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# ADOPTION OF CLIMATE SMART AGRICULTURE (CSA) AT ISHWARGANJ UPAZILA UNDER MYMENSINGH DISTRICT OF BANGLADESH

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**ABSTRACT**

The current study assesses the adoption of Climate-Smart Agriculture (CSA) practices by farmers in some selected areas at Ishwarganj Upazila under Mymensingh district of Bangladesh, looking at socio-economic profiles, extent of adoption, factors driving CSA implementation, and any existing challenges to implementation. Based on structured interviews in Bhatichar-Nowpara and Shahaganj village of Ishwarganj Upazila by using simple random sampling with 65 farmers (30 CSA adopters and 35 non-CSA adopters), data were analyzed through descriptive statistics, a participation index and binary logistic regression model was employed to attain the objectives. Results show that the examples of popular CSA practice are the use of organic fertilizer (regular adoption percentage is 100%) and alternative wetting and drying (regular adoption percentage is 86.66%), while rainwater harvesting and floating vegetable beds were identified to be the least common due to the lack of resources and full awareness. High costs, lack of technical expertise, and poorly developed infrastructure are some of the barriers to wider adoption. The study suggests that even though CSA practices are most likely to enhance productivity and resilience, adoption depends on targeted interventions. Overcoming these challenges can lead to the sustainable integration of CSA practices, which will support food security and build climate resilience in the agricultural practices areas of Bangladesh.

**Key words:** Climate-Smart Agriculture, technologies, adoption, challenges, awareness.

## Introduction

Climate Smart Agriculture (CSA) has come up as a game-changer in addressing the challenge posed by the changing climate. It is based on integration of three primary objectives: sustainable increase in agricultural productivity, adoption to climate variability and its effects, and reduction of greenhouse gas emissions wherever possible. CSA has been focused on efficient use of natural resources and application of updated technologies toward food production for again sustainable. More importantly, such a way of thinking is especially relevant for countries like Bangladesh whose agriculture is inextricably linked with livelihood and ecology

The case of CSA: The case of Mymensingh District in north-central Bangladesh is, in a small way, a prototype of issues and opportunities surrounding CSA. The district of Mymensingh was historically known for its fertile lands and diversified cropping system, and it's considered a vital agricultural hub since ancient times. The farmers cultivate diverse crops in this district, such as rice, vegetables and jute, as well as livestock and fisheries. But like much of the country, Mymensingh is under deep threat from the forces of climate change. Wide seasonal variations in rainfall, abnormally long droughts and torrential floods have been common features that have battered agriculture and imperiled farming communities. With emerging awareness about these issues, various stakeholders, including government agencies, NGOs, and research institutions have started promoting CSA practices in the regions of Mymensingh.

Education level is one of the significant socio-economic factors that influence the uptake of CSA (Rahman *et al.*, 2022). Another factor, a major one, is to access to funds. Smallholder farmers always have very limited budgets, and most do not have the capital investment needed in CSA technologies. Credit facilities, subsidies, and other financial support are thus paramount for more widespread adoption. Extension services and training programs are very important in the dissemination of knowledge on CSA practices and their benefits respectively. The experiences of peers and farm networks often dominate the assessment of costs and benefits for the adoption of new practices for farmers [especially in developing countries (Ahmed *et al.*, 2021)]. Women play a crucial role in promoting CSA as well. Women in rural areas are heavily engaged in agriculture, contributing to planting, weeding, post-harvest processing and livestock care. It is thought that taking a gender sensitive approach to CSA would be an empowering mechanism for women, thus increasing the level of engagement by women to increase agricultural productivity and resilience (Weltin *et al.* 2017). Yet despite the promise of CSA, there are also serious challenges: one of the key barriers in question is the very high upfront costs of some technologies that go hand in hand with CSA implementation-like precision-farming tools and advanced irrigation systems. Those are usually out of reach for most small-scale farmers, though the benefits could be longer-term. In addition to this, insufficiencies in key infrastructural networks, including that of storage facilities and a transportation network, also restrict proper adherence to CSA practices. It will require the collective commitments and efforts of policy makers, researchers and the private sector. The adoption of CSA in Mymensingh district can also be viewed through the lens of need and opportunity. Agricultural productivity can be improved through the construction of resilience capacity against climate change which can help food security and sustainable livelihoods among farming communities by making use of CSA. This will be achieved in a holistic manner; it is a need to address the various issues that influence adoption-from socio-economic milieu and institutional support to cultural mindset and gendered realities. The present study, therefore, attempts to contribute to this understanding the socio-economic profile of the CSA farmers in Mymensingh District, practice intensity of CSA and factors helping to adopt it. These findings will be a stepping stone to design and enforce policies and programs to scale-up promotion of CSA for sustainable agriculture for a secured future of Bangladesh.

