). Small and landless farmers were found to adopt temporary seasonal migration, especially during the rainy seasons when there was limited scope of both farming and non-farming employment to improve their livelihood and food security. Tree plantation was practiced mainly by large and medium farmers who had sufficient land.

4.3. Barriers to Adaptation

Although the households were adopting adaptation strategies, they reported some barriers that prevented them from adapting successfully.

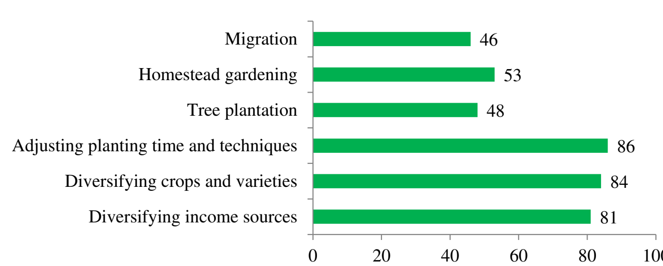

Fig. 2. Main adaptation strategies of households.

[6] Taka (Tk) is the Bangladesh currency, US$1 = Tk 76.15 as on 27 October 2015.

The main barriers were the lack of information about riverbank erosion and related climate issues, one's own land for cultivation, appropriate crop varieties, knowledge of appropriate adaptation and credit facilities (Table 2). Also mentioned were other post-production related problems such as a lack of storage facilities, marketing and transportation facilities which are crucial for policy intervention.

However, the barriers were felt heterogeneously among the farming groups. For example, the main barriers to adaptation for households with relatively less land ownership were the lack of credit, own land and knowledge about appropriate adaptation: the lower average land size among these households was highly significant ($p < 0.007$) compared to the households who did not mention these as a main barrier (independent sample *t*-test). The lack of storage and marketing facilities were mentioned mainly by the large and medium farmers as these might prevent them from getting the best price for their products. Connecting the small farmers to supermarkets could be a strategic option for both government and NGOs who are working to improve the livelihoods by enabling them better access to market. They also mentioned a lack of knowledge about appropriate adaptation strategies and transport facilities as barriers. A lack of credit is appeared to be the main barrier for small and medium farmers. A lack of institutional access and credit can limit their ability to get the resources and technologies they might need for adaptation.

4.4. Econometric Results

Table 3 presents the results of the MNL model of estimated parameters and marginal effects.

Overall, the model offers a good fit with factors predicting the adoption of adaptation strategies by the study households. The chi-square statistics (LR–213.43) indicate the strong explanatory power of the model. In other words, the joint null hypothesis that all variables are jointly significant is accepted. Goodness of fit of the model given by the McFadden pseudo R^2 of 0.29 also indicates reasonable explanatory power of the model (Table 3). We also tested the IIA by employing the Hausman test. The test result failed to reject the null hypothesis of IIA at the 5% level (p value 0.231). Moreover, most of the explanatory variables in the model and their marginal values were found to be statistically significant with an expected sign (see discussion below).

4.4.1. Level of Education

It is expected that household head with more education are more likely to adopt better adaptation strategies. The study found a significant positive relationship on the adoption of diversifying crops and varieties (0.112, $p < 0.05$), homestead gardening (0.019, $p < 0.10$), tree plantation (0.123, $p < 0.05$) and diversifying income sources (0.034, $p < 0.10$). It implies that a one unit (year) increase in a respondent's level of education will increase the probability of adopting diversifying crops and varieties by 0.112 relative to the base category while the effect on the remaining options is negligible. Negative relationship implies that a one unit (year) increase in a respondent's level of education will decrease the probability of adopting the particular adaptation strategy. The same interpretation holds true for the other variables. This finding supports the empirical evidence that farmers with higher educational levels were likely to adapt better to climate change in the African context (Gebrehiwot and van der Veen, 2013; Deressa et al., 2011) and in Bangladesh (Alam, 2015; Alauddin and Sarker, 2014). However, the education facilities in the area were found inadequate. Many institutions such as schools and hospitals were found to be eroded. They had to travel a longer distance (>2.5 km) to reach the school and health centre. Therefore, investing in education and health facilities in the study area should be in top policy priority.

4.4.2. Age of Household Head

The age of the household head acts as a proxy for experience and so influences the adoption of adaptation strategies. We found the household head's age was a significant positive factor on adopting diversifying crops and varieties (0.012, $p < 0.10$). It may be due to the fact that experienced people have good knowledge about weather and climate variability and thus adapt to this risk-aversion strategy. However, the impact was negative in adopting a migration decision (−0.105, $p < 0.05$). Households with low income and resources tend to migrate for few months to improve their livelihood and food security. Seasonal migration is less likely for an aged household head (negative impact) as it represents their vulnerability. This finding is consistent with previous adaptation studies (Hisali et al., 2011; Deressa et al., 2009).

