



Farmers Adaptation Strategies to Drought and Their Adoption Determinants in Northwestern Parts of Bangladesh

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ABSTRACT

Background: Drought-induced substantial production decline in agricultural sectors results in a seasonal food crisis in Bangladesh. Nevertheless, the farmers in Bangladesh have not yet adequately adopted adaptation strategies to address the detrimental effects of drought, especially in agriculture. The study was conducted to identify the farmers' current adaptation strategies to drought and their adoption determinants in northwestern parts of Bangladesh.

Methods: A total of 150 farmers were selected through simple random sampling from two drought affected districts of Bangladesh. The collected data were then analyzed by using the descriptive statistics and Poisson regression model.

Result: The results indicated that approximately 38% of farmers adopted three out of the 9 strategies for adaptation to address the drought scenario. The Poisson regression suggested that the gender of the primary farmer, education, training and agriculture credit positively influence the adoption of adaptation strategies. For example, positive and significant coefficient of training suggests that farmers who have undergone training exhibit a 0.21 unit greater difference in the logs of expected counts compared to farmers who have not received any training. Farmers identified several obstacles to adoption, including insufficient knowledge about suitable adaptation, limited access to financing facilities and inadequate level of extension services.

Key words: Adaptation, Agriculture, Climate change, Drought, Poisson regression.

INTRODUCTION

Now-a-days climate change (CC) is regarded as one of the most pressing issues that has substantially altered or is in the process of changing earth's ecosystems (Arora, 2019). In low-income or developing countries, CC has a substantial impact on food and nutrition security, as well as agriculture (Praveen and Sharma, 2019; Malhi *et al.*, 2021; Kumar *et al.*, 2022). Bangladesh, a south Asian developing country, is one of the most climate vulnerable countries in the world due to its geographical location, climatic variability, dense population and dependence on agriculture which is susceptible to climate change (Hossain *et al.*, 2016). In Bangladesh, drought is a substantial obstacle to achieving sustainable agricultural production and ensuring food security in Bangladesh. Drought predominantly impacts Bangladesh during the pre-monsoon and post-monsoon seasons. The drought results from the cumulative impact of dry days, high temperatures and lack of rainfall. The north-western part of Bangladesh is primarily affected by drought, specifically impacting the 1.2 million hectares of farmland (Rahman *et al.*, 2022). Bangladesh endured more than 20 droughts in the past 50 years (Habiba *et al.*, 2012). Therefore, in recent years, there has been a growing emphasis on the implementation of various adaptation strategies to address the escalating severity of drought and crop production losses. Adaptation is crucial in addressing CC by mitigating its negative impacts (Alam *et al.*, 2016; Terefe, 2023). Hence, this study was conducted to explore the current strategies employed by farmers to cope with drought and their determinants in the drought affected northwestern regions of Bangladesh.

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The literature on adaptation strategies of the farming population is extensive, with a predominant focus on African countries in terms of geographical coverage (Deressa *et al.*, 2009; Dabesa *et al.*, 2022). A dearth of research has been carried out in regions of Bangladesh that are prone to drought, specifically focusing on the identification of adaption strategies and the factors that influence their adoption (Alauddin and Sarker, 2014; Ahmed *et al.*, 2019; Al-Amin *et al.*, 2019; Anik *et al.*, 2021). In the above empirical literature, the notable and common adaptation strategies are raising livestock, developed irrigation and water harvesting channels, drought-tolerant and short-duration crop varieties and change in planting and harvesting date.

A few studies conducted in Bangladesh suggested that education, income, extension services, the use of ICT in farming, credit and the membership in societal organizations, positively influence the likelihood of adopting adaptation strategies (Kabir *et al.*, 2017; Anik *et al.*, 2021). Several other studies examined the adaptation strategies adopted in regions of Bangladesh affected by coastal and riverbank erosion (Alam *et al.*, 2016; Khan *et al.*, 2022; Rahman *et al.*, 2023; Rahman *et al.*, 2024).

The following limitations can be identified from the existing literature. The study conducted in drought prone areas mainly focused on analyzing farming strategies suitable for rice farmers, while a farmer may adopt strategies beyond the domain of rice farming. Several studies exclusively examine the viewpoint of indigenous farmers, disregarding a significant section of the general farming population. Most of the research have mostly concentrated on the African context and coastal regions, which may not be applicable to drought-prone areas in a developing country setting. Therefore, this study was undertaken to provide answers to the following research questions: What are the adaptation strategies currently adopted by the farmers in drought prone areas? and What factors influence the adoption of those adaptation strategies.