**Rationale for the study:** Climate Smart Agriculture (CSA) practices are needed to prevent rising disasters against climate change and CSA can be a most effective way to achieve climate smartness for Mymensingh district, as Mymensingh district is highly vulnerable to climate change and agriculture is the lifeblood of the people. The study is justified because it aims to better understand socio-economic determinants of CSA adoption; current practices; and key barriers faced by farmers. Such insights can inform not only policy interventions and community-level programs for sustainable agricultural production in Bangladesh.

**Objectives of the study:** The specific objectives of the study are as follows:
1) To assess the socio economic profile of CSA farmers;
2) To examine the extent of CSA practices;
3) To evaluate the factors influencing the adoption decision of CSA farming and
4) To identify the major problems faced by farmer in CSA practices.

## Materials and Methods

**Study Area:** The selection of a study area is one of the most important steps in research since it has a great bearing on the quality and relevance of the findings. It must be representative enough so that meaningful and generalizable insights can be obtained from the area. Practical considerations include access to data, accessibility, communication facilities, and potential biases. Besides, it needs to be chosen, considering the physical demands: constraints over the budget, limitation of time. Bhatichar-Nowpara and Shahaganj were two villages under Ishwarganj upazila of Mymensingh district are the two selected sites (Fig. 1), representing research sites in this study. As such, those were selected purposively, representing all purposes of this research and specific concentration of this study relating to the issues on Climate Smart Agriculture (CSA) practices.

**Preparation of the survey questionnaire:** A draft questionnaire was developed for this study to collect required primary data on CSA adoption in Ishwarganj upazila. The draft was, therefore, pre-tested with a small number of respondents in the selected CSA farming areas for clarity and relevance. Based on the response during the pre-test, the questionnaire was revised and improved to make it more realistic for the farmers' practical experiences.

**Period of data collection:** This research took place from October to November 2024. The respondents had been interviewed at their convenience time in order for them not to hurry over answering the questions. Data were collected in local units to avoid errors and the responses given were reliable.

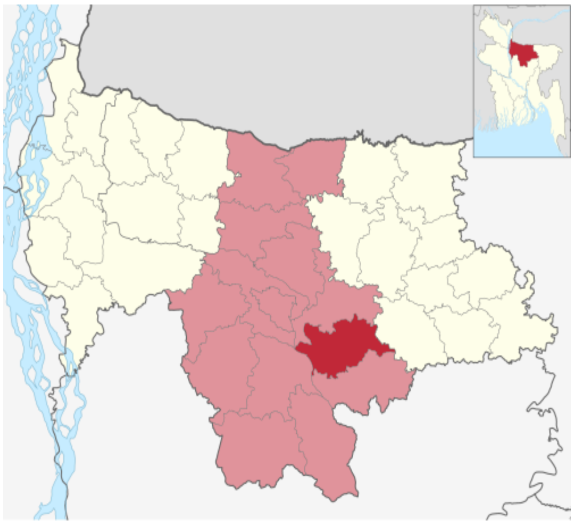

**Fig. 1. Location of the Ishwarganj Upazila in Mymensingh District**

**Methods of data collection:** The collection was done through a semi-structured interview schedule to capture the detailed response of the different aspects, namely, adoption to CSA, farming practices followed, climate-smart technologies, and problems faced by the farmers while adopting the various techniques of CSA. All interviews were conducted by the researchers themselves, which allowed maintaining consistency and accuracy of the data collected. Other data collection in this regard was taken from secondary sources that encompassed government reports, academic journals, and publication reports from different agricultural organizations.

