

Perception of climate change and driving factors for the adoption of drought tolerant rice varieties in Bangladesh

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Abstract. Karim MR, Pramanik MAM, Muhammad N, Chowdhury A, Aurangozeb MK, Sultana R. 2026. Perception of climate change and driving factors for the adoption of drought tolerant rice varieties in Bangladesh. *Asian J Agric* 10 (1): g100137. <https://doi.org/10.13057/asianjagric/g100137>. The adoption of Drought Tolerant Varieties (DTV) of rice can be a significant solution to combat water scarcity and reduce grain yield loss. The main objective of the study is to determine farmers' perceptions of climate change and to explore the drivers of the adoption of drought tolerant rice varieties. The study was conducted in two villages of Farakkhabad Union Parishad of Biral Upzila under Dinajpur District of Northern Bangladesh. The data were collected from 181 sampled rice farmers who experienced seasonal drought in crop cultivation due to decreasing rainfall over the years. The observed meteorological data on temperature and rainfall closely aligned with perceptions of climate change. The study found that 61.32% of farmers adopted the drought tolerant rice varieties. The logit regression analysis showed that eight factors, such as gender, education, farm size, income, training access, extension service, credit access, and access to Information, Communication and Technology (ICT), significantly influenced the adoption of drought tolerant rice varieties. Non-adopter farmers cited a lack of information, unavailability of seeds, and a lack of cash to purchase seeds as major obstacles to the adoption of drought tolerant rice varieties. Therefore, in term of novelty, this study highlights and incorporates the institutional factors along with socio-economic factors of the rice farmers by indicating their climate change perception and aligning with meteorological data. The study recommends that different government and non-government extension programs can promote institutional services for training, credit and information access to overcome the challenges of non-adoption. Further relevance policies and uptake programs could accelerate the adoption of drought tolerant rice varieties to cope with the impacts of drought.

Keywords: Adoption, climate change, drought tolerance, perception, varieties

INTRODUCTION

Rice is one of the major cereal crops that plays a crucial role in the world's economy. In terms of production, rice ranks 3rd globally after wheat and maize (Khan et al. 2022), and it is estimated that worldwide rice demand will increase to 584 million tons by 2050 (Rahman et al. 2022). Moreover, Asia is the largest producer and leading exporter of rice, meeting worldwide demand (Ho et al. 2022). However, by 2050, Bangladesh's population is expected to reach about 215 million; as a result, an additional 10.8 million tons of rice would be required to feed the additional people (Rahaman et al. 2021). Rice production is mainly influenced by climatic variability and hazardous events, such as floods, droughts, and salinity, which can reduce yields (Mishra et al. 2015; Nayak et al. 2022; Emmanuel et al. 2024). The increasing frequency and intensity of natural disasters, such as drought, pose a significant threat to livelihoods (Mulia and Handayani 2024). The northern region, composed of sixteen districts that contribute to 40% of the national rice production (Islam et al. 2022). However, this region experienced severe drought in 1999, 2000, 2006, 2009, and 2012 (Islam et al. 2014; Rahman et

al. 2022). According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2013), the past century has experienced a global temperature increase of 0.74 degrees Celsius, with significant impacts on crop production (Lobell et al. 2008; Islam et al. 2022). The prolonged drought reduces rice production, which accounts for 25% of the world's rice area, posing a serious threat to food security (Islam et al. 2017).

In Bangladesh, water scarcity is a crucial problem which triggers drought and causes reduction of rainfed rice yield of about 5.7 million hectares cultivated land (Nayak et al. 2022). Drought can delay or completely constrain rice flowering (Mas-ud et al. 2022), even water scarcity at reproduction stage can reduce significant yield by increasing the spikelet sterility. Drought Tolerant Varieties (DTV) are the crops or specific varieties of crops that can tolerate water scarcity at a certain level (Aryal et al. 2018a). Considering the facts of increasing drought severity and losses of rice yield, Bangladesh Rice Research Institutes (BRRI) already releases drought tolerance varieties of rice such as BRRI dhan 43, BRRI dhan 55, BRRI dhan 56, BRRI dhan 57, BRRI dhan 65, BRRI dhan 71 and BRRI dhan 83 (Rahman et al. 2022). These varieties

can produce optimum yield with less than 20% soil moisture contents and even the water table depth goes downward more than 70-80 cm from the surface.