4.4.3. Gender of Household Head

This study found a significant relationship between adopting the strategies of diversifying crops and varieties (0.002, $p < 0.05$) and a migration decision (−0.021, $p < 0.05$) for male-headed households. This result is in accordance with our field experience. But mixed opinion exists in African context that male-headed households are more likely to take up climate adaptation strategies (Deressa et al., 2009) contrary to the findings of Nhemachena and Hassan (2007).

4.4.4. Household Income

Household income was a significant positive factor in adopting the strategies of diversifying crops and varieties (0.101, $p < 0.05$) and tree plantation (0.007, $p < 0.10$). Modern agriculture is capital intensive: more capital is required when adopting new crops and varieties, agricultural technologies and fertilizer management. This opportunity is somewhat limited for small and marginal farmers unless they get access to credit. Previous studies found a positive relationship between income and adaptation also (Alam, 2015; Alauddin and Sarker, 2014). However, with the increase of income the probability of adopting a migration decision will be reduced (negative impact, −0.103, $p < 0.001$). It indicates that affluent households are in better position than poor households despite apparent difficulties of hazards.

4.4.5. Farm Status

Land ownership plays a key role in the livelihood of most of the rural households and this was expected to be a factor in increasing adaptation in farming. Large and medium farmers are relatively well resourced and more likely to adopt strategies earlier than small and landless farmers. This study found a significant positive relationship in adopting diversifying crops and varieties (0.231, $p < 0.001$ and 0.101, $p < 0.001$) and tree plantation (0.074, $p < 0.05$ and 0.045, $p < 0.05$), and a significant negative relationship in the case of a migration decision (−0.103, $p < 0.001$ and −0.073, $p < 0.05$) for large and medium farmers, respectively. It is understandable that households with sufficient land are not likely to migrate. In contrast, small and landless farmers migrate seasonally frequently (0.094, $p > 0.001$ and 0.113, $p > 0.001$ for small and landless farmers, respectively). They cannot generate enough income to

Table 2
Perceived barriers to adaptation measures.

Barriers to adaptation	Response by farm category			
	Large	Medium	Small	Landless
Lack of information about riverbank erosion and related climatic issues	xx	xx	xx	xx
Lack of appropriate variety of crops	xx	xx	xx	–
Lack of knowledge concerning appropriate adaptation strategies	x	x	xx	xx
Lack of credit/money/saving	–	x	xx	xx
Lack of suitable land for cultivation	–	–	xx	xx
Lack of own land	–	–	xx	xx
Lack of storage facilities	xx	xx	–	–
Lack of marketing facilities	xx	xx	xx	–
Lack of transportation facilities	x	x	x	–

Where, xx = main barriers, x = barriers.

Table 3
Estimated results from MNL model.