**Processing and tabulation of data:** After the collection of primary data, consistency, and accuracy of the filled-up survey schedules were checked, and then analysis of data was commenced. A cross-check on the data is done to ensure that errors or discrepancies can be identified and corrected so that the sanctity of the information is maintained. Then, it organized all the data collected in a tabulated form. The use of Stata 15 and Microsoft Excel was found to be quite efficient for both data entry and analysis. The data were ttabulated into relevant categories systematically in line with the objectives of this study to ensure that the information collected would be duly analysed. It involved the development of tables and figures that were helpful in addressing the research questions with regard to adoption of CSA, socio-economic characteristics, and perceived impacts of climate smart practices in the study area.

**Selection of sample and sampling technique**

**Sampling Design:** Since it is not realistically feasible to involve all the farmers in this study area due to resource and time constraints, the selected sample size had a closer representative of the population that was workable within the limits of this research. In arriving at the sample size, the following two important factors were considered:

**Sample Size:** The sample size was determined to be sufficient to ensure statistical validity and reliability and at the same time as small as possible to be managed in fieldwork, data processing, and analysis with the given resources. Sampling was designed to be simple to carry out with the physical, human, and financial constraints. A sample size of 65 respondents was sufficient to realize the objectives of the study within the resource and time limits set by the study.

**Distribution of the sample farmers in the study areas**

| Sample farmers | Bhatichar-Nowpara (Number) | Shahaganj (Number) | Total (Number) |
|---|---|---|---|
| CSA Farmers | 16 | 14 | 30 |
| Non- CSA Farmers | 16 | 19 | 35 |
| Total | 32 | 33 | 65 |

Source: Author's estimation, 2024

**Participation index (PI):** The intensity of adoption of different CSA practices by farmers was measured using a 4-point Likert scale. In this respect, the frequency of farmers with regard to six different CSA practices was measured: organic farming, rainwater harvesting, integrated pest management, crop rotation, water-saving techniques, and climate-resilient varieties. The four categories on the Likert scale included:

- **Regularly** (assigned a score of 3)
- **Occasionally** (assigned a score of 2)
- **Rarely** (assigned a score of 1)
- **Not at all** (assigned a score of 0)

Farmers were requested to indicate their participation in each of the CSA practices; from these responses, information on the degree of adoption and engagement in climate-smart methods could be obtained. The participation index for each of the CSA practices was calculated using the expression below:
Participation Indices (PI) = (Regularly × 3) + (Occasionally × 2) + (Rarely × 1) + (Not at all × 0)
This assessment method provided a quantifiable and systematic analysis of the adoption of CSA, hence giving a clear understanding of the level of engagement among farmers of Ishwarganj upazila.

**Analysis of logistic regression:** Logistic regression analysis was estimated using binary dependent variable (Gujrati *et al.*, 2003). The logit model has been specified as follows:

$$Y_i = ln[(P_i)/(1-P_i)] = \beta^0 + \beta^1X^1 + \beta^2X^2 + \beta^3X^3 + \beta^4X^4 + \beta^5X^5 + \beta^6X^6 + \beta^7X^7 + U_i \quad ..................(i)$$

Where,
$P_i$ = Probability that farmer adopted CSA strategies;
$(1-P_i)$ = Probability that farmer not being adopted CSA strategies;

$$L_i = \beta^0 + \beta^1X^1 + \beta^2X^2 + \beta^3X^3 + \beta^4X^4 + \beta^5X^5 + \beta^6X^6 + \beta^7X^7 + U_i \quad ..........(ii)$$

Here, Y is dichotomous dependent variable having 1 if farmer adopted CSA strategies and 0 otherwise.
$\beta_0$ =the intercept; $\beta_i$= regression coefficients that explain the probability of adoption of CSA farmers.
$X_1$= Age; (Years)
$X_2$= Education; (No of schooling years)
$X_3$= Farm size (Hectare)
$X_4$=Farm income; (TK)
$X_5$=Farming experience; (No. of years)
$X_6$= distance to farm from household; (kilometer)
$X_7$= Access to credit facilities; (Dummy; Yes =1, No = 0) and
$U_i$ = Error term.

