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Adoption of Climate Smart Agricultural Practices among Coastal Farmers: Insights from a Selected Southern Area of Bangladesh

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ABSTRACT

Climate-smart agriculture (CSA) methods must be implemented to protect both ecological stability and sustainable livelihoods, as climate change poses significant dangers to coastal agriculture. Understanding the motivations behind farmers adoption of these methods is crucial for creating focused and successful policies, especially in climate-vulnerable areas like coastal zones of Bangladesh. The purpose of this study is to evaluate coastal farmers' adoption of climate-smart agriculture (CSA) methods and investigate the associations between a few chosen farmer attributes and adoption levels. In the Kalapara Upazila of Patuakhali district, 310 coastal farmers were chosen using a multi-stage random selection approach, and data was collected from them using a pre-tested interview schedule. The results showed that coastal farmers' adoption of CSA techniques varied from 40.25 to 75.29, with a possible range of 0 to 100. The standard deviation was 8.50 and the mean adoption level was 56.53. Among farmers, the majority (60%) showed a medium degree of adoption, followed by low adoption (21.29%) and high adoption (18.71%). CSA adoption was significantly positively correlated with agricultural expertise, training exposure, communication exposure, innovativeness, risk orientation, and economic motive, according to correlation analysis. In contrast, farm size exhibited a significant negative relationship with adoption levels. Regression analysis indicated that 31.8% of the variation in CSA adoption was explained by farmers' communication exposure (30.4%) and innovativeness (1.3%). One methodological limitation of this study is its reliance on self-reported data from a single region, which may limit the generalizability of findings to broader coastal contexts. However, the study provides a strong theoretical basis for policy formulation by linking farmer-level attributes with CSA adoption, emphasizing the importance of behavioral and socio-economic factors. To enhance CSA adoption, stakeholders- including policymakers, extension agents, and local NGOs should prioritize targeted training, improve access to climate information, and promote farmer-led innovation and communication networks. Future study is necessary to examine impediments to greater adoption and evaluate the long-term effects on farmers' livelihoods and environmental sustainability, as these findings offer important insights into the factors driving coastal farmers' adoption of CSA methods.

INTRODUCTION

Agriculture is the backbone of Bangladesh's economy, contributing significantly to employment, food security, and rural development (BBS, 2022). However, the country is highly vulnerable to climate change due to its geographical location, low-lying coastal regions, and frequent natural disasters such as cyclones, floods, and saline water intrusion (Chowdhury *et al.,* 2022). Millions of smallholder farmers in coastal regions depend on these climate-related issues for their livelihoods, as they affect agricultural productivity (Islam & Wadud, 2020). A viable solution to these issues is climate-smart agriculture (CSA), which aims to improve agricultural resilience while maintaining environmental sustainability and food security (FAO, 2018).

A variety of methods and tools are included in CSA with the goals of increasing productivity in a sustainable manner, enhancing climate change resistance, and lowering greenhouse gas emissions whenever feasible (Fuad *et al.,* 2025; Lipper *et al.,* 2014). Utilizing crop varieties that can withstand stress, conservation agriculture, enhanced water management, agroforestry, and integrated soil fertility management are some of these methods (Debnath *et al.,* 2019). Because coastal farmers in Bangladesh are more vulnerable to harsh weather events, increasing sea levels, and salinized soil, which have a detrimental effect on agricultural productivity and household incomes, it is especially important that they adopt CSA methods (Islam *et al.,* 2022).

Farmers in coastal Bangladesh continue to implement CSA at unequal rates despite its demonstrated benefits because of a number of institutional, socioeconomic, and environmental variables (Hoque *et al.,* 2023). According to earlier research, farmers' desire to use climate-smart practices is significantly influenced by a number of factors, including risk perception, financial resources, training, and information availability (Saha *et al.,* 2019). Adoption is further hampered in many coastal regions by poor infrastructure, a lack of extension services, and

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problems with land tenure (Biswas *et al.,* 2024).

Given the significance of CSA in promoting climate resilience and guaranteeing sustainable agricultural development, it is critical to comprehend the adoption patterns and variables affecting its uptake among Bangladeshi coastal farmers. Assessing the degree of CSA adoption in the southern coastal belt and investigating the connection between important farmers attributes and adoption behavior are the objectives of this study. The results will help development organizations, extension services, and policymakers create focused interventions to encourage the broad adoption of CSA practices, improving agricultural resilience and sustainability in the coastal regions of Bangladesh.