Drought tolerance rice varieties for both Aus (BRRI dhan 43 and BRRI dhan 55) and Aman (BRRI dhan 56 and BRRI dhan 57) are tested on a trial basis in the drought-prone northern region and showed satisfactory performance under adverse water stress conditions. The biggest challenge for adoption of drought tolerant crops in developing countries, apart from the technological support, is lack of institutional support (Tanti et al. 2022). Few research studies were undertaken in drought prone region of Northern Bangladesh addressing only adaptation strategies (Habiba et al. 2012; Alam 2015; Al-amin et al. 2019), and welfare impacts of drought tolerance rice varieties (Rahman et al. 2022). But these existing research studies do not cover the driving factors, especially the institutional factors that can influence adoption of drought tolerance rice varieties. This study incorporates the institutional factors on the aspects of driving factors that can affect the adoption of drought tolerant rice varieties, both in the context of Bangladesh and global perspectives. In addition, several research evidence focus on the perception of climate change in the context of both Bangladesh and worldwide (Brechin and Bhandari 2011; Hansen et al. 2012; Uddin et al. 2014, 2022; Al Mamun et al. 2021). However, these existing researches did not make any comparison between the public perception of climate change and meteorological data of the real context. So, in order to mitigate the rice yield losses identifying socio-economic and institutional factors are very essential that affect the adoption of drought tolerant rice varieties. Therefore, the specific objectives are: (i) to determine and describe the driving factors including both socio-economic and institutional factors of the rice farmers; (ii) to assess farmers' perception of climate change and to compare with the meteorological evidences of temperature and rainfall; and (iii) to explore the driving factors that can affect the adoption of drought tolerant rice varieties and to identify the obstacles faced by the non-adopters rice farmers.

MATERIALS AND METHODS

Roadmap and theoretical framework of the study

Different socio-economic influence the adoption of drought tolerant crops varieties. Many researchers found that there was no significant relationship between age and adoption of drought tolerance varieties (Rahman et al. 2022). The adoption of drought tolerant technologies varies by gender, with women often showing lower adoption rates due to perceived risk aversion (Khatri-Chhetri et al. 2017; Aryal et al. 2018a). Household heads with higher education are more likely to adopt the stress tolerant varieties (Aryal et al. 2018a). Indeed, most studies show a non-significant relationship between family size and adoption of drought tolerance varieties (Rahman et al. 2022). Various studies found a positive significant relationship between adoption of drought tolerant varieties and larger farm size (Aryal et al. 2018a). Low-income farmers are more likely to adopt

traditional technologies (Khatri-Chhetri et al. 2017), while high income increases the adoption of innovative technology because of risk-taking attributes (Mulwa et al. 2017).

Institutional factors like training, extension services, organization affiliation, credit support and access to ICT are crucial factors that can affect the adoption of drought tolerant varieties. Studies shown that training significantly increases the adoption of various technologies such as stress-tolerant varieties, minimum tillage and site-specific nutrient management (Aryal et al. 2018a, b; Rahman et al. 2022; Tanti et al. 2022). Extension services serve as vital sources of climate information, positively affecting innovative technology adoption (Abegunde et al. 2020). Organization affiliation and participation in group activities, also play significant roles in adoption decisions (Tanti et al. 2022). Participating in group activities enables farmers to exchange information on innovative technologies and more inclined to adopt drought tolerant varieties (Mulwa et al. 2017; Aryal et al. 2018a; Tanti et al. 2022). However, Abegunde et al. (2020) found no significant influence of organizational affiliation and adoption of innovative technologies in South Africa. Aryal et al. (2018b) reported mixed results, indicating that credit access increased the adoption of site-specific nutrient management, while decreased the adoption of stress-tolerant varieties. Access to Information and Communication Technology (ICT) such as television or mobile devices also increases the adoption of stress tolerant varieties (Rahman et al. 2022; Tanti et al. 2022; Aryal et al. 2018a). Figure 1 shows the conceptual framework in which farmers' perception of climate change variability could lead to adoption of drought tolerance rice varieties. Conceptual framework showing that the adoption of Drought Tolerant Varieties (DTV) is influenced by three main drivers: perception of climate change variability, socio-economic characteristics, and institutional factors. The adoption of DTV ultimately leads to reduced drought risk and increased rice yield.

Study area

The study was conducted in Biral Upazila (sub-district) at Dinajpur District located in between 25°31' and 25°46' north latitudes and in between 88°26' and 88°38' east longitudes in Northern Bangladesh (Figure 2). The study area covers the Level Barind Tract, one of the agroecological zones of Bangladesh. The climate of this agroecological zone is marked by semi-arid winters, as well as hot and humid summers. This location receives on an average 1270-1780 mm less rainfall than the southern part of the country. In June, temperature can reach 42°C, while in December lows down to 4°C. Due to low rainfall, the area is facing severe drought during the period of October to May in every year. Hence, seasonal drought is the major climatic change effect in the study area. Rice is vigorously grown throughout the region in three seasons, namely, *Aus* season (March to August); *Aman* season (June to November), and *Boro* season (December to May) (BBS 2022). *Aus* and *Aman* rice are primarily cultivated by natural rainfall. But supplemental irrigation is required for

uneven and low rainfall or a long dry spell. On the other hand, production of *Boro* rice depends on the irrigation either surface or groundwater (Islam et al. 2022).