MATERIALS AND METHODS

Study areas

The study was carried out in the northwestern districts of Bangladesh, where drought is a persistent and more conspicuous issue in comparison to other locations (Rahman *et al.*, 2022). The study employed a multistage sampling technique. At first, the districts of Rajshahi and Chapainawabganj, located in the northwest region, were selected based on the intensity of the drought they were

experiencing (Hossain *et al.*, 2016). For the second stage, a purposive selection was made of one upazila (sub-district) from each district, taking into consideration the objectives of this study (Fig 1). In the third step, three villages were selected randomly from each upazila for data collection.

Sampling technique

The study's population consisted of farmers from the selected villages. The research team collected the list of the farming households from the local agricultural extension offices. A total of 715 farming households are living in the selected villages. Given that the farmers in the area have similar socio-economic, environmental and climate characteristics and are involved in farming activities, they can be considered a relatively homogeneous group. Therefore, instead of using a statistical formula, the sample size for this study was determined based on the context. Moreover, prior research has also indicated that a representative sample consists of 20% of the population (Kabir *et al.*, 2022). Consequently, a total of 143 samples constitutes the representative sample for this study. However, finally we surveyed 150 farming households, that includes 75 from each upazila.

Data collection

The survey participant was the primary farmer of the household. Prior to conducting the final survey, the interview schedules underwent a pretest with a limited sample of farmers from a different village. The suggestions and feedback gained during the pretesting were integrated into the final interview schedule. Prior to commencing the survey, explicit verbal consent was obtained from every participant. In addition, the participants were provided with a brief explanation of the extent and goals of the research to ensure that the confidentiality of their data would be

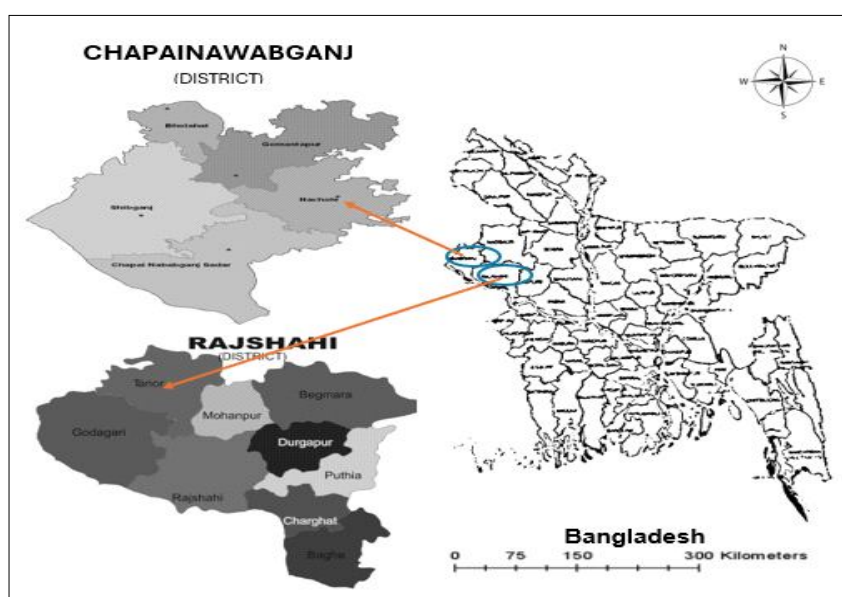


Fig 1: Map of study areas.

preserved and utilized solely for the purposes of the study. The final field survey was carried out between July 2022 and August 2022, either at the respondents' residence or at the farm site. The formal analysis was carried out in the department of agricultural finance and management, Sher-e-Bangla Agricultural University, Bangladesh.

Analytical techniques

Both descriptive statistics and econometric model were used to achieve the objectives of the study. The random utility framework was utilized to identify the factors influencing the adoption of various adaptation strategies. According to this framework, a farmer would adopt an adaptation strategy if the benefits gained from adoption outweigh those of non-adoption. Previous studies have assessed this relationship using binary probit or logit regression, assigning a score of one to adopters and zero to non-adopters, without considering the number of adaptation strategies adopted (Ahmed *et al.*, 2021). However, in areas prone to drought, farmers may adopt multiple adaptation strategies simultaneously, rendering binary probit or logit regression unsuitable. To address this issue, different studies have employed various models based on the nature of the data (Rahman *et al.*, 2023; Moniruzzaman *et al.*, 2023). In this study, we utilized a Poisson regression model to identify the factors influencing the adoption of adaptation strategies. The Poisson regression model was chosen because of its advantages in estimating a farmer's expected degree of adoption among different adaptation strategies with his or her given characteristics (independent variables). The definition of the independent variables used in this study is given in Table 1. The analysis was performed in STATA 14. The

following empirical Poisson regression model was used (Ewunetu *et al.*, 2021).

$$E(Y_i) = \beta X_i + \varepsilon_i \quad \dots (1)$$

Where,

$E(Y_i)$ = Dependent variable's expected value for the i^{th} farmer (number of adaptation strategies).