MATERIALS AND METHODS

The study was conducted at Kalapara upazila of Patuakhali district where a scope of adoption of climate-smart agricultural practices exists to be pursued as the study was concerned with the farmers' adoption of CSA practices. The study's population consisted of all agricultural household heads, with the exception of Kalapara Upazila absentees. Instead of collecting data from the entire population, a sample was used. The sample was chosen using a multi-stage random sampling technique (Upazila, unions, villages, and households). Two of the twelve unions that make up Kalapara Upazila were chosen at random during the initial phase. Eight villages were chosen at random from the communities that were part of these two unions. With the assistance of Sub-Assistant Agricultural Officers, local union parishad staff, and local leaders of the affected villages, a list of all the farm household heads in these eight villages was created in the third stage. The sampling population for this study was made up of 1601 of these farm household heads. Using a sample size calculator (www.surveymonkey.com), 310 farmers (household heads) were chosen as the final sample, dispersed proportionately among chosen villages, taking into account a 50% response distribution, a 5% margin of error, and a 95% confidence level. The sample size was 310 as a result. Standard procedures were used to measure the study's independent variables, such as age in years, education in school years, farming experience was measured in years, agricultural knowledge was measured in scores, training experience was measured in day, farm size was measured in hectare, annual income was measured in taka, communication exposure was measured in scores, cosmopoliteness was measured in scores, innovativeness was measured in scores, risk orientation was measured in scores, economic motivation was measured in scores, attitude towards modern technology was measured in scores. The study's dependent variable was the adoption of climate-smart agriculture techniques. With a mean of 56.53 and a standard deviation of 8.5, the respondents' observed scores on the implementation of climate-smart farming practices varied from 40.25 to 75.29. Low adoption (40-48), medium adoption (49-65), and high adoption (66 and above) were the three categories into which farmers were divided (mean=/- standard deviation).

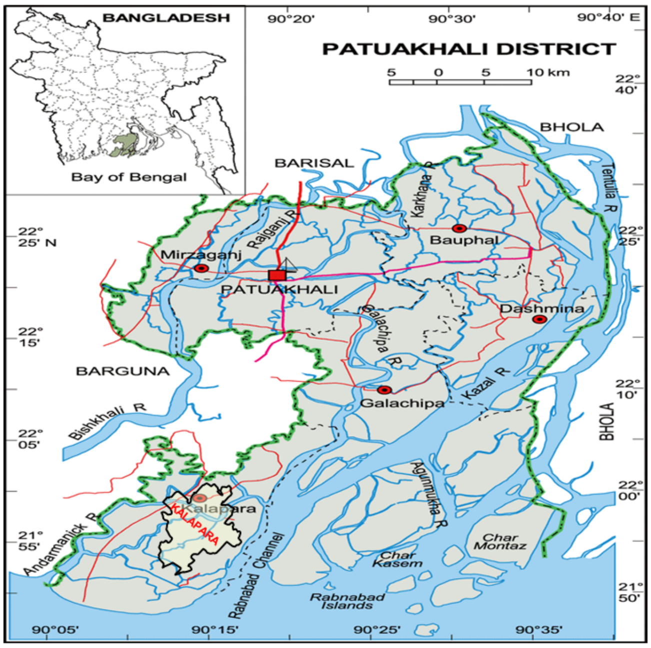

Figure 1: Map illustrating the data collection location in Kalapara upazila, situated in the Patuakhali District of Bangladesh

RESULTS AND DISCUSSION

The profile of the respondent's sociodemographic traits was established, and the findings are shown in Table 1. The findings showed that the majority of farmers (42.6%) were middle-aged (42.6 percent), no formal schooling (68.1 percent), medium farming experience (49.4 percent), medium agricultural knowledge (56.1 percent), no training experience (72.3 percent), small farm size (46.1 percent), low annual income (65.8 percent), medium communication exposure (61.0 percent), medium cosmopoliteness (76.1 percent), medium innovativeness (57.8 percent), medium risk orientation (75.8 percent), medium economic motivation (61.3 percent), medium attitude towards modern technology (70.7 percent).