Sampling, data collection and analysis

The primary data was collected by household surveys from the rice growing farmers. The rice farmers were selected following multistage sampling technique. Firstly, the Farakkhabad the Union Parishad (the lowest tier of administrative body) of Biral Sub-district under Dinajpur District was selected purposively. Secondly, among nine villages, Moheshpur and Kanaibari Villages under Farakkhabad the Union Parishad were selected randomly. Finally, an updated list of 332 rice farmers was collected from the agricultural office, which constituted the total population of the study. Then, sample size (181 rice farmers) is determined by a mathematical formula given by Yamane (1967) as:

$$n = \frac{N}{\{1 + N(e^2)\}}$$

Where, N is the sample frame or population, n is the required sample size and e is the margin of error (fixed at 0.05). Structured interview schedule was used for data collection from the sampled farmers. The collected data were analyzed using Stata 15.0 software. Besides primary survey data, the secondary data on temperature and rainfall were collected from the Bangladesh Wheat and Maize Research Institute (BWMRI) which is located near about 15 km from the study area. To investigate farmers’ perception of climate change variability, they were asked to provide their opinion on whether the climatic events frequency over 20 years had increased, not changed, decreased or if they did not know. Then, the perception of climate change was calculated based on the total number of citations of farmers against each of the climate parameters. Similar techniques were also used in previous studies (Al Mamun et al. 2021).

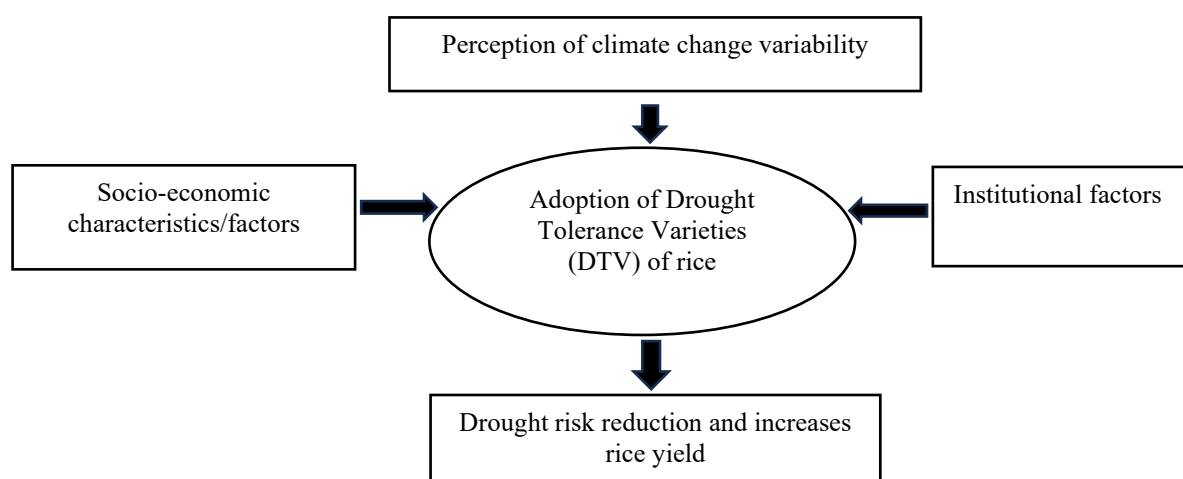


Figure 1. Theoretical and conceptual framework developed for the study

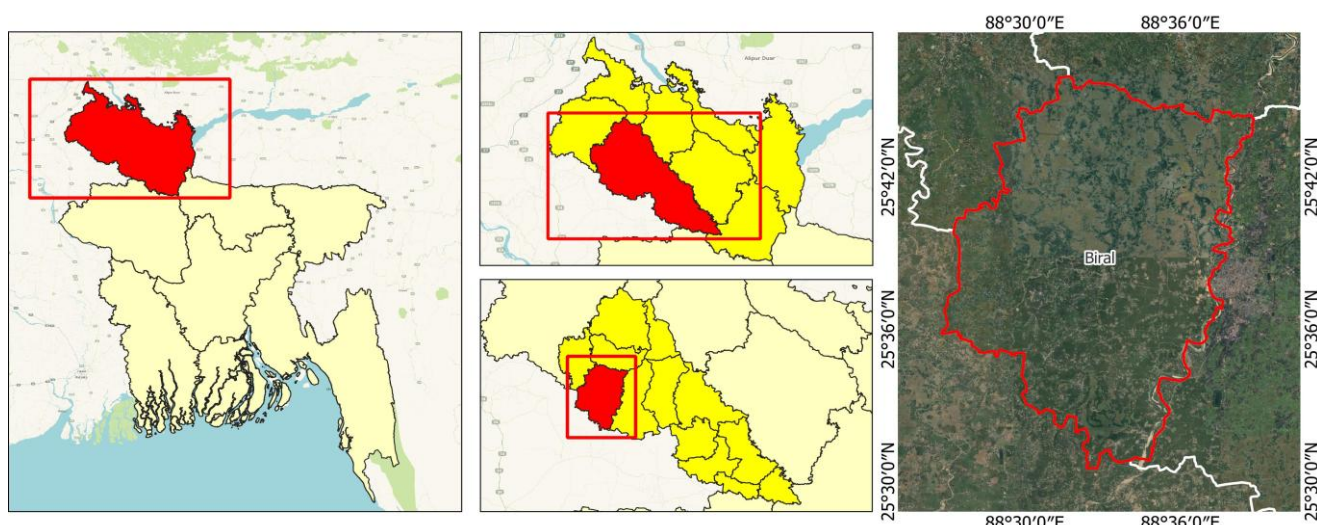


Figure 2. Map of Biral Upazila, Dinajpur District, Northern Bangladesh, showing the study location

