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Determinants of Adoption of Climate-Smart Agriculture Technologies in Rice Production in Bangladesh

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Abstract: Climate change is expected to have significant environmental, economic, and social consequences for coastal farmers whose livelihood is dependent on nature. Agriculture is their main occupation and climate has a great impact on agriculture. As the economy of Bangladesh mainly hangs on agriculture so the impact is shown in the economy of this country. The factors that influence the adoption of climate-smart agriculture technology (improved stress-tolerant cultivars) in rice production in Bangladesh's Satkhira District were investigated in this study. Climate-Smart Agriculture refers to agricultural strategies that increase efficiency, improve resilience (adaptation), and reduce greenhouse gas emissions (mitigation). This study based on 100 rice-farming households from three villages in the sub-district of Tala Upazila in the coastal district of Satkhira, Bangladesh, an area likely to face increasing salinization due to relative sea-level rise, to determine the factors explaining which households were more likely to convert to salt-tolerant varieties of rice. This study found that higher levels of education, more farming experience, subsistence farming, access to credit and smaller family size were all significant predictors. The DAE, NGOs, policymakers, and government should keep attention to Education, Experience in farming, eating from own food and Family size, and Access to credit. It is possible to by increasing literacy and availability of information in the coastal area.

Keywords: Climate-Smart Agriculture (CSA), Adoption, Rice, Agriculture, Farmers, Bangladesh, Climate Change

1. Introduction

Agriculture is Bangladesh's largest job sector, accounting for 14.2% of GDP in 2017 and employing about 42.7 percent of the total [1]. It is one of the most crucial sectors for achieving the SDGs' goals of ending hunger and malnutrition, as well as poverty. Rice is the principal nourishment of our individuals and has developed in this nation from time antiquated. It contributes to around 92% of the whole food grains delivered within the nation covering almost 77% of rural arrival. As per the USDA information, with a production of 36 million tons of rice, Bangladesh stands within the third position all-inclusive in rice production after China and India which produce 146 million tons and 116 million tons separately. Climate variability and change is the most influential factor in agricultural production [2]. Despite regularly poor climatic circumstances, Bangladesh's labor-intensive agriculture has achieved consistent increases in nourishing grain production due to a variety of factors [3]. Besides, COVID-19 made a serious crisis in this sector [4]. In spite of technological advances (such as improved crop varieties and water system possibilities), the climate is still a key determinant for agricultural efficiency and sustainability in Bangladesh. Climate is a region's valuable physical condition for crop production. Rice production in Bangladesh is heavily influenced by climate elements such as temperature, rainfall, humidity, day length, and so on. Floods, droughts, soil and water salinity, cyclones, and storm surges have all had a significant impact on rice production. These variables are crucial environmental factors that influence plant species' ecological niches and dispersion patterns [5]. Climate change poses a global threat to crop production sustainability and food security [6, 7]. To cope with the problems of climate change, agriculture in underdeveloped nations must undergo a dramatic transition into food and nutrition security [8]. Any changes in climate and weather over time, whether caused by natural variations or man-made actions, are referred to as climate change. Agriculture around the world will likely confront increased temperatures, water scarcity, inconsistent and unexpected precipitation, and extreme weather events. South Asia has just lately emerged as a major source of greenhouse gas emissions [9]. Climate change has had a negative impact on the world's agriculture and food chain [10]. Climate change has an impact on all four dimensions of food and nutrition security: availability, accessibility, utilization, and stability, by reducing agricultural production, increasing post-harvest losses, inefficient marketing and distribution systems, and ineffective food systems -storage, food quality, and food safety [11]. Climate change vulnerability in agricultural systems can be minimized by boosting farmers' climate change resilience capability and lowering greenhouse gas emissions. Land degradation, salt water intrusion, infrastructure loss, reduced agricultural productivity, reduced fish and aquatic production, water shortages, and nutritional insecurity are all examples of how climate change affects basic livelihoods, socioeconomic patterns, and eco-systems [12, 13]. Dynamic change in monsoon and seasonal rainfall patterns; increased temperature with warmer winters; increased salinity in coastal areas as a result of rising sea levels and reduced discharge from major rivers; weakening ecosystems; decline of Himalayan glaciers; and increased frequency and/or severity of extreme weather events could be some of the main reasons [12]. “Rural livelihoods and economic development of Bangladesh largely depend on agriculture, which apart from climate change, is additionally beneath weight due to limited land availability” [14]. Climate-smart agriculture (CSA) is a method of adopting innovative agricultural methods to increase productivity, adapt to climate change, and mitigate its effects [15]. “According to the Food and Agriculture Organization of the United Nations (FAO), CSA speaks to the agricultural practices that increment productivity, contribute to upgrading versatility (adaptation), minimize greenhouse-GHGs (mitigation) where applicable, conjointly expand the achievement of food security, and development goals” [16]. CSA technologies provide prospects for addressing climate change issues as well as economic development and improvement in the agriculture industry. To address their individual conditions and strategy, farmers can alter or mix different CSA methods with other practices and technologies. Climate change mitigation and adaptation programs have been launched in Bangladesh by a variety of governmental and non-governmental organizations (NGOs), and bilateral and multi-national organizations. The Delta Plan 2100, for example, is a blueprint to mitigate the effects of sea-level rise, including the injection of saline into Bangladesh's coastal rivers and canals, which is supported by the Dutch government. As a result, scientists and policymakers should focus more on determining the factors that influence farmers' adoption of individual and combined CSA technologies. Improved stress-tolerant cultivars are the CSA technologies explored in this study. As a result, it is critical to perform such research in order to discover the elements that influence the country's effective adoption of CSATs. Policymakers can use the findings of this study to develop policies and programs for disseminating appropriate CSATs and reducing the detrimental effects of climate change on agriculture.