Table 1: Demographic and socio-economic characteristics of the respondents

Characteristics (Measuring units)	Range		Farmers			Mean	SD
	Possi-ble	Obse-rved	Categories	No.	Perc-ent		
Age (Year)	Unknown	23-61	Young (up to 35)	79	25.5	43.45	10.86
			Middle (36-50)	132	42.6		
			Old (>50)	99	31.9		
Education (Year of Schooling)	Unknown	0-14	No formal schooling	211	68.1	1.39	2.5
			Primary level	70	22.5		
			Secondary level	28	9.1		
			Above secondary	1	0.3		
Farming experience	Unknown	5-45	Low farming experience	129	41.6	21.59	7.941
			Medium farming experience	153	49.4		
			High farming experience	28	9		
Agricultural knowledge	Unknown	10-29	Low (Upto 12)	61	19.7	17.73	5.63
			Medium (13 to 22)	184	56.1		
			High (23 and above)	65	24.2		
Training experience (day)	Unknown	0-6	No training	224	72.3	1.09	1.9
			With training	86	27.3		
Farm size (Ha)	Unknown	0.15-3.20	Marginal (between 0.02 and 0.2 ha)	19	6.1	1.12	0.75
			Small (between 0.2 and 1 ha)	143	46.1		
			Medium (between 1 and 3 ha)	138	44.5		
			Large farmers (above 3 ha)	10	3.2		
Annual income (TK))	Unknown	64.10-427.22	Low income (Upto Tk 116)	204	65.8	116.05	55.06
			Medium income (Tk. 116.01 to 232.0)	86	27.7		
			High income (Tk. 232.01 – 427.22 and above)	20	6.5		
Communication exposure	Unknown	14-39	Low (14-17)	55	17.7	23.78	6.69
			Medium (18-29)	189	61		
			High (30-39)	66	21.3		
Cosmopoliteness	Unknown	3-14	Low (3)	32	10.3	5.98	2.27
			Medium (4-8)	236	76.1		
			High (9 and above)	42	13.5		
Innovativeness	Unknown	11-20	Low innovativeness (11-14)	33	10.6	15.98	1.49
			Medium innovativeness (15-16)	179	57.8		
			High innovativeness (17-20)	98	31.6		
Risk orientation	Unknown	16-38	Low (16-26)	30	9.7	29.94	3.23
			Medium (27-32)	225	75.8		
			High (33 and above)	45	14.5		

Economic motivation	Unknown	13-32	Low economic motivation (13-18)	56	18.1	22.51	4.51
			Medium economic motivation (19-27)	210	61.3		
			High economic motivation (28-32)	44	14.2		
Attitude towards modern technology	Unknown	13-29	Low (13-22)	55	17.7	24.06	2.20
			Medium (23-26)	219	70.7		
			High (27 and above)	36	11.6		
Adoption of climate smart agricultural practices	Unknown	40.25-75.29	Low adoption (40-48)	66	21.29	56.53	8.5
			Medium adoption (49-65)	186	60		
			High adoption (66 and above)	58	18.71		

The respondents' observed scores for the adoption of climate-smart agricultural practices ranged from 40.25 to 75.29, with a mean score of 56.53 and a standard deviation of 8.5. Based on the mean and standard deviation, farmers were classified into three categories: low adoption (scores between 40 and 48), medium adoption (scores between 49 and 65), and high adoption (scores of 66 and above). The distribution of farmers across these categories is presented in the following table. Table 2 indicates that the majority of respondents (60.00 percent) had a medium level of adoption of CSA practices, followed by 21.29 percent with low adoption and 18.71 percent with high adoption. These findings suggest that most farmers fall within the medium to low adoption categories. This may be attributed to limited access to available CSA technologies and practices. Similarly, previous study reported that 56.3 percent of farmers had adopted CSA practices, which aligns with the results of this study (Ewulo *et al.,* 2025).

Table 2: Characteristics of waste management in poultry farms

Categories (Scores)	Frequency	Percentage	Mean	SD
Low adoption (40-48)	66	21.29	56.53	8.5
Medium adoption (49-65)	186	60.00		
High adoption (66 and above)	58	18.71		
Total	310	100		

Relationship between selected farmer characteristics and their influence on the dependent variable

The study determined the relationship between the adoption of CSA practices of the coastal farmers on climate smart agricultural practices as dependent variables and 13 selected characteristics of the coastal farmers as independent variables discussed below under following sections:

Relationships between Selected Characteristics (Independent Variables) and the Adoption of CSA Practices (Dependent Variable)

This objective sought to examine the relationships between selected characteristics of coastal farmers (independent variables) and their adoption of CSA practices (dependent variable). The correlation coefficients between the independent variables and the dependent variable are presented in Table 3.

Table 3 indicates that from 13 selected characteristics, 7

Table 3: Relationship with selected independent variables with the adoption of CSA practices of the respondents

Variables	Selected Independent Variables	Value of correlation coefficient (r)
Adoption of climate smart agricultural practices	Age	.010
	Education	.041
	Farming experience	-.008
	Agricultural knowledge	.228**
	Training experience	.276**
	Farm size	-135*
	Annual income	.016
	Communication exposure	.552**
	Cosmopoliteness	-.066

	Innovativeness	.169*
	Risk orientation	.163*
	Attitude towards modern agricultural technology	-.049
	Economic motivation	.211**

*** Significant at 0.01 level of significance Significant at 0.05 level of significance*

characteristic out of which 6 characteristics viz. agricultural knowledge, training experience, communication exposure, innovativeness, risk orientation, economic motivation showed positive significant relationships with the adoption of CSA practices (dependent variable) and only 1 characteristic viz. farm size showed negative significant relationships with the adoption of CSA practices (dependent variable).