## Results and Discussion

### *Socioeconomic characteristics*

**Educational status of the sampled farmers:** Education has a significant influence on farmers' decision-making capabilities and their adaptation to modern agricultural practices. In table below shows the record of educational status of sampled farmers (no formal education, primary and secondary education). The comparative analysis indicates that CSA farmers have relatively higher literacy levels referring to their non-CSA fellow farmers, the proportion of CSA adopters (farmers) attaining secondary education is much higher. This revealed that CSA adopters have relatively higher literacy levels compared to non-adopters and this therefore better equips them with the ability to comprehend and apply modern agriculture practices, which is fundamental for the success of CSA implementation. On the other hand, the higher percentage of non-CSA farmers without formal education indicates a possible hindrance to adopting innovative farming practices (Table 1).

Table 1. Distribution of the sampled farmer according to educational status

| Education Category | CSA Farmers (Number) | CSA Farmers (%) | Non-CSA Farmers (Number) | Non-CSA Farmers (%) |
|---|---|---|---|---|
| No formal education | 4 | 13.33 | 8 | 10 |
| Primary education | 13 | 43.33 | 17 | 56.67 |
| Secondary education | 13 | 43.33 | 10 | 33.33 |

Source: Author's estimation based on field survey, 2024

**Farm size of the sampled farmers:** Farm size was stratified into three groups to have a clear view of the pattern by which land was distributed among the sampled farmers, small farm scale (0.5–1.0 ha), medium farm scale (1.1–1.5 ha) and large farm scale (1.51–2.0 ha). Among the CSA farmers, 33.33% were small-scale farmers, 60.00% were medium-scale farmers while 6.67% were cultivating on a large scale (Table 2). This comparison exposes a marked dichotomy between the two groups: CSA farmers had a greater concentration of medium and large farm sizes, which probably brought more resources, physical assets, and access to institutional support required for CSA uptake.

Table 2. Distribution of sampled farmers according to farm size

| Farm Size (Hectare) | CSA Farmers (%) | Non-CSA Farmers (%) |
|---|---|---|
| Small | 33.33 | 66.67 |
| Medium | 60.00 | 33.33 |
| Large | 6.67 | 0.00 |
| Total | 100.00 | 100.00 |

Source: Author's estimation based on field survey, 2024.

**Farming experience:** Table 3 presents the distribution of sampled CSA and non-CSA farmers categorized into four groups based on years of farming experience: between 6 and 10 years, between 11 and 15 years, between 16 and 20 years, and above 20 years. The data indicates that CSA farmers have on average been farming longer than those not engaged in CSA, possibly accounting for their increased adoption of practices such as cover cropping or direct seeding. Highly experienced CSA farmers can serve as mentors to less-experienced farmers within non-CSA groups.

Table 3. Distribution of sampled farmers according to farming experience

| Farming Experience (Years) | CSA Farmers (%) | Non-CSA Farmers (%) |
|---|---|---|
| 6–10 | 13.33 | 33.33 |
| 11–15 | 20.00 | 26.67 |
| 16–20 | 26.67 | 23.33 |
| Above 20 | 40.00 | 16.67 |
| Total | 100.00 | 100.00 |

Source: Author's estimation based on field survey, 2024.