β = Parameters to be estimated.

X_i = Independent variables.

ε_i = Error term in the model.

RESULTS AND DISCUSSION

Descriptive statistics

The descriptive statistics of the independent variables used in the model are presented in Table 1. The average age of farmers is 41.69 years, suggesting that most of the farmers are in their middle age. The mean education of the primary farmer is 5.32 years, suggesting that the majority of farmers possess a primary level education and may have a lower level of formal education qualification. The mean family size exceeds the national average of four by 4.63 (BBS, 2022). Furthermore, the results reveal that only 34% of the farmers cultivate their own land, while the remaining farmers are classified as tenant farmers. The proportion of farmers who obtained training in farming activities was about 9%. The findings indicated that there is significant potential for launching training programs in the study areas. Furthermore, the results reveal that only 23% of farmers obtained agricultural credit from various sources including banks and NGOs. Prior research has indicated that agricultural households in Bangladesh frequently face challenges in accessing credit (Moniruzzaman *et al.*, 2023), which

Table 1: Description of the independent variables used in the model.

Variables	Description	Mean	Standard deviation
Age (X_1)	Primary farmers' age in years	41.69	10.17
Gender (X_2)	Dummy: 1 if the primary farmer is male and 0 otherwise	0.97	0.16
Education (X_3)	Completed years of schooling of the primary farmer	5.32	4.35
Family size (X_4)	Total number of family members	4.63	1.77
Farm ownership (X_5)	Dummy: 1 if the primary farmer is owner of the cultivated land and 0 otherwise	0.34	0.48
Training (X_6)	Dummy: 1 if the primary farmer has received training in agriculture and 0 otherwise	0.09	0.28
Societal membership (X_7)	Dummy: 1 if any member of the family has any societal membership and 0 otherwise	0.27	0.44
Credit (X_8)	Dummy: 1 if any member of the family has received any agricultural credit and 0 otherwise	0.23	0.42
Access to farming information (X_9)	Dummy: 1 if any member of the family uses mobile phone for farming information and 0 otherwise	0.65	0.48
Distance from local market (X_{10})	Distance of home from local market in kilometers	1.15	0.99

could impede the adoption of effective adaptation strategies.

The state of farmers' adaptation strategies

Despite the prevalence of CC events like drought in the study areas, the farmers have not yet adequately adopted adaptation strategies to meet their expectations. The existing literature has also indicated that the adoption of adaptation strategies to drought in Bangladesh is somewhat limited (Ghose *et al.*, 2015; Roy *et al.*, 2020). The previous studies categorized the adaptation strategies into five principal groups: (i) Climate-resilient crop varieties, (ii) Crop diversification, (iii) Improved agronomic practices, (iv) Income diversification and (v) Irrigation enhancement (Ahmed *et al.*, 2021). Our analysis revealed that farmers adopted a total of nine adaptation strategies across five groups, of which five were to improvements in agronomic practices. Table 2 represents the proportion of farmers who have adopted different adaptation strategies in the selected study areas. Most farmers (74%) have augmented the frequency of irrigation in order to alleviate the water scarcity resulting from drought. This has been achieved by excavating ponds to retain rainwater for irrigation and operating shallow and