Table 1. Explanatory variables

Explanatory variables	Description and unit	Expected sign
Socio-economic factors		
Age	Age of farmers measured in years	-
Gender	If male headed=1, otherwise=0	+
Education	Years of schooling from educational institution completed	+
Family size	Total family members in the household	-
Dependency ratio	Dependent members divided by earning members	+
Farm size	Total cultivated area (hectare) by the farmer's household	+
Income	Total yearly household income in BDT (Bangladeshi Taka)	+
Institutional factors		
Traning access	If training access on climate change and DTV=1, otherwise=0	+
Extension services	If farmers receive information and input from government extension services=1, otherwise=0	+
Affiliation with NGOs	If the farmers affiliated with NGO (Non-Government Organization) =1, otherwise=0	+
Credit access	If credit received=1, otherwise=0	+/-
Access to ICT /mobile	If farmers receive information via mobile =1, otherwise=0	+

Dependent variable and the econometric model

Adoption of Drought Tolerant Varieties (DTV) of rice i.e., dependent variable was measured by dummy response, if the DTV of rice adopted=1, otherwise=0. In quantitative estimation, when the outcome variable is measured as a dummy (1 or 0 response), probit or logit model could be used (Mango et al. 2017). The role of logit and probit models are to estimate the maximum likelihood of adoption. Logit model is the cumulative distribution function of logistic distribution, while probit model is the cumulative distribution function of standard normal distribution. Logit model estimates the coefficients as odd ratio, and its distribution has flatter tails than probit model (Gujarati 2009). However, outcomes of probit and logit model are not varied too much (Mango et al. 2017). When dependent variables are more than two, multivariate probit model is more suited, and many researchers used multivariate probit model (Ouédraogo et al. 2019; Tanti et al. 2022). Moreover, logit model is suited for single variate analysis, so in this article we use odd ratios which can estimate the probability of change in adopting Drought Tolerant Varieties (DTV) of rice as single outcome variable, using functional form of logit model expressed by Gujarati (2009) as:

$$P_i = \frac{1}{1 + e^{-(\beta_0 + \beta_i X_i)}}$$

For simplicity can be expressed as

$$P_i = \frac{1}{1 + e^{-Z_i}}$$

Where, P_i : Probability of adoption of the i^{th} respondent, e^{Z_i} : stands for the irrational number e raised to the power of Z_i , Z_i : is a function of N -explanatory variables and expressed as:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \mu_i$$

Where, β_0 : Constant term, β_1, \dots, β_n : Regression coefficient.

Prior to the estimation of the logit model, the explanatory variables were checked for the existence of multicollinearity, using Variance Inflation Factor (VIF). Most commonly the thumb rule of VIF value more than 10 is regarded as a sign of multicollinearity (Rahman et al. 2022).

Explanatory variables and expected sign

Based on the above literature of the theoretical framework, a total of 12 explanatory variables were included to predict their influences on the adoption of DTV in rice cultivation. The study considers several socio-economic and institutional factors. The description and measurement unit as well as expected signs as hypothesis of the explanatory variables are given in Table 1.

RESULTS AND DISCUSSION

Descriptive profiles of the farmers' socio-economic characteristics

The descriptive statistics of the socio-economic characteristics are shown in Table 2. The average age of the rice farmers was 42.02 years, as farmers were dominated by young (and middle-aged groups. The farm households were mostly covered the male headed household. Most of the farmers had primary and secondary level education, with an average literacy of 5.13. In addition, around one-third of farmers were illiterate without formal education. The overwhelming majority of households (49.18%) had small size families while the average of 4.91. Average dependency ratio (3.24) indicates that more than three non-earning members, either unable to work or have no work, depends on the earning member of the household. Around 38.12% of farm families had a high dependency rate. The average farm area owned by the farm household was 0.68 Hectare (Ha), as around two-thirds of farm households were categorized into small scale farm size. Farming was the dominant earning source of farmers.

In addition, few households earn from non-farming enterprises such as jobs, small businesses, and short time migration. The average yearly income was 121.76 thousand Bangladeshi Taka (BDT).

Institutional factors

Table 3 shows that more than half of the farmers receive training on climate change adaptation technologies and agricultural farming. The overwhelming majority of the farmers receive information and input support from the government extension services. It is found that only one-third of farmers are affiliated with the Non-Government Organization (NGO), namely Building Resources Across Committees (BRAC), Association for Social Advancement (ASA), Grameen Bank (GP) etc. These NGOs support farmers by providing microcredit for agricultural production and cattle fattening activities. About half of the farmers have access to credit facilities from non-governmental organizations as well as government banks. In contrast, only about one-third of the farmers obtain and exchange agricultural information through Information and Communication Technology (ICT) platforms such as mobile phone calls or social media applications (e.g., Messenger or WhatsApp groups).