2. Material and Methods

2.1. Study Area

Tala Upazila of Satkhira the district was selected as it is known as the Costal area and which is directly related to salt tolerance. The Ganges Brahmaputra Meghna (GBM) river system and the Bay of Bengal are geomorphology and hydrologically dominant in Bangladesh's coastal zone. Bangladesh consists 19 coastal districts. “The districts of Bangladesh are divided into sub-districts called Upazilas” [17]. Satkhira is one of them. Satkhira is a district in southwest Bangladesh, situated on the Arpangachia River's bank. Agriculture is Bangladesh's largest economic sector, employing more than 45 percent of the population [18]. Agriculture in the Satkhira district, which is based on a salty wet rice habitat, is characterized by smallholder subsistence. Farmers mostly grow Aman rice, a monsoon-dependent rice that is planted in June/July and harvested in December/January.

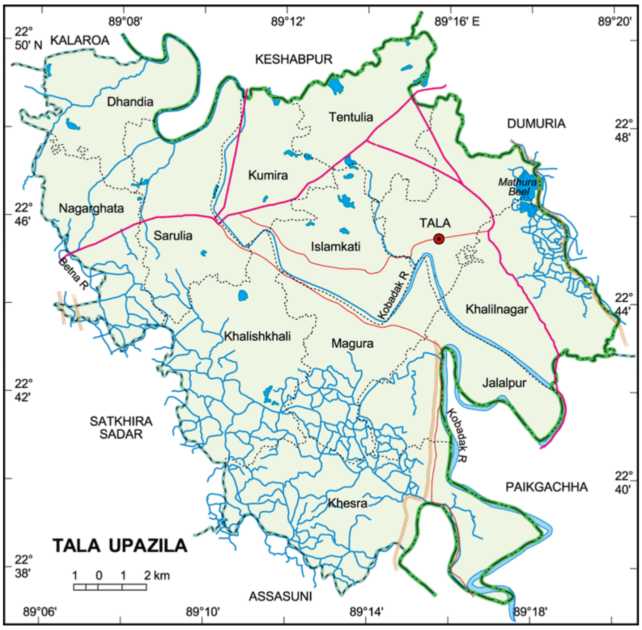

Figure 1. *Map of Tala Upazila.; Map courtesy: Banglapedia.*

2.2. Data Collection

The study is based on primary data. Face-to-face interviews were conducted with 100 rice-farming households in Tala Upazila of Satkhira district throughout the 2020 crop seasons. A two-stage sampling procedure was undertaken. Firstly, Preliminary information about rice production in the villages of tala Upazila was collected, and select 3 villages of Tala Upazila. Next, 100 agricultural households were chosen for the study from a total of 558 farming households. A basic random sampling approach was used to pick sample responders. Face-to-face interviews were conducted by two professional interviewers. During the questionnaire design process, special attention was paid to the language of the questions such that the respondents found it clear and understandable.