**Extent of CSA practices in selected areas:** Here, table 4 presents a summary of the magnitude by which farmers in the selected areas are using the various CSA practices. The results indicate wide dispersion of the different CSA practices among farmers. For example, the use of vegetable cultivation in floating beds is underutilized (76.67% farmers never practice) and only 23.33% sometimes practice this method. The vegetable gardening on pond side is very common, and all respondents stated that it is occasionally practiced; however, it is neither practiced regularly nor rarely. Use of organic fertilizer is commonly practiced, as the all respondents (100%) are using this practice regularly, and suggesting heavy dependence on organic inputs for farming. Variation in the practice of mulching is more, among the original respondents 50 per cent occasionally used, 33.33 per cent rarely used 16.67 per cent practice regularly. No farmers practiced consistently or occasionally used and none of the rainwater harvesting methods showed to be adopted at wide level due its benefits. Finally, alternative wetting and drying (AWD) is the CSA practice that farmers adopt the most, at 86.67%. AWD is not applied at all by a small subgroup (13.33%) but by the majority indicating a prevailing trend. In short, the table clearly shows the level of adoption of CSA practices varies while a practice such as organic fertilizer and AWD are most common, others are used infrequently or not at all for cultivating vegetables, for example, rainwater harvesting and floating bed vegetable cultivation.

Table 4. Percentage distribution of CSA practices by adoption frequency (N = 30)

| CSA Practice | Not at all (%) | Rarely (%) | Occasionally (%) | Regularly (%) | Participation indices (PI) | Rank order |
|---|---|---|---|---|---|---|
| Vegetables in Floating Beds | 76.67 | 23.33 | 0.00 | 0.00 | 7 | 6 |
| Pond side Vegetable Cultivation | 0.00 | 0.00 | 100.00 | 0.00 | 60 | 3 |
| Organic Fertilizer | 0.00 | 0.00 | 0.00 | 100.00 | 90 | 1 |
| Mulching | 0.00 | 33.33 | 50.00 | 16.67 | 55 | 4 |
| Rainwater Harvesting | 60.00 | 40.00 | 0.00 | 0.00 | 12 | 5 |
| Alternative Wetting and Drying | 13.33 | 0.00 | 0.00 | 86.67 | 78 | 2 |

The PI scores were then used to rank the CSA practices, with higher indices indicating greater adoption levels. Table 4 also highlights the extent of participation for each CSA practice, ranked by PI. The results suggest that organic fertilizer and alternative wetting and drying are the most adopted CSA practices, with which farmers are regular or occasional users. A significant majority does not practice these nor rarely practice them. Rainwater harvesting and vegetables in floating beds have the least adopting with the majority of farmers either not practicing them or rarely practicing them. These results indicate the necessity of specific interventions and greater awareness and support to promote further adoption of these CSA practices.

***Factors affecting CSA farmers' in adoption decision***

**Specification of the model (Logistic regression):** A logistic regression model is a type of regression analysis used to model the relationship between a dependent variable (also called the target variable) and one or more independent variables (also called predictors or features) when the dependent variable is categorical. Specifically, it is used when the dependent variable is binary (i.e., it takes on two possible outcomes, typically coded as 0 and 1).

**Dependent variable:** The binary dependent variable in this study was constructed using whether the farmer practiced at least one CSA operation. In particular, a farmer was defined as CSA adopter (Y=1) if adopts at least one of the following CSA practices: rainwater harvesting, alternate wetting and drying (AWD), mulching, organic fertilization. Farmers who did not use any one of these practices were classified as non-adopters (Y=0).

**Regression model:** A logistic regression model can be used to analyze the data because the dependent variable (CSA-Adoption) is binary.

Model:

$$L_i = \left[\frac{p}{1-p}\right] = Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + U_i$$

Where:

- P= 1 is the probability of adopting CSA practices.
- $X_1$, $X_2$, $X_3$, $X_4$, $X_5$, $X_6$, $X_7$: Independent variables.
- $\beta_1$, $\beta_2$, $\beta_3$, $\beta_4$, $\beta_5$, $\beta_6$, $\beta_7$: Coefficients showing the effect of each factor on CSA adoption.
- U: Error term.