Farmers' perception of climate change

According to Figure 3, many farmers (about 78.45%) have observed an increase in temperature over the past 20 years, while 76.80% of farmers have observed a decrease in rainfall during the same period. When asked about changes in monsoon flood, most of the farmers (40.88%) reported no change, but 23.76% perceived a decrease in the monsoon flood during June-July. More than half of the farmers (54.7%) believed that seasonal changes have increased due to unpredictable events such as storms and

rainfall variability. Additionally, more than two-thirds of farmers (74.03%) reported an increase in insect-disease attacks in crops due to the fluctuation of seasonal temperature and rainfall.

Comparison of farmers' perceptions of climate change with meteorological evidence

The study compared the perception of farmers about climate change with the temperature and rainfall data from 2001 to 2020. The data was collected from the nearest meteorological station, Bangladesh Wheat and Maize Research Institute (BWMRI). The findings are presented in Figure 4. The temperature data in Figure 4.A shows a slight increase in the annual maximum temperature by 0.34°C and minimum temperature by 0.12°C in the next 10 years (2011-2020) compared to the previous 10 years (2001-2010). However, the monthly average rainfall decreased by around 9.32 mm in the next 10 years (2011-2020) compared to the previous 10 years (2001-2010). The annual rainfall data also indicated an increasing number of rainfall-deficient years from 2010 onwards, especially in 2010, 2012, 2014, 2018, and 2019. This means that most of the farmers' perception of increased temperature and decreased rainfall coincided with the meteorological data.

Table 3. Descriptive statistics of the institutional factors (binary variables)

Institutional factors	Frequency of response 1	Percent (%)
Traning access	100	55.25
Access to extension services	111	61.33
Affiliation with NGOs	62	34.25
Credit access	92	50.83
Access to ICT /mobile	58	32.04

Table 2. Descriptive statistics of the socio-economic factors

Socio-economic factors (Units)	Categories	Percent	Observed range	Mean	Std. Dev.
Age (years)	Young (up to 35)	35.91	20-67	42.02	11.702
	Middle aged (36-50)	39.78			
	Old aged (above 50)	24.31			
Gender (binary)	Male (if 1)	84.53	0-1	-	-
	Female (other than 1)	15.47			
Education (years of schooling)	Illiterate (0)	33.15	0-16	5.13	4.377
	Primary (1-5)	23.20			
	Secondaty (6-10)	35.92			
	Above secondary (>10)	7.73			
Family size (total family members)	Small (up to 4)	49.18	3-9	4.91	1.393
	Medium (4-6)	36.46			
	Large (>6)	14.36			
Dependency ratio (Score)	Low (up to 2.5)	28.18	1.7-5	3.24	0.739
	Moderate (2.51-3.5)	33.70			
	High (>3.5)	38.12			
Farm size (Ha)	Marginal (up to 0.2)	16.57	0.06-3.2	0.68	0.584
	Small (0.21-1.0)	65.75			
	Medium (1.1-3.0)	17.13			
	Large (>3.0)	0.55			
Income yearly (in 1000 BDT)	Low (up to 48)	9.94	35-420	121.76	73.460
	Medium (49-195)	73.49			
	High (>195)	16.57			

The data presented in Figure 4.B shows the monthly variability in temperature and rainfall. From mid-September to May, there is very low or no rainfall, which covers the end of the Aman season and the beginning of the Aus season for rice. This means that both Aus and Aman rice face water shortages during their life cycle. To overcome this water scarcity, drought tolerant varieties are very effective during the growth stage for *Aus* rice and the reproductive stage for Aman rice. The monsoon season, which lasts from June to October, accounts for around 80% of the total yearly rainfall. June-July is the optimal time for transplanting Aman seedlings. However, according to the Meteorological Department of Bangladesh (as reported on August 4th, 2023, in Prothom Alo, one of the most

prominent daily newspapers in Bangladesh), the average rainfall in Bangladesh is usually 523 mm in July and 460 mm in June. In the past couple of years, the country has received more than 50% less rain in June-July. The report stated that the low rainfall in June-July in the previous two years (2021-22) was the lowest in 41 years in Bangladesh. In the study area, the average rainfall in June-July over 20 years has been below 400 mm, indicating water scarcity. This requires either a 15-day delay in planting Aman rice or supplementary irrigation with additional costs for transplanting seedlings. As planting of Aman is completed within 15 to 20 days of July, even early planted Aman rice faces water scarcity during its growth stage.

