

# A Study on Factors Influencing Economic Sustainability of Maize Cultivation in Char Regions of Assam, India

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## Abstract

This paper deals with the measurement of the economic sustainability of maize cultivation and the factors influencing it in the char region (small riverine islands or sandy bars located in the vicinity of the river basin) of Assam, India. To do so, a total of 674 maize cultivators were sampled covering both char and non-char (higher plain) regions. The char regions are characterized by flooding and waterlogging during the monsoons, which leads to soil erosion and sand deposition on cultivable land, rendering cultivation impossible in the summer months. In this connection, it may be mentioned that cultivators belonging to the char region usually have little to no income in the summer months. However, in the char region, wide-scale maize cultivation has been observed during the winter months. In fact, the present study found higher rate of economic viability in char region's maize cultivators compared to non-char regions, which stood at 61.03 percent and 37.54 percent for the former and latter, respectively. The results indicate that the farmer with a higher level of education, longer farming experience, better access to irrigation, institutional credit, char regions and farm size are has positive influence, while dependency ratio, better financial status and alternative occupations have negative and significant influence on it. Hence, we call for a policy implication that these constraints be solved to enhance the income of these char cultivators in general and maize cultivators in particular.

**Keywords:** Char region, Economic Sustainability, Assam, Maize Cultivation and logit-probit.

## Introduction

Assam is a riverine agrarian state of Northeast India. The mighty the Brahmaputra, the Barak and their numerous tributaries are scattered all over the state. There are three distinct agrogeological zones in Assam, viz., the Brahmaputra Valley, Barak Valley and Hills regions (Singh and Sharma, 2007). One of the peculiar features of the river and its tributaries in Assam is presence of char or river islands with dense population observed during recent years (Goyari, 2005). The extremely braided channels of rivers, along with their unique gradient, suspended particles and bed load combined, during floods give rise to an almond-shaped alluvial formation called char (Bhagabati, 2001). Char regions of Assam are purely agrarian and are regularly affected by floods and soil erosion every year (Chakraborty, 2014).

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Rice is the principal crop in Assam and it is cultivated across all regions of the state, irrespective of seasons. It occupies the largest share of gross cropped area and is grown under all seasons, namely Ahu in autumn, Shali in winter and Boro in summer. But recently, there has been a gradual change in cropping patterns in Assam, especially during the winter months. Earlier wheat and summer rice was dominated the winter months in the plain region and highlands, whereas maize cultivation was confined to the only hilly regions of the state. But in the present scenario, winter cropping pattern reflects that there is a tendency toward maize cultivation even in plains during winter by substituting area under wheat and summer paddy. Primarily due to this reason, maize became the fastest-growing crop in terms of area under cultivation and production among all cereals in Assam. However, from 2013 onwards, maize has turn into the second-highest cereal crop in Assam, overtaking wheat (Kalita and Bora 2019). It is important to highlight that, unlike rice, maize is cultivated only for final sales only, rather than for self-consumption purpose. Thus, there is a clear case of the adoption of maize in plane areas of Assam during the winter months. During the last decade, the mean annual growth rate of area under maize in Assam is 6.56, with a mean annual yield of 1,897.49 kg per hectare.

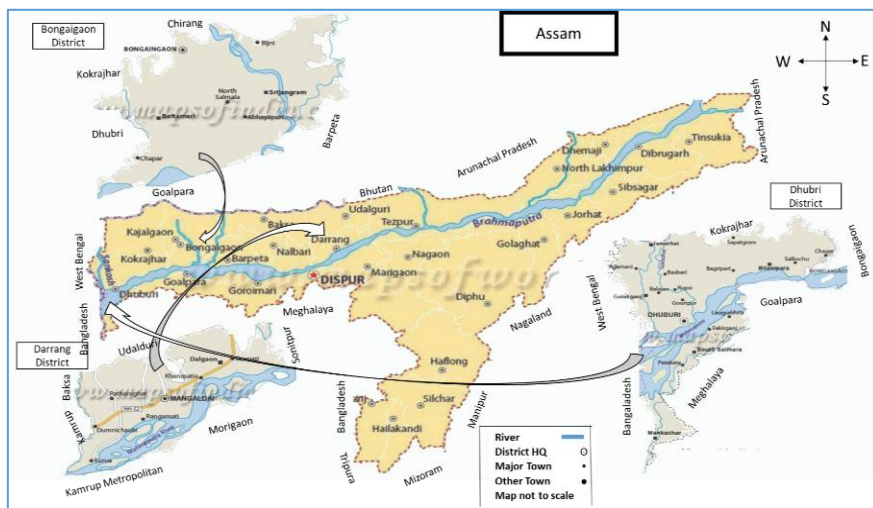
Economic sustainability in agriculture sector has becomes a central issue in development and planning, particularly for developing nations like India, where majority of workforce either directly or indirectly depends on agriculture and allied activities. About 70 percent of rural population in Assam depends on agriculture for their livelihood and their income remains relatively low and unstable (Government of Assam, 2023). In corresponding with the ‘Situation Assessment Survey of Agricultural Households’ conducted by the National Sample Survey Office (NSS SAS, 2019), only 50 percent of the total income of farming households in India is derived from cultivation, with the remaining income coming from livestock, wage labour, and non-farm activities. Therefore, the economic sustainability of cultivators becomes a serious issue to sustain interest in farming community. Considering this situation, it's crucial to have acquire information on cultivation cost for decisions on allocation of their scarce resources among alternate crops to enhance profit.