2.3. Statistical Analyses

This study used descriptive statistics to describe the data and a logistic regression model to explore the determinants of the respondent's "adoption of salt-tolerant variety". All analyses were performed by using the SPSS package.

2.4. Descriptive Statistics

Descriptive analyses involved calculations of frequency distribution, percentage, mean and tabular statistics for reporting socioeconomic characteristics, Experience in farming, Rice Income, Off-farm income, Eating from own Production, Savings, Access to credit, and Marital status.

2.5. Logistic Regression

For the prediction of the likelihood of an event, logistic regression is used. Logistic regression allows one to predict a discrete outcome based on a set of factors that can be continuous, discrete, dichotomous, or a combination of these. The dependent or response variable is usually binary, such as presence/absence or event success/failure. The following Logistic model was fitted to the empirical data which determine respondents' adoption of "salt-tolerant variety".

$$CSA_i = \ln\left(\frac{Pi}{1-Pi}\right) = B_0+B_1X_{1i}+B_2X_{2i}+B_3X_{3i}+B_4X_{4i}+B_5X_{5i}+B_6X_{6i}+B_7X_{7i}+U_i$$

Where,

CSA_i = 1 if the respondent use salt-tolerant variety and 0 otherwise.

Pi = the probability of using salt-tolerant variety.

X1 = educational background of the respondent (year of schooling).

X2 = age (years).

X3= 1 for male respondent.

X3 = 0 for female respondent.

X4= 1 for married respondent.

X4 = 0 for unmarried respondent.

X5 = Income from agricultural source (Tk. per year).

X6 = Income from non-agricultural sources (Tk. per year).

X7=Experience in farming (Years).

X8=Access to credit 1 for Yes.

X8=Access to credit 0 for No.

X9=Eat from own production of Rice (month per year).

β_1 to β_9 are coefficients of the respective explanatory variables.

3. Result and Discussion

3.1. Descriptive Statistics of Variables

Variables are grouped as dependent (i.e., technologies and practices) and independent variables (gender, age, schooling, experience in farming, rice income, off-farm income, eating from own production, savings, access to credit, marital status). Descriptive statistics of the study mockup are shown in *Table 1.* It presents the number of respondents, minimum, maximum, mean, and standard deviation of dependent variables and covariates. In this test, the average age and schooling of the respondents are 40.05±12.696 years and 9.01±3.594, individually. The average family size and eat from own production of the respondent are 1.86±0.975 and 10.06±2.628, respectively. And Rice income and off-farm income of the respondent are 138.9±188581.33310 and 125900.0000±246622.00660.

Table 1. *Descriptive statistics of variables.*

	N	Minimum	Maximum	Mean	Std. Deviation
Gender	100	0	1	.70	.461
Age	100	17	70	40.05	12.696
Schooling	100	0	15	9.01	3.594
Family size	100	1	8	1.86	.975
Experience in farming (Years)	100	0	60	16.86	16.531
Rice Income (thousand)	100	20	150	138.9	188.58
Off-farm income (thousand)	100	20	250	125.9	246.62
Eat from own production	100	6	12	10.06	2.628
Use of salt-tolerant variety	100	0	1	.44	.499
Savings	100	0	1	.87	.338
Access to credit	100	0	1	.25	.435
Marital status	100	0	1	.88	.356

3.2. Educational Status of Respondents

In figure 1: Education is an inevitable prime prerequisite for progress in any field. It is vital in eliminating poverty and inequality, promoting health, and facilitating the application of knowledge. Farmers' education may aid in increasing output. Literate farmers have better access to the relevant technical information for the improvement of Climate Smart Agricultural (CSA) technologies. Education also has a significant impact on environmental pollution issues such as households' knowledge about arsenic pollution [19]. "The educational level of a farmer typically correlates positively with the adoption of technological innovations because of the assumed link between education and knowledge accumulation and the farmer's capacity for decision making" [20-25]. To examine the educational status of the respondents were divided into four groups. These were illiterate, primary, secondary, and Graduate. Those who can't sign, read and write were considered illiterate. The level of education of the respondents is given in *Figure 1*. It is evident from *Figure 1* that out of 100 farmers 9% are illiterate, 30% are the primary level passed, 42% are high school passed which is the maximum among them and 19% are graduates.