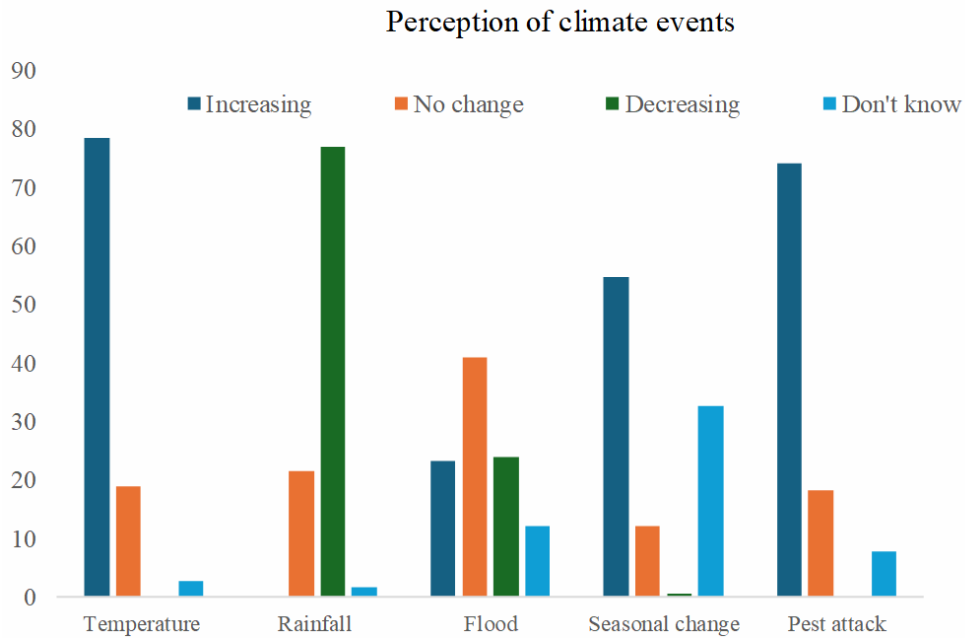


Figure 3. Farmers’ perception of climate change variability

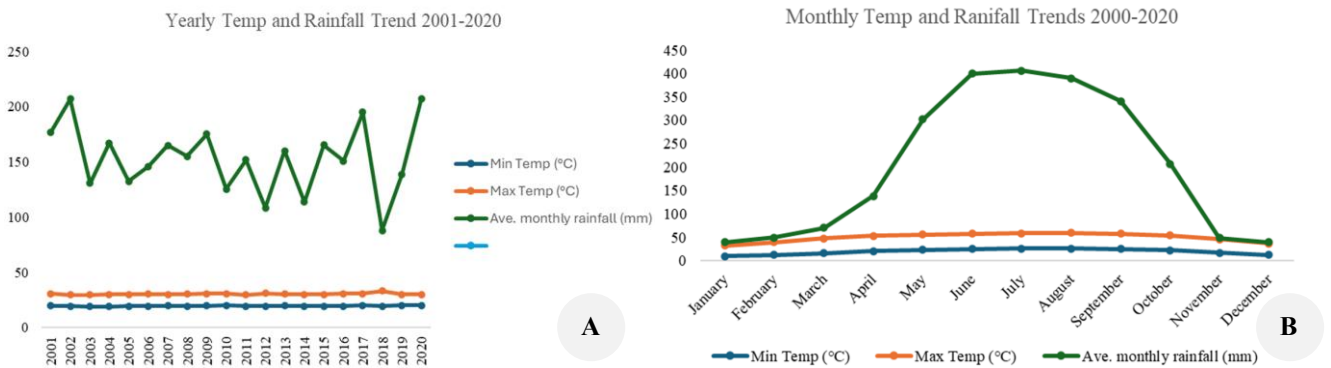


Figure 4. A. Yearly temperature and rainfall trend 2001-2020, and B. Monthly temperature and rainfall trend 2001-2020. Source: BWMRI (2021)

Factors affecting the adoption of DTV of rice

About 61.32% of farmers adopted the drought tolerant rice varieties. The findings of the logit estimation are presented in Table 4. The results show that the model well fits the data as the LR $\chi^2(12)=63.16$, Prob > $\chi^2=0.0000$ rejects the null hypothesis at 99% of significant level. It means that adoption of DTV of rice is influenced by at least one of the explanatory factors. There are a total of 12 explanatory variables considering the socio-economic and institutional factors that could influence the adoption of DTV of rice. As there was no value of VIF over 10 observed for the explanatory variables, indicating that no multicollinearity existence among them, and no variables were omitted from final analysis (Table 4)

In Table 4, the logit regression analysis shows that four factors age, family size, dependency ratio and affiliation with NGO did not influence adoption of DTV of rice significantly, while the rest 8 factors significantly influence the likelihood of adopting of DTV of rice. It is observed that gender, education, farm size, income, training access, extension services, credit access and access to ICT positively affect the likelihood for the adoption of DTV of rice. This means that the probability of adopting DTV increases with the increases of these positive and significant factors. On the contrary, farm size is negatively significant with adoption of DTV of rice indicating that the probability of adopting DTV decreases with the increases of farm size.

Obstacles faced by the non-adopters of DTV of rice

Besides asking farmers in the survey about adoption of DTV, the interview also identified reasons for non-adoption by non-adopters. Reasons for non-adoption of DTV of rice are presented in Figure 5. For adopting tolerance rice varieties, lack of cash for purchasing seed input (27.14%) appears the major obstacle among the non-adopters followed by lack of information (25.71%), unavailability of seed input (24.9%), lack of training (12.86%), and lack of experience (10%). It means that lack of cash, information and seed input unavailability are found to be the major constraints for non-adopting DTV of rice. Farmers mention that the cost of drought tolerance rice seed is relatively expensive compared to the conventional rice varieties. In addition, the availability of seed is limited for large scale cultivation of drought tolerance rice varieties.