Table 5. The effect of each factor on CSA

| Variable | Odds Ratio | Std. Err. | z | P>z | [95% Conf. Interval] |
|---|---|---|---|---|---|
| Age | 0.989 *** | 0.0038 | -2.89 | 0.006 | 0.982 – 0.996 |
| Level of Education | 1.019 | 0.0142 | 1.30 | 0.198 | 0.991 – 1.047 |
| Farm Size (Hectare) | 1.771*** | 0.1314 | 4.35 | 0.000 | 1.360 – 2.299 |
| Annual Farm Income (TK) | 1.0000002* | 1.17e-07 | 1.71 | 0.092 | 1.00e-07 – 1.00e-07 |
| Farming Experience (Year) | 1.025*** | 0.0055 | 4.50 | 0.000 | 1.013 – 1.036 |
| Distance to Farm (Kilometers) | 1.383*** | 0.1009 | 3.21 | 0.002 | 1.129 – 1.704 |
| Access to Credit Facilities | 1.249** | 0.0832 | 2.67 | 0.010 | 1.057 – 1.629 |
| Constant | 1.548 | 0.1939 | -2.25 | 0.029 | 0.436 – 2.329 |

Notes: *** $p<0.01$, ** $p<0.05$, * $p<0.1$; Pseudo $R^2 = 0.8200$; Log likelihood = -62.5373; Number of observations = 65

Table 5 show the output of a binary logistic regression model of factors that affect adoption of CSA (Climate-Smart Agriculture). The model contains multiple predictive factors, each with a different influence on the probability of CSA adoption. The findings stated that the older the farmer the less likely to have embraced CSA orientation and practices. Yearly incomes of the farm operator and education level have a lower and sometimes nonsignificant impact, indicating that other factors play a larger role in the decision to adopt CSA. In reality, the diffusion of CSA practices is influenced by a complex web of connected factors related to information access, institutional support/financial incentives. Amongst them, access to resources strongly influences the CSA adoption (Islam *et al.*, 2021). Credit availability and subsidies that affect financial barriers encountered by smallholders are other influences on the adoption decision. Perceived risk and benefits are also suggested to impact adoption behavior. Those farmers who think that advantages of CSA that improve productivity and result in reduced susceptibility of agriculture to climate shocks are greater in future will be more inclined to emulate its practices. Social factors such as peer influence and community network are strong determinants of the process of decision making because farmers typically rely on collective experiences and knowledge (Rahman *et al.*, 2021).

### *Challenges faced by CSA farmers*

1) Input cost, low market price are the most critical challenges and affected a significant proportion of the CSA farmers. To address these, policy interventions are required in the form of subsidies for inputs and mechanisms for fair market prices. High input costs with low market selling prices, highly critical ones; infrastructural barriers; and operational barriers round out the second and third challenges CSA farmers face.
2) Operational constraints are input procurement, lack of machinery. These issues reflect logistical and resource-based challenges that limit farmers' ability to optimize productivity.
3) Electricity, storage, irrigation are infrastructural gaps which are Less frequent, but these challenges indicate systemic gaps in rural infrastructure that block farming efficiency and sustainability.
4) Overcoming these challenges will require full mixing of policy reforms and investment in rural infrastructure, with innovative solutions to support CSA farming for sustainable livelihoods.
5) Improvement in access to inputs, markets, and resources will surely contribute toward improving productivity, profitability, and resilience among CSA farmers.

## Conclusion

The farming of CSA has high potentials for enhancing the sustainability and building resilience in agriculture in Bangladesh. The potential development of farmers for productivity enhancement in addressing identified challenges through specific interventions and policy reforms empowers the farmers practicing CSA towards overall rural community development.

### Limitations of the study

The limited number of participants is unlikely to be considered a representative CSA farming community sample, as participation was as low as 30 respondents. Hence, this present study contributes to an in-depth understanding of the practices and challenges of CSA and therefore provides a base for future research and policy formulation amidst such limitations.

- **Recall bias:** The information depended on farmers remembering facts, hence leading to faults in responses.
- **Unmeasured factors:** At least important determining factors, like weather, market conditions, and government support, were excluded from analysis.
- **Time constraints:** The limited time taken for data collection and its analysis had its own limiting effect on the depth of the study.

### Direction for future research

Future CSA research should thus consider that marginalized farmers face and analyze the long-term impact CSA on productivity and resilience. There are also knowledge gaps on the effectiveness of policy, climate information services, post-harvest management, and the incorporation of renewable energy. This not only boosts CSA adoption but also sustains it in the long run, exploring CSA models that have succeeded in other regions and can be replicated to scale too.

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