deep-water pumps to extract water from the ground. This result is in line with the findings of Hossain *et al.* (2016), which indicated that adaptation measures such as re-excitation of ponds are appropriate for farmers who own their own ponds. The vast majority of farmers (57.3%) reported applying organic fertilizer, specifically cow dung and compost, which enhances soil water retention and thereby stimulates crop growth in drought conditions. Approximately 49.3% of farmers chose to engage in 'non-farm activities' alongside their farming activities to boost their income and overcome difficult circumstances. Petty business, van or auto rickshaw driving, day labor, services were the most prevalent non-farm economic activities observed in the study areas. As an adaptation strategy, around 24.7% of the farmers turned for drought-tolerant varieties of rice such as BRRI dhan 56 and BRRI dhan 57. However, rather than relying solely on rice, a significant proportion of farmers also adopted other innovative strategies such as crop diversification (38.7%) as an adaptation strategy. The farmers generally grow maize, potatoes, onions and other crops rather than rice because rice farming requires extra water. Crop diversification aids in mitigating uncertainty and enhancing soil fertility (Dabesa *et al.*, 2022). Approximately 40% of farmers are altering the crop calendar by planting rice one to two weeks earlier than the recommended date to mitigate the adverse effects of drought. A prior study indicated that farmers exhibited a preference for innovative methods such as crop diversification over monoculture of rice (Islam *et al.*, 2019).

The results further indicated that approximately 38% of farmers in the study areas adopted three out of the 9 strategies for adaptation to address the drought scenario (Fig 2). Approximately 44% of farmers in Nachole upazila adopted three adaptation strategies, whereas around 32% adopted such strategies in Tanore upazila. The results

Table 2: Adaptation strategies adopted by farmers.

Adaptation Strategies	Per cent (%)
Organic fertilizer use	57.30
Drought tolerant varieties (rice)	24.70
Increase in irrigation frequency	74.00
Crop Diversification	38.70
Mixed cultivation/ Intercropping	28.00
Practicing fruit gardening	6.00
Alternate wetting and drying	20.70
Change in planting date (crop calendar)	40.00
Non-farm activities	49.30

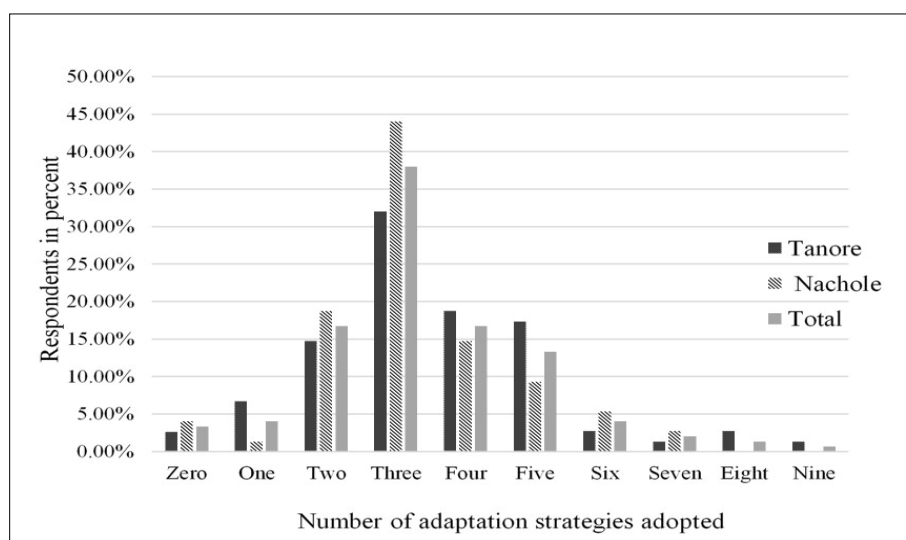


Fig 2: The number of adaptation strategies adopted by farmers.

indicate that the levels of adaptation strategies adoption rate were almost identical in both upazilas.

Determinants of farmers' adaptation strategies

Before running the final model, the study assessed multicollinearity among independent variables by variance inflation factor (VIF). The calculated VIF is within the range of 1.05-2.60, indicating there is no multicollinearity issue. The LR chi-square statistics illustrate the model's potent explanatory potential (Table 3).

The positive and significant co-efficient of gender suggests that the difference in the logs of expected counts is 1.36 unit higher for male farmers compared to their counterparts. The finding is in line with earlier studies that revealed that gender of the primary farmers is a significant driver of the adoption of strategies for adaptation (Deressa *et al.*, 2009; Khan *et al.*, 2022). Nevertheless, it does not mean that women have a reduced inclination to adopt. Since males are the default head and main decision maker of households in Bangladesh; consequently, the adoption rate is better in households where males are the primary farmer.

A positive and significant coefficient of education indicates that for each unit of rise in a farmer's education (year of schooling), the difference in the logs of expected counts is expected to increase by 0.03 unit. One possible explanation for this is that education enhances knowledge and the readiness to financially support any emerging technology. When the primary farmer of a household is educated his/her inclination towards adaptation strategies increases. Several previous studies also find the similar findings (Deressa *et al.*, 2009; Alauddin and Sarker, 2014; Quraishi, 2021; Mohanraj *et al.*, 2024).