Discussion

The results of this research reveal that more than three-fourths of farmers perceive that climate change is causing seasonal water stress in rice production. This result is consistent with the evidence of Al Mamun et al. (2021). Temperature and rainfall are the key climatic variables that significantly influence crop production (Ho et al. 2022). Unlike other studies, we compared the farmers' perception with meteorological data. Farmers' perceptions of increasing temperatures and decreasing rainfall were consistent with observed meteorological data on temperature and rainfall trends. A similar pattern of rainfall variability was observed by Shelley et al. (2016). In recent

years, drought has posed a major challenge for rice farmers, affecting their livelihoods and assets, particularly food security. To overcome water scarcity in rice cultivation, drought tolerant varieties could be useful.

The results of logit analysis indicate that the probability of adopting DTV technology is associated with several factors, including both socio-economic and institutional factors. However, four factors (4) such as age, family size, dependency ratio, and affiliation with NGOs were non-significantly associated with the adoption of DTV for rice. The non-significant negative association between age and DTV adoption suggests that older farmers are more accustomed to cultivating traditional rice varieties. This finding aligns with those of Aryal et al. (2018a). Again, the non-significant negative sign of family size and dependency ratio means that households with so many family members and high dependency ratio had a lower likelihood of adopting DTV for rice. Because households with large family sizes and a high dependency ratio are more likely to adopt labor-intensive crop farming, such as crop diversification and intercropping, rather than monoculture rice (Rahman et al. 2022), as these practices provide higher yields and income to avoid the drought risk.

Table 4. Logit regression in estimating the factors influencing the adoption of DTV of rice

Explanatory variables	Coefficient (Odds ratio)	Std. Error	P-value	VIF
Age	-0.016	0.019	0.396	1.25
Gender	1.154**	0.564	0.041	1.33
Education	0.151**	0.058	0.010	1.59
Family size	-0.038	0.146	0.793	1.12
Dependency ratio	-0.204	0.266	0.442	1.42
Farm size (ha)	-1.532**	0.776	0.048	5.54
Income (Bangladeshi Taka)	0.015**	0.006	0.016	5.54
Traning access	0.881**	0.412	0.033	1.50
Extension services	1.622***	0.435	0.000	1.38
Affiliation with NGOs	-0.472	0.426	0.267	1.17
Credit access	1.089**	0.427	0.011	1.41
Access to ICT /mobile	0.983*	0.543	0.070	1.40

Note: Number of observations: 181, Log likelihood=-89.196826, LR $\chi^2(12)=63.16$, Pseudo $R^2=0.2615$, Prob> $\chi^2=0.0000$; *, ** and *** refers to significant at 5%, 1% and 0.1% level of significance

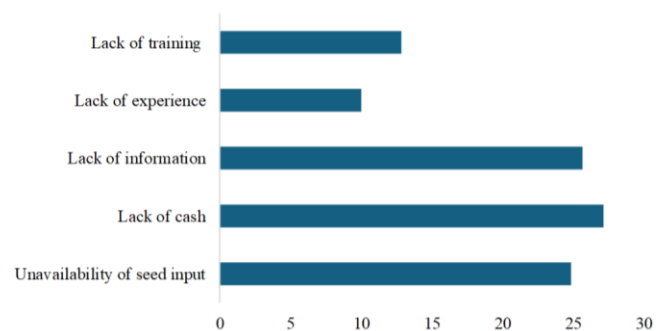


Figure 5. Obstacles for non-adoption of the DTV of rice (%)

Moreover, the non-significant relationship between organization affiliation and adoption of DTV of rice aligned with the findings of Abegunde et al. (2020) who found no significant influence of organizational affiliation or group membership on drought tolerant crops adoption in South Africa. As only around one-third rice farmers were affiliated with different non-government organizations, so the organizational affiliation did not significantly affect the adoption of DTV of rice in the study area.

Eight factors (8) significantly affect the adoption of DTV of rice. It was found that gender plays an important role in DTV adoption, with male-headed households more likely to adopt DTV due to male farmers' higher mobility than female-headed households. This finding is consistent with previous studies showing that the gender of the household head significantly affects the adoption of innovative practices. As DTV is an innovative technology that requires more information from external sources, the mobility of male farmers in developing countries like Bangladesh provides them with greater exposure to new technologies (Aryal et al. 2018a). These differences highlight the need to consider gender dynamics, as gender-specific factors may shape adoption patterns of DTV of rice among farmers. However, farmers with more education are more likely to adopt DTV for rice because of their higher knowledge and lower risk aversion (Karim et al. 2017; Mulwa et al. 2017). Education helps farmers expand their thinking and knowledge, and it is one of the most important attributes assisting the adoption of innovative technologies (Karim et al. 2022).