Contribution of Independent Variables to Adoption of Dependent Variable

The correlation coefficients indicate the linear relationships between pairs of variables but do not show the extent to which the independent variables-i.e., the farmers' characteristics- contribute to the adoption of climate-smart agricultural practices. Therefore, a linear multiple regression analysis was conducted to determine the individual contributions of various characteristics of coastal farmers to their adoption of these practices. Only those variables that showed significant correlations with the adoption of climate-smart agricultural practices were included in the regression model. As a result, seven characteristics- agricultural knowledge, training experience, farm size, communication exposure, innovativeness, risk orientation, and economic motivation were included in the analysis. The results of the regression analysis are presented in Table 4.

Among the seven variables, the regression coefficients for only four- farm size, communication exposure, innovativeness, and economic motivation were statistically significant, indicating that these factors made a meaningful contribution to variations in the adoption of CSA practices (Aryal *et al.,* 2018). The remaining three variables- agricultural knowledge, training experience, and risk orientation did not show a significant contribution.

The results of the multiple regression analysis are presented in Table 4. It was found that four variables- farm size, communication exposure, innovativeness, and economic motivation were included in the regression model, collectively explaining 34.8 percent of the total variation in adoption. The F-value of 23.075 was statistically significant at the 0.000 level of probability.

Therefore, the relevant null hypotheses were rejected, and it can be concluded that each of these factors made a significant contribution to the adoption of CSA practices by coastal farmers. In other words, the coastal farmers who had high communication exposure, innovativeness and economic motivation had high adoption and coastal farmers who had high farm size had low level of adoption. The contributions of the respondents with their adoption for climate smart agricultural practices are discussed below:

Table 4: Regression coefficients of the selected farmer characteristics in relation to their adoption CSA practices

Variable entered	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
	B	**Std. Error**	**Beta**		
(Constant)	21.123	5.700		3.706	.000
Agril. knowledge	.113	.075	.075	1.516	.131
Training exposure	-.295	.242	-.069	-1.223	.222
Farm size	-1.276	.620	-.096	-2.058	.040
Communication exposure	.673	.076	.522	8.840	.000
Innovativeness	.578	.270	.102	2.141	.033
Risk orientation	.190	.125	.072	1.522	.129
Economic motivation	.186	.091	.099	2.038	.042
R^2= 34.8	F, 23.075	P= .000			

The unique contribution of each of the three variables was determined by observing the change in the R^2 value resulting from the entry of each variable into the stepwise regression model. The results are presented in Table 5. Together, the two variables accounted for 31.8 percent of the total variation in adoption among coastal farmers. Communication exposure alone contributed 30.4 percent, followed by innovativeness, which accounted for 1.3 percent of the variation.

Table 5: Change in multiple R for enter of a variable into the step-wise multiple regression model for adoption of CSA practices

Model	Variables entered in the model	R^2	Adjusted R^2	Change in R^2	Variation explained (percent)	Level of significance
Constant+X8	Communication exposure	.304	.302	.304	30.4	.000
Constant+ X8+X10	Communication exposure+ innovativeness	.318	.313	.013	.013	.015

Communication Exposure

Adoption would be higher with the increase of communication exposure i.e. communication media used by the farmers. The farmers who have more contact with communication media can easily gain various help in adoption of CSA practices. So it can be inferred that the higher the communication exposure, the higher is the adoption level (r= .552**). A previous study also suggests that communication exposure, such as the communication access and their alignment with existing farming activities, strongly motivate farmers to enhance farmers' capacity to adopt and sustain CSA practices (Ajwang *et al.,* 2024).

Innovativeness

Adoption would be higher within the innovative farmers. The farmers who are more innovative can search for suitable climate smart agricultural practices in adoption. Therefore, it can be inferred that a higher level of innovativeness is associated with a greater level of adoption (r = .169*). A previous study also found that agricultural innovativeness has a significant direct influence on the intention to adopt CSA practices (Mondal & Hasan, 2025).

CONCLUSIONS

This study explores how coastal farmers adopt climate-smart agriculture by looking at their socioeconomic characteristics, how much they use CSA practices, the challenges they face, and the information they need. The findings provided valuable insights into the factors influencing CSA adoption, revealing both enabling conditions and significant barriers that hinder widespread implementation. Key challenges included limited access to resources, inadequate knowledge, and infrastructural constraints, which necessitate well-structured interventions. Additionally, the study identified the critical need for improved access to relevant information and support systems to enhance farmers' capacity to adopt and sustain CSA practices. These insights can guide policymakers and agricultural stakeholders in designing targeted policies, extension services, and capacity-building programs that facilitate the seamless integration of CSA practices into coastal farming systems. The study advances the larger objective of guaranteeing sustainable agricultural development, boosting climate resilience, and strengthening the livelihoods of coastal farmers in the face of growing climate variability by addressing adoption barriers and knowledge gaps.

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