Explanatory variables	Adaptation strategies (dependent variable)									
	Diversifying crops and varieties		Homestead gardening		Tree plantation		Diversifying income sources		Migration	
	Coefficient	Marginal effect	Coefficient	Marginal effect	Coefficient	Marginal effect	Coefficient	Marginal effect	Coefficient	Marginal effect
Constant	-5.31^{**}		-3.41^{*}		-1.75^{*}		-1.23^{**}		-2.65^{*}	
	(2.441)		(2.201)		(0.905)		(0.571)		(1.361)	
Age	0.125^{**}	0.012^{*}	0.141	0.025	0.130^{*}	0.019	0.102^{*}	0.037	-0.321^{***}	-0.105^{**}
	(0.051)	(0.013)	(0.112)	(0.017)	(0.077)	(0.031)	(0.052)	(0.025)	(0.121)	(0.047)
Education	0.313^{**}	0.112^{**}	0.065^{*}	0.019^{*}	0.071^{**}	0.123^{**}	0.093^{**}	0.034^{*}	0.071	0.006
	(0.124)	(0.053)	(0.037)	(0.011)	(0.033)	(0.061)	(0.043)	(0.018)	(0.032)	(0.012)
Gender	0.011^{**}	0.002^{**}	0.017	0.009	0.061	0.015	0.023	0.009	-0.131^{***}	-0.021^{**}
	(0.004)	(0.001)	(0.014)	(0.021)	(0.047)	(0.012)	(0.013)	(0.011)	(0.041)	(0.01)
Average household income	0.135^{**}	0.101^{**}	0.023	0.001	0.013^{*}	0.007^{*}	0.013	0.002	-0.211^{***}	-0.103^{***}
	(0.061)	(0.047)	(0.021)	(0.000)	(0.007)	(0.004)	(0.006)	(0.000)	(0. 056)	(0. 031)
Large farmers	1.128^{***}	0.231^{***}	0.017	0.005	0.193^{**}	0.074^{**}	0.011	0.000	-0.171^{***}	-0.103^{***}
	(0.331)	(0.083)	(0.102)	(0.014)	(0.065)	(0.026)	(0.104)	(0.000)	(0.051)	(0.035)
Medium farmers	0.122^{***}	0.101^{***}	0.023	0.007	0.103^{**}	0.045^{**}	0.027	0.003	-0.112^{***}	-0.073^{**}
	(0.039)	(0.029)	(0.142)	(0.105)	(0.035)	(0.022)	(0.204)	(0.093)	(0.036)	(0.026)
Small farmers	0.118	0.072	0.191^{***}	0.108^{**}	0.076	0.012	0.213^{***}	0.112^{***}	0.172^{***}	0.094^{**}
	(0.103)	(0.041)	(0.061)	(0.045)	(0.045)	(0.014)	(0.067)	(0.036)	(0.054)	(0.035)
Landless farmers	0.105	0.051	0.115^{**}	0.073^{**}	0.114	0.065	0.059^{**}	0.023^{**}	0.237^{***}	0.113^{***}
	(0.076)	(0.031)	(0.041)	(0.025)	(0.102)	(0.073)	(0.021)	(0.011)	(0.067)	(0.037)
High institutional access	0.511^{***}	0.191^{***}	0.130^{**}	0.071^{**}	0.028^{**}	0.011^{**}	0.106^{**}	0.013^{**}	0.074	0.005
	(0.183)	(0.072)	(0.064)	(0.034)	(0.014)	(0.005)	(0.045)	(0.006)	(0.055)	(0.012)
Low institutional access	-0.216^{**}	-0.108^{*}	−0.167	−0.013	−0.102	−0.007	−0.135	−0.052	0.024	0.004
	(0.112)	(0.063)	(0.106)	(0.014)	(0.132)	(0.076)	(0.108)	(0.047)	(0.077)	(0.015)
High social capital	0.215^{***}	0.102^{***}	0.251^{**}	0.127^{**}	0.151	0.016	0.113^{**}	0.031^{*}	0.153^{***}	0.119^{***}
	(0.073)	(0.04)	(0.097)	(0.055)	(0.312)	(0.145)	(0.051)	(0.017)	(0.053)	(0.041)
Low social capital	-0.114^{*}	−0.016	−0.084	−0.006	−0.031	−0.003	−0.106	−0.071	-0.119^{**}	-0.018^{*}
	(0.108)	(0.013)	(0.124)	(0.046)	(0.116)	(0.035)	(0.117)	(0.091)	(0.051)	(0.010)
Log likelihood	−227.12									
Pseudo R^2	0.29									
LR (Chi-square)	213.43 ($p < 0.02$)									

N = 380. Adjusting planting time and techniques is used as base category. Robust standard errors are indicated in parentheses.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.001$.

sustain their livelihood mainly due to the lack of employment opportunities in farming. They are more likely to adopt homestead gardening (0.108, $p > 0.05$ and 0.073, $p > 0.05$ for small and landless farmers, respectively) for the effective and sustainable use of their limited land resources. This strategy provides nutrients in their food chains and is an important source of subsequent income throughout the year. The significant positive relationship between farm size and adaptation are consistent with previous studies (Alauddin and Sarker, 2014; Deressa et al., 2009).

4.4.6. Institutional Access

We found evidence that suggests a household's access to institutional facilities greatly influences the likelihood of adopting adaptation strategy. High institutional access increase the probability of adopting adaptation strategies such as diversifying crops and varieties (0.191), homestead gardening (0.071), tree plantation (0.011) and diversifying income sources (0.013) which were found significant at 5% level. However, limited institutional access reduces the probability of adopting such adaptation strategies. The availability of information can promote adaptation through better management of crops, land, fertilizer and climate variability. Access to credit has been reported to have a significant positive impact on adaptation decisions (Bryan et al., 2009; Deressa et al., 2009). Gebrehiwot and van der Veen (2013) mentioned that access to markets can serve as a platform for providing information for farmers. Information on climate change can create awareness among farmers and increase the probability of adopting adaptation strategies (Alam, 2016; Deressa et al., 2009). Survey results suggest that small and landless farmers have limited access to institutional facilities, especially in terms of access to credit and extension services, which limits their scope to adopt adaptation strategies. Strong government intervention is required to ensure these vulnerable households' access to institutional facilities.