Economic sustainability of agriculture, may defined as the ability of a farming system to sustain livelihoods, generate surplus income and tolerate financial shocks is influenced by a host of factors including landholding size, market linkages, access to credit, input costs and climatic vulnerability (Chand et al., 2017). In the circumstance of char regions (higher plain) of Assam, unstable agro-ecosystem characterised by recurring floods during monsoon, river bank erosion and sand deposition in plots create complex farming conditions (Sharma & Patowary, 2013; Brahma, 2018). Regardless of these challenges, winter maize cultivation has expanded rapidly in char regions due to its adaptability to sandy soils, lower irrigation cost, and favourable market demand (Pretty, 2008; FAO, 2022). But there is no systematic econometric analysis on the determinants of economic sustainability of maize cultivation in the context of char region of the state. Therefore evaluation of economic sustainability of maize cultivators turn out to be essential for formulating under attack policies and sustainable agricultural expansion strategies. This study attempts to fill this gap by measuring economic sustainability, comparing it across char and non-char regions and empirically analysing the determinants of economic sustainability among maize-growing households in the state.

The principal objective of the present study is to measure economic sustainability in maize cultivation in char and non-char regions in Assam and to identify the factors affecting economic sustainability of the farmers. More specifically, the principal hypothesis of the study is that char and non-char have no association with the economic sustainability of farmers.

**Data and Study Area**

This study is completely based on primary data on farm-level maize cultivators, information collected between November 2023 and March 2024, from the Brahmaputra Valley in Assam. Since the focused crop is maize, the top three maize-cultivated districts from the study region are selected purposively on the basis of annual mean production of maize. One block from each district chosen purposively, where dominance of maize is observed on the basis of a pilot survey during mid-December 2022 and where char and non-char villages are available. Finally, two maize cultivation-dominant villages, one from char and another from non-char were selected from each selected block purposively. Finally, samples is collecting by using snowball sampling technique.



**Table 1. Sample size**

| District   | Block         | Village                             | Sample Size |
|------------|---------------|-------------------------------------|-------------|
| Darang     | Pub Mongaldoi | Nangli (char village)               | 116         |
|            |               | Bahabari (non-char village)         | 108         |
| Bongaigaon | Srijongram    | Harirchar (char village)            | 117         |
|            |               | Mulbari (non-char village)          | 108         |
| Dhubri     | Golokganj     | Purnirchar (char village)           | 117         |
|            |               | Kanaishingerghat (non-char village) | 108         |
| Total      | 3             | 6                                   | 674         |

Source: Researcher’s calculation on the basis of pilot survey

## Methodology

This section outlines the methodological framework used to analyse the factors influencing the economic sustainability of maize cultivation in Assam. First, determined whether a farmer is economically sustainable or not based on their household consumption expenditure and income earned from maize cultivation only. The study defines economic sustainability as a condition where a farmer's income from maize cultivation exceeds the household's total consumption expenditure for six months. This operational threshold is used to assess whether maize farming alone can support the basic consumption needs of the household, without relying on alternative income sources. The criterion provides a clear and measurable threshold for evaluating the economic performance of maize-based livelihoods in the study region. Given the binary nature of the dependent variable (1 for economically sustainable and 0 otherwise), a binary logistic regression model was selected for analysis. The model was estimated using the Maximum Likelihood Estimation (MLE) method.