One of our notable findings is the negative correlation between farm size and the adoption of DTV for rice. The reasons are that farmers with larger farms are less likely to adopt DTV because drought tolerant seed is unavailable at the primary stage, and seeds are expensive. This is particularly true for drought tolerant rice seeds, which are not easily available for large-scale rice production, as the majority of farmers in the study area are marginal and small-scale. Tanti et al. (2022) also found that land size is significantly negatively associated with the adoption of drought-resistant seeds. However, the negative effect of farm size was inconsistent with the findings from other studies (Aryal et al. 2018a). But this negatively significant result of farm size is contrasted with Aryal et al. (2018a). On the other hand, income is positively associated with the adoption of DTV for rice, because higher income and income from off-farm sources increase the adoption of innovative technology (Fernandez-Cornejo et al. 2007; Mulwa et al. 2017), due to risk-taking attributes (Mulwa et al. 2017). The majority of farmers are marginal and small-scale farmers who also earn income from off-farm sources, such as business and migration to nearby or capital cities (Karim 2015; Karim and Muhammad 2018).

However, training access for farmers increases the adoption of DTV of rice. Similar results are observed by previous studies imply that training provides insightful knowledge and skill on the use of innovative technologies like drought tolerance varieties (Aryal et al. 2018a, b; Ouédraogo et al. 2019). In addition, training significantly increases the adoption of stress-tolerant varieties, minimum

tillage and site-specific nutrient management (Aryal et al. 2018a, b; Rahman et al. 2022; Tanti et al. 2022). Most of the farmer training has been received from the government extension services. Training brings farmers into contact with extension professional and expertise which boosts their knowledge and skills (Aryal et al. 2018a, b; Rahman et al. 2022; Tanti et al. 2022) and hence, effective for the adoption of DTV of rice. Moreover, extension services also significantly increase the probability of adopting DTV of rice. The first reason is that extension services provide farmers with information about the DTV of rice. Because farmers require easy access and details of weather and climate information to choose the appropriate technologies that enable them to adapt well with the changes in climatic conditions. Secondly, input subsidy, low cost and available seed in the local market drive the farmers to adopt DTV of rice, as relevant to the evidence of Tanti et al. (2022). Indeed, farmers with easy access to input subsidies on seeds are more likely to adopt innovative technologies (Ouédraogo et al. 2019).

Credit access significantly and positively affects the probability of adopting DTV of rice. These results are consistent with the evidence of Mulwa et al. (2017), as both DTV of rice need high initial cost for purchasing seed and other input materials. Farmers also mention that they spend credit money on taking land as rent contract and a small business. But the result is contrasted with Aryal et al. (2018b) who reported the decreasing adoption of stress-tolerant varieties with the increasing of credit access. However, Information, Communication and Technology (ICT), especially mobile access is positively affecting the probability of adoption DTV of rice. This result corresponds to the findings of Aryal et al. (2018a, b) and Rahman et al. (2022). Many rural farmers are using mobile phones (phone calls, text message via messenger and WhatsApp group) for sharing information. Information access via mobile phone makes farmers aware of weather forecasting and challenging conditions. Mobile phones are very useful ICT tools for dissemination of information and innovative technology (Karim et al. 2020). Mobile ownership gives farmers up-to-date knowledge and information by contacting other farmers and extension staff (Rahman et al. 2022).

Moreover, the adoption status shows that despite being informed about it, non-adopter farmers do not adopt DTV of rice due to a lack of cash for purchasing seed input, unavailability of seed input, lack of training and experience. Additionally, the cost of drought tolerance seed is relatively expensive compared to existing rice varieties. Availability of seed is also limited for large scale cultivation of drought tolerance rice varieties. These types of obstacles are also faced by the small-scale farmers in the production of sorghum and maize in the drought prone Awdal region, Somaliland (Ali et al. 2023).

In conclusion, the study reveals that practically farmers face frequent seasonal drought in the study area for rice cultivation. More than half of the farmers adopt the Drought Tolerant Varieties (DTV) of rice. Institutional driving factors such as training, extension services, access to credit, and ICT are playing significant role in the

adoption of DTV of rice. Furthermore, input subsidies like seed supply with lower prices may increase the likelihood of adopting DTV of rice. This implies that government should promote these incentives to encourage non-adopters towards the intensification of DTV. The Department of Agricultural Extension (DAE) should provide more technical training to help farmers to cultivate suitable drought tolerance rice varieties. If the government subsidizes seed prices and provides credit support, farmers may be more inclined to switch drought tolerance varieties. Access to mobile devices with internet connectivity is also helpful for adoption of drought tolerance rice varieties. Therefore, extension programs should be established to disseminate information about drought tolerance rice varieties and weather forecasting through mobile apps like Messenger or WhatsApp. Additionally, the government should incentivize marginal farmers to own mobile devices. The study suggests for policy implications that government and non-government agricultural extension agencies should use different ICT and mass media for providing information on region-specific DTV that are better suited for drought-prone areas of rice production. In addition, the government organization such Bangladesh Agricultural Development Corporation (BADC) and other the private company could make higher amount seed available for the larger farmers. It recommends for future research on socio-economic impact and cost benefit analysis of drought tolerant rice production that could be undertaken in the context Bangladesh or similar context globally.

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