4.4.7. Social Capital

The study results show a highly significant role of social capital on the likelihood of adoption of adaptation strategy. High social capital increases the probability of implementing the strategy of diversifying crops and varieties (0.102, $p < 0.001$), especially for large and medium farmers. In case of small and landless farmers, social capital increases the probability of adopting the strategies of migration (0.119, $p < 0.001$), homestead gardening (0.127, $p < 0.05$) and diversifying income sources (0.031, $p < 0.10$). Low social capital, on the other hand, reduces the probability of adoption of those strategies. The probability of taking migration decision was found reduced (−0.018, $p < 0.10$) for the small and land less farmers those had low social capital. It is because they did not get appropriate information and help from others to go for work in distance places. Since plurality of households depends on wage labour, they need to adopt the temporary seasonal migration decision, especially during the rainy seasons when the scopes of employment become limited. This result is consistent with the findings that the presence of a strong kinship network can increase the adaptive capacity of farmers by providing economic, managerial and psychological help (Smit and Wandel, 2006). Deressa et al. (2009) found a highly significant negative relationship between social capital and no adaptation decision. Households have reported that access to farmer-to-farmer extension and government extension services stimulated them to cultivate in the new '*char land*'[7] which was fallow previously. Households which adopted homestead gardening and changing profession towards livestock, poultry and duck rearing reported a positive contribution for adopting such strategies through their involvement in different organizations and NGOs. Small and landless farmers expressed an opinion that sharing and exchanging information and views with each other helped them to take the seasonal migration decision to improve their food security and livelihood. Islam and Walkerden (2015) mentioned that households' links with NGOs can promote their resilience. However, we observed during our field visit that the presence of NGOs and government services were very limited to those vulnerable areas. Activities of government organizations and NGOs should be strengthened to support and promote the local adoption process in the areas.

5. Conclusions and Policy Implications

Bangladesh is located in disaster-prone area resulting in recurrent floods, cyclones surges and perennial riverbank erosion problem. Local level adaptation strategies are the key to reducing the impacts of such hazards on agriculture, food production and the vulnerability of rural households. This research goes beyond examining the determinants of hazard-prone resource-poor rural households' local adaptation choices and the barriers to adaptation. It focuses on the influence of institutional access and social capital on adaptation choice as a way forward to support and sustain local adaptation process of these vulnerable households. The MNL model passes the assumptions of the IIA and does not suffer from the potential multicollinearity, heteroskedasticity and endogeneity problems as confirmed by the statistical tests.

The study reveals that households have somewhat responded to the riverbank erosion hazards and other climate change issues through adopting a range of adaptation strategies depending on their socio-economic and household characteristics, and access to institutional facilities and social capital. Migration appears to be an important adaptation strategy for small and landless farmers in particular while other important adaptation strategies are diversifying crops and varieties, diversifying income sources, adjusting plantation time and techniques, planting trees and homestead gardening. The important barriers to adopting the adaptation strategies include a lack of information about riverbank erosion and related climatic issues, a lack of knowledge about appropriate strategies, unsuitable crop varieties, the limitations of one's own land and limited access to credit.

Model results suggest that access to institutional facilities and social capital are the key factors influencing the adoption of adaptation strategies by the resource-poor households. This underscores the need for strengthening the extension services in the study area and providing rural households with better information on production techniques, agronomic and land management practices, and climate change issues. Access to financial institutions and the creation of off-farm employment opportunities in riverine rural areas are also crucial to support the households in adapting adaptation strategies at the farm level. Government organizations and NGOs can play a greater role by helping to form social organizations/clubs with the farmers (e.g., an Integrated Pest Management club) or assisting cooperative farms in these poorly resourced communities so that the adoption of adaptation strategies is likely to contribute to their successful continuation. Since the crop production environment in riverbank erosion-prone areas is somewhat unfavourable, livestock rearing could be encouraged with appropriate policy support. For instance, government organizations and NGOs can provide poor farmers with livestock support or credit for having livestock. Results also indicate that investment in education and a supply of high yielding crops and varieties suitable to local conditions particularly for the *char land* can potentially contribute to reducing the adverse impact of erosion and other climate change hazards of the households, and be means to improve their livelihoods.

[7] Due to the dynamics of erosion some 'char land' (sandbars/sand and silt landmasses) have emerged as islands within the river channel or attached land to the riverbanks in Bangladesh. The char area covers about 5% of the total land area of the country and is occupied by about 6.5 million people (5% of the total population) (CEGIS, 2000).

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