### Statistical Method: The Binary Logit Model

To examine the factors that influence the probability of economic sustainability among maize cultivators, the study employs binary logistic regression, an appropriate statistical method when the dependent variable is binary (1 and 0). In this case, the dependent variable is the economic sustainability of a maize farmer, defined as

$$\text{Logit}(p_i) = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \sum_{k=1}^n \beta_k x_{ik} + u_i \quad (1)$$

Where  $p_i$  is probability that the  $i^{\text{th}}$  farmer is economically sustainable,  $\frac{p_i}{1-p_i}$  is odds of economic sustainability,  $\beta_0$  is intercept,  $x_{ik}$  is  $k^{\text{th}}$  explanatory variables of  $i^{\text{th}}$  observation,  $\beta_k$  is coefficient corresponding to  $x_{ik}$ ,  $u_i$  is error term assumed to follow a logistic distribution. Logistic regression ensures that the predicted probabilities always lie between 0 and 1, which is suitable for binary outcome analysis (Gujarati & Porter, 2009). Several model performance indicators are used to assess the robustness and fit of the logistic models like McFadden R-squared: Indicate the proportion of variability explained by the model. Likelihood Ratio (LR) Statistic: Tests the overall significant of the model. Akaike Information Criterion (AIC) and Schwarz Criterion (SC): Used to compare model specifications and identify the best-fitting model. Z-statistics and p-values: Assess the individual statistical significant of the explanatory variables. All statistical estimations and diagnostics were carried out using EVIEWS 10 for Windows.

### Model-1: Basic Socioeconomic Model

This model includes individual-level and household-level characteristics that are assumed to influence economic sustainability. The model is specified as:

$$\text{logit}(p_i) = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 \text{age}_i + \beta_2 \text{education}_i + \beta_3 \text{experience}_i + \beta_4 \text{maizearea}_i + \beta_5 \text{irrigation}_i + \beta_6 \text{loan}_i + \beta_7 \text{finencialstutus}_i + u_i \quad (2)$$

Where  $p_i$  is probability that the  $i^{\text{th}}$  farmer is economically sustainable,  $\text{age}_i$  is age of farmer in year,  $\text{education}_i$  is years of formal education of farmer,  $\text{experience}_i$  is experience of

maize cultivation in year,  $maizearea_i$  is total area under maize cultivation in bigha,  $irrigation_i$  is a binary dummy (if the farmer cultivating maize by using own irrigation tools then 1 otherwise 0)  $age_i$  is age of farmer in year,  $loan_i$  is dummy variable (if the farmer taken a loan then 1 otherwise 0),  $financialstatus_i$  is dummy variable (if the farmer either owner of pakka or semi-pakka house then 1 otherwise 0).

### Model-2: Extended Related Model

Model 2 extends model 1 by including two related variables that may influence economic sustainability

$$logit(p_i) = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 age_i + \beta_2 education_i + \beta_3 experience_i + \beta_4 maizearea_i + \beta_5 charregion_i + \beta_6 alternativeoccupation_i + u_i \quad (3)$$

Where  $charregion_i$  is dummy variable (1 if the farmer belongs to char region, otherwise 0),

$altarnativocccupation_i$  is dummy variable (1 if the person is engaged in alternative occupations otherwise 0).

### Model Specification

The table 2 represents a comparative analysis of binary logit and probit models using basic model fit statistics. From the table it is clear that both models fit well and statistically significant as McFadden R-squared values—0.431 for Probit and 0.433. McFadden R-squared values greater than threshold of 0.2 for discrete choice models indicate an excellent model fit (McFadden, 1974).

**Table 2. Comparative model fit statistics of binary probit and logit models**

| Model  | McFadden R-squared | Akaike info criterion (AIC) | Schwarz criterion (BIC) | Hannan -Quinn criter. | Criterion LR | Prob (LR statistic) | Log likelihood |
|--------|--------------------|-----------------------------|-------------------------|-----------------------|--------------|---------------------|----------------|
| Probit | 0.431              | 0.809                       | 0.856                   | 0.828                 | 402.214      | 0.000               | -265.311       |
| Logit  | 0.433              | 0.806                       | 0.853                   | 0.824                 | 404.431      | 0.000               | -264.311       |

Source: Researcher's estimates on the basis of primary data at the cultivator level using EVIEWS 10 for Windows.

The Logit model shows a marginally better performance than Probit as it contain slightly lower values across multiple criteria (Akaike, 1974; Schwarz, 1978; Hannan & Quinn, 1979). The Akaike Information Criterion (AIC = 0.806), Schwarz Criterion or Bayesian Information Criterion (BIC = 0.853), and the Hannan-Quinn Criterion (HQ = 0.824), all of which are lower than the corresponding values for the Probit model. Furthermore, the Logit model has a slightly higher Log Likelihood (-264.311 vs. -265.311) and a greater Likelihood Ratio (LR) statistic (404.431 vs. 402.214), suggesting a marginally stronger improvement over the null model (Greene, 2018). Both models are statistically significant, as shown by p-values of 0.000. While

both Probit and Logit models fit well, overall Logit model is a slightly better choice based on these results. Hence the Logit models has estimated for the present study.