The positive coefficient of training indicates that the difference in the logs of expected counts is 0.21 unit higher for farmers who have received training compared to farmers who did not receive any training. In this study, we found that only a small proportion of the farmers received agricultural

training. Given adequate training, farmers' decision-making capacity can be enhanced to a certain degree. Hence, it is imperative for relevant authorities to organize regular field days, community-based education and training programs to enhance the knowledge of farmers and ensure the provision of necessary extension services.

The coefficient of credit indicates that the difference in the logs of expected counts is 0.28 unit higher for farmers who have received agricultural credit in comparison to farmers who have not received agricultural credit. The finding is in line with several previous studies (Kabir *et al.*, 2017; Quraishi, 2021). In general, farming households in Bangladesh face several challenges, such as insufficient income or capital availability. Consequently, the provision of financial resources can enhance the inclination to invest in adaptation strategies, hence boosting the rate of adoption. Hence, financial institutions could consider broadening their credit services to ensure that a larger number of households can avail themselves of their credit.

Stated barriers to adoption of adaptation strategies

The majority of respondents (73.33%) encountered substantial difficulties with irrigation water usage (Table 4). Prior research has indicated that the limited availability of irrigation water caused by reduced rainfall and depletion of groundwater is a significant issue in regions susceptible to drought (Ahmed *et al.*, 2019). Nevertheless, farmers still need to oversee the management of irrigation water for agricultural purposes, resulting in higher production costs and thus decreased profitability. Approximately 47.3% of farmers indicated that limited availability of finance facilities is another challenge they encounter while implementing adaptation strategies. The exorbitant interest rates, demands for collateral and intricate documentation pose significant challenges for farmers seeking access to conventional credit from banks. Approximately 42.6% of farmers revealed that the main

Table 3: Estimated values and co-efficient of poisson regression.

Independent variable	Coefficient	Standard error	P-value
Intercept	-0.505	0.511	0.323
Age (X_1)	-0.001	0.006	0.872
Gender (X_2)	1.360***	0.421	0.001
Education (X_3)	0.030**	0.015	0.043
Family size (X_4)	0.028	0.028	0.305
Farm ownership (X_5)	0.015	0.010	0.877
Training (X_6)	0.210**	0.105	0.046
Societal membership (X_7)	0.110	0.106	0.302
Credit (X_8)	0.280**	0.137	0.038
Access to farming information (X_9)	0.127	0.126	0.313
Distance from local market (X_{10})	-0.034	0.047	0.465
LR chi-squared	96.80		
Pseudo R^2	0.17		

*** and ** denote significance at the 1% and 5% levels, respectively.

Table 4: The barriers faced by farmers.

Barriers	Per cent (%)
Lack of irrigation water	73.33
Low credit facilities	47.33
Lack of adequate extension service	42.67
Scarcity of labor	19.33
Lack of knowledge concerning appropriate adaptation	13.33

obstacle they encountered during the process of adaptation was the insufficient provision of extension services. By virtue of the absence of extension services, they were deprived of the necessary information and opportunities for capacity building that are essential for adoption.

CONCLUSION

Drought is argued to be a significant barrier to attaining sustainable agricultural output and guaranteeing food security in Bangladesh. This study aimed to determine the adaptation strategies adopted by farmers to mitigate the adverse effects of drought and to identify the factors influencing their adoption decision by employing descriptive statistics and econometric modelling. The results revealed that the adopted adaptation strategies largely involved agricultural practices such as the application of organic fertilizer, cultivation of drought resistant rice varieties, increase of irrigation frequency and modification of planting date. Furthermore, numerous farmers additionally engage in non-farm work as a means of adaptation. Gender, education, training and credit availability were statistically significant independent variables that influenced the adoption of adaptation strategies. The results indicated that farmers in the study area have augmented the frequency of irrigation to mitigate the severity of the drought. To mitigate irrigation water shortage, the government and relevant authorities need to take measures such as re-excavation of canals and ponds. Many farmers have been accustomed to growing indigenous varieties, apart from rice, even though such varieties may lack the ability to endure drought conditions. Hence, apart from rice, it is imperative to expand the introduction of drought resistant varieties for other crops. Non-governmental organizations and other stakeholders ought to provide information to their members regarding the benefits of adaptation strategies through regular activities.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are

responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect loss resulting from the use of this content.

Conflict of interest

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