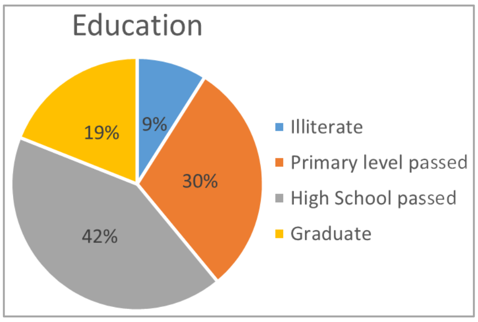

Figure 2. *Educational status of respondents.*

3.3. Logistic Analysis of the Respondents' Using of Salt-Tolerant Variety

The logistic model was applied to define the respondent's "Using of salt-tolerant variety". In this model, the descriptive factors were gender, age, schooling, experience in farming, rice income, off-farm income, eating from own production, savings, access to credit, and marital status. The comes about of a calculated condition for respondents, "Using of salt-tolerant" variety are existing in *Table 2*. The logistic analysis displayed that education, experience in farming, eating from own food, and family size, access to credit are statistically significant at 1% and 5% levels, respectively.

Table 2. *The results of the estimated logistic equation of respondents "using of salt-tolerant variety".*

Variables	Coefficients	Std. Err.
Gender	0.312	0.416
Age	-0.136	0.187
Education	0.077**	0.0389
Family size	-0.246***	0.114
Experience in Farming	0.162**	0.081
Marital Status	0.147	0.182
Rice Income	0.061***	0.029
Off-farm income	0.002	0.004
Access to Credit	0.371***	0.120
Savings	-0.148	0.143
Eat from own Food	0.036**	0.018
Constant	3.241234	1.783932

Asterisks **and *** indicate statistical significance at 5% and 1% levels respectively.

3.4. The Relationship Between Salt Tolerant Variety and Access to Credit

Table 3 the relationship between the Use of salt-tolerant variety and access to credit. Access to credit is significant for the people who use salt-tolerant variety. 69 farmers have access to credit among 100. The farmer who uses salt-tolerant variety, 89.3% of them has access to credit and for those who do not use Salt tolerant variety, only 43.2% of them has access to credit and for the farmer who uses salt-tolerant variety, 10.7% of them has no access to credit and those who do not use Salt tolerant variety 56.8% of them has no access to credit.

Table 3. *Relationship between salt tolerant variety and access to credit.*

Use of Salt Tolerant Variety	Access to Credit	Access to Credit Percentage	No access to Credit	Not access to credit Percentage	Total
Yes	50	89.3%	6	10.7%	100%
No	19	43.2%	25	56.8%	100%

3.5. The Relationship Between Salt Tolerant Variety and Savings

In *Table 4,* the percentage of people with savings is higher among those who do not use salt-tolerant variety. But most of the farmers have savings. Among the farmers with savings, 37 of them use salt-tolerant variety 50 of them do not use salt-tolerant variety.

Table 4. *Relationship between salt tolerant variety and savings.*

Use of Salt Tolerant Variety	People with savings	Percentage	People with no savings	Percentage	Total
Yes	37	84.1%	7	15.9%	100%
No	50	89.3%	6	10.7%	100%

4. Conclusions

Small farmers have a critical role in ensuring food security for future generations, but they face a number of barriers to promoting access to information, technological breakthroughs, and new value chains. To overcome these obstacles and achieve the goals of growing profitable farming, a lot of commitment and effort is required. All partners, including the government, businesses, farmers, researchers, and banks, must be committed. In this way, it appears that using climate-smart agriculture technology in rice production is a better way to plan and use mediations to overcome challenges to developed farming sustainability. Bangladesh has an amazing cluster of climate-smart agriculture exercises. Extreme climatic occasions hit habitually within the coastal zone of Bangladesh, such as tornados, storm surges, droughts, and salinities. The DAE, NGOs, and researchers are attempting to spread CSA along the coastal farmers to manage these climatic impacts. This study gives the investigation of determinants of the adoption of climate-smart agriculture technologies in rice production in Bangladesh. The findings show that the current choice of the salt-tolerant variety of CSATs in Bangladesh is significantly affected by education, experience in farming, eat from own food, family size, and access to credit, in common, these components are found to have distinctive impacts on the adoption choice of CSATs in Bangladesh. By adapting CSA technologies, and organizations and arranging progress, new transformational changes can increase the production of rice during the time of climate difficulties.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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