### Empirical Results and Discussion

Comparison of economic sustainability of maize cultivation between char and non-char regions of Assam in table 3 below. As observed the table it is clear that in the non-char region, only 37.54 percent of the maize cultivators are economically sustainable, implying they are able to generate gross profits sufficient to meet or exceed the threshold of six months' household expenditure. Consequently, the remaining 62.46 percent of cultivators in the non-char areas are economically unsustainable, as their income from maize falls below the threshold of six months' household expenditure. This implies a high level of economic vulnerability among maize farmers in these flood-prone and ecologically fragile regions.

**Table 3. Percentage of cultivators whose gross profits exceeds (or falls short of) six × monthly consumption expenditure {N = 325 (non-char) and N = 349 (char)}**

| Categories  | Non-char | Char  |
|---|----------|-------|
| Gross Profits > (six × monthly consumption expenditure)<br>Or Economically sustainable livelihood   | 37.54    | 61.03 |
| Gross Profits < (six × monthly consumption expenditure)<br>Or Economically unsustainable livelihood | 62.46    | 38.97 |

Source: Researcher's estimates on the basis of primary data at the cultivator level.

In contrast, the char region shows a significantly better outcome. Here, 61.03 percent of cultivators are economically sustainable. Indicating generating enough gross profit from maize cultivation to meet their basic consumption needs for six months. Only 38.97 percent of cultivators in char areas fall below the threshold of six months' household expenditure. This suggests that a majority of char maize farmers benefited more from stable and productive agricultural conditions, allowing them to sustain their livelihoods more effectively through maize cultivation.

### Maximum Likelihood Estimates of the Binary Logit Models

The Maximum Likelihood Estimates of the binary logit model to explain the factors that influence the probability of economic sustainability of maize cultivation are presented in table 4 below. The dependent variable here is binary in nature (i.e. 0 or 1) where score one is assigned to the economically sustainable cultivator and score zero otherwise. The operational definition of economic sustainability is already defined in table 3. The model was based on 674 valid observations. Results of the estimated models are shown in the table 4 given below.

**Table 4. Maximum likelihood estimates of binary logit model to explain the factors that influence the probability of economic sustainability of maize cultivation (N = 674)**

| Variables | Coefficients | Slandered Error | Z-Statistic | P-Value |
|-----------|--------------|-----------------|-------------|---------|
|-----------|--------------|-----------------|-------------|---------|

|                                    | Model<br>1    | Model<br>2    | Model<br>1  | Model<br>2  | Model<br>1                | Model<br>2 | Model<br>1 | Model<br>2 |
|------------------------------------|---------------|---------------|-------------|-------------|---------------------------|------------|------------|------------|
| Constant                           | -<br>5.587*** | -<br>5.836*** | 0.648       | 0.754       | -8.624                    | -7.744     | 0.000      | 0.000      |
| Age                                | 0.010         | 0.014         | 0.011       | 0.011       | 0.888                     | 1.255      | 0.375      | 0.210      |
| Education                          | 0.072***      | 0.073***      | 0.022       | 0.021       | 3.289                     | 3.454      | 0.001      | 0.001      |
| Experience                         | 0.146***      | 0.029         | 0.043       | 0.047       | 3.419                     | 0.611      | 0.001      | 0.541      |
| Area Under<br>Maize<br>Cultivation | 0.587***      | 0.602         | 0.052       | 0.058       | 11.27                     | 10.436     | 0.000      | 0.000      |
| Irrigation                         | 0.017***      |               | 0.048       |             | 4.971                     |            | 0.000      |            |
| Loan                               | -0.309        |               | 0.461       |             | -0.670                    |            | 0.503      |            |
| Financial<br>Status                | -0.046        |               | 0.283       |             | -1.437                    |            | 0.151      |            |
| Dependency<br>Ratio                | -<br>0.045*** |               | 0.225       |             | -3.780                    |            | 0.001      |            |
| Char                               |               | 1.654***      |             | 0.272       |                           | 6.077      |            | 0.000      |
| Joint Family                       |               | -0.003        |             | 0.239       |                           | 0.014      |            | 0.988      |
| Alternative<br>Occupations         |               | -<br>0.335*** |             | 0.251       |                           | 4.670      |            | 0.000      |
| Mean Dependent Variable            |               |               | 0.497       | 0.496       | McFadden R-<br>Squared    |            | 0.433      | 0.474      |
| S. D. Dependent Variable           |               |               | 0.500       | 0.500       | Akaike Info<br>Criterion  |            | 0.806      | 0.750      |
| Sum of Squared Residual            |               |               | 76.711      | 84.022      | Schwarz<br>Criterion      |            | 0.853      | 0.797      |
| SE of Regression                   |               |               | 0.339       | 0.355       | Hannan-Quinn<br>Criterion |            | 0.824      | 0.768      |
| Log Likelihood                     |               |               | -<br>245.68 | -<br>264.31 | Restr. Deviance           |            | 932.94     | 934.34     |
| Restricted Log Likelihood          |               |               | -<br>467.17 | -<br>466.47 | LR Statistic              |            | 4.4.32     | 442.99     |

|                    |        |        |                   |    |       |       |
|--------------------|--------|--------|-------------------|----|-------|-------|
| Avg Log Likelihood | -0.365 | -0.393 | Prob<br>Statistic | LR | 0.000 | 0.000 |
| No. of Observation |        |        |                   |    | 674   |       |

Source: Researcher's estimates on the basis of primary data at the cultivator level using EVIEWS 10 for Windows.

From the above table it is clear that constant term in both the models are negative and statistically significant at the 1% level ( $p < 0.01$ ). This implies that if all descriptive variables are considered at zero, then the probability of economic sustainability is very low. The negative coefficient implies that without considering influence of other variables, farmers are unlikely to achieving economic sustainability. The variable education is found to have a strong positive impact on economic sustainability in both models and the results are statistically significant at the 1% level of significant. This implies that farmers with higher education levels are likely to earn more profit from maize cultivation. That is mainly due to educated farmers have better knowledge about farming techniques, markets, and resource management.

Similarly, farming experience has a positive coefficient and statistically significant at the 1% level of significant in first model. Which implies that experienced maize farmers are likely to be economically more sustainable. However, in second model, the coefficient is also positive but statistically insignificant. This implies that the role of experience overlap with other factors. Interestingly the variable to represent the farmer belongs to a char region (riverine island or sandy bar of river) has a positive coefficient and statistically significant at the 1% level of significant in the second model. The results show that farmers in char regions are more likely to be economically sustainable.

Moreover, the variable area under maize cultivation and irrigation has a positive effect and statistically significant at the 1% level of significant. It implies that farmers who cultivate maize in larger area with better irrigation are more likely to be economically sustainable. This may be due to better manage costs and risks. Finally, the variable financial status has a negative coefficient but statistically insignificant in first model. However in case of second model it has a positive and significant coefficient. Which implies that financially strong maize farmers are more likely to be economically sustainable. In Model 1, the variables representing whether a farmer has taken a loan and their financial condition show negative signs, but these are not statistically significant. This means that having a loan or being in poor financial condition does not have a clear impact on economic sustainability, at least in this model.

However, coefficients of the variables representing whether a cultivator has taken a loan, age of cultivator and engaged in alternative occupations contain negative signs, but except alternative occupations are not statistically significant. This means that having a loan or being in poor financial condition does not have a clear impact on economic sustainability and maize farmers engaged in alternative occupations are likely to be less economically sustainable.

The analysis implies that education, farming experience, region under maize cultivation, land type (char region), and the presence of alternative occupations are important factors in

determining the economic sustainability of maize farming. However, cultivating maize along with other occupations significantly decreases the probability of economic sustainability.

### **Conclusion**

In summary, it can be considered that several factors positively influence the probability of economic sustainability among maize farmers. Variables like years of education, experience in maize cultivation and area under maize cultivation are consistently positive and statistically significant. It indicates higher educated and more experienced farmer with larger area under maize cultivation are likely to be more economically sustainable. Moreover, cultivator belongs to char region and dedicated to maize cultivation only also increase the probability of economic sustainability. Finally, char regions in Assam are more suitable for maize cultivation than non-char regions. That is why maize cultivation continuously extending in char regions with their numerous structural and natural barriers like recurring flood, erosion, sand deposition, lack of connectivity, no electricity, lack of marketing facility, credit availability and many more.

A focused policy framework on the development of flood and erosion resilient infrastructure, easy access to credit, providing marketing facilities to insure better price realisation in char regions of Assam should be priorities. Such policy support will not only improve economic performance of maize cultivator in char regions but also will help to achieve better livelihood security and long-term agricultural sustainability.

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