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Farm-Level Profitability and Determinants of Maize Production in Northern Bangladesh

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ABSTRACT

This study examines the farm-level profitability of maize production and identifies the key determinants of gross revenue among maize producers in Northern Bangladesh. Using primary data collected from 100 farmers through a multistage sampling technique during the 2024–2025 production season, the analysis integrates descriptive statistics, cost–return analysis, and a Cobb–Douglas production function estimated by the ordinary least squares (OLS) method. The results indicate that maize cultivation is economically viable, with an average profit of Tk. 14,462.6 per bigha, reflecting strong income potential for smallholder farmers. The regression findings represent that hired labor, machinery, seed, and pesticide costs exert statistically significant positive effects on gross revenue, highlighting the importance of modern inputs and efficient farm management practices. In contrast, plowing cost shows a negative association with revenue, suggesting inefficiencies in land preparation, while irrigation, fertilizer, and harvest–transport costs are found to be statistically insignificant, possibly due to uniform usage patterns or suboptimal application. The model demonstrates strong explanatory power, accounting for a substantial proportion of variation in farm revenue. Despite profitability, farmers face several constraints, including limited access to credit, inadequate extension services, and high input costs, which hinder optimal resource utilization. Therefore, this study recommends strengthening institutional support, improving access to quality inputs and affordable credit, and enhancing extension services to promote sustainable and efficient maize production in Bangladesh.

Keywords: Agriculture; C-D production function; Cost–benefit analysis; Maize; Profit efficiency.

1. Introduction

Maize farming has emerged as a significant agricultural activity in Bangladesh especially in the northern regions playing a decisive role in the national economy and food security (Mainuddin et al., 2021). Given its high productivity, nutritional value and diverse applications maize is increasingly recognized as a crop with substantial future potential (Biswas et al., 2022). Among various crops, maize has become the third most important cereal after rice and wheat. Its demand is rising rapidly for food, feed, industrial use employment generation. It plays a vital role in rural livelihoods by contributing a high yield compared to cereals. It also helps reduce malnutrition and foreign currency expenditure on food imports (Yadesa and Diro, 2023). Therefore, understanding the nuances of its profitability is paramount for stakeholders aiming to optimize agricultural development and food security initiatives in Bangladesh (Basera et al., 2016).

Based on Bangladesh Bureau of Statistics (BBS) data and related reports, maize production in Bangladesh has seen remarkable growth in recent years reaching record-high levels. This surge is driven by several factors including strong market demand from the feed industry, higher profitability for farmers compared to traditional crops and the adoption of modern cultivation methods. The study is grounded in the Cobb–Douglas production function, which assumes a functional relationship between inputs and output under constant elasticity conditions. This model is widely used in agricultural economics to estimate production efficiency and input contributions due to its simplicity and empirical robustness.

According to Bangladesh Bureau of Statistics, maize production in Bangladesh has experienced rapid growth, increasing from around 4.26 million tonnes in 2022 to 4.87 million tonnes in FY 2023–24, with further expansion observed in FY 2024–25 due to increased cultivated area and productivity improvements. It has reached record-high levels. This increase is attributed to strong feed demand, higher relative profitability and modern cultivation practices. According to Rahman and Rahman (2020), maize cultivation is highly profitable and economically efficient (BCR = 1.63; efficiency = 87%). However, opportunities for cost reduction remain. The education of farmers, farm size, and regional variables significantly influence efficiency. Asare et al. (2019) revealed that maize cultivation is lucrative. They reported an average profit efficiency of 48.4%. This efficiency is affected by variables such as education, gender, access to extension services, infrastructure, and loan availability. Similarly, Anang and Shafiwui (2020) found a mean profit efficiency of 71%. This was influenced by education, access to extension services, age, herd ownership, and membership in agricultural associations. Moreover, Biswas et al. (2023) determined that maize cultivation was economically viable. They reported a benefit-cost ratio (B/C) of 1.40–1.72, utilizing cost-return analysis and a Cobb-Douglas production function.

Adnan et al. (2021) analyzed the efficiency of Maize farming in Bangladesh. The study found an efficiency level of 0.71, indicating 29% inefficiency. Age, education, extension contact, and non-farm income were identified as the primary determinants. Additionally, Mohiuddin et al. (2007) examined the sustainability of maize cultivation in Bangladesh. They found that maize is profitable (BCR = 1.37–2.66) with high technical efficiency (98%).

However, inadequate resource utilization still persists. In contrast, Ogunniyi (2011) investigated profit efficiency among maize growers in Oyo State, Nigeria. The results showed significant variability in efficiency levels (1–99.9%), with an average profit efficiency of 41.4%. This indicates substantial scope for improvement. Education, farming experience, extension contact, and non-farm employment significantly enhance profit efficiency. This highlights the critical role of human capital and institutional support in improving agricultural performance.

The northern region of Bangladesh is characterized by fertile soil and favorable climatic conditions. It has become a major hub for maize cultivation (Alam et al., 2016). Despite its growing importance, the profitability of maize farming depends not only on productivity but also on the efficiency with which farmers utilize inputs. Profit efficiency reflects the ability of farmers to achieve maximum profit given input levels, output prices, and production technology. It provides a more comprehensive measure than productivity alone. It indicates how effectively farmers transform resources into revenue by minimizing costs and losses (Adnan et al., 2021). Identifying the factors affecting profit efficiency among maize farmers in northern Bangladesh is essential for policymaking. It helps in designing effective interventions to increase farm income, reduce inefficiencies and ensure sustainable agricultural growth. This study aims to assess the profit efficiency of maize cultivation in northern Bangladesh. It also analyzes the socio-economic and institutional factors influencing efficiency levels. The findings are expected to provide valuable insights for policymakers, researchers and development practitioners. These insights can support inclusive and sustainable agricultural development in the region.

2. Literature Review

The existing literature on maize production primarily focuses on profitability, efficiency, and the contribution of maize to agricultural growth, using diverse methodological approaches. At the macro level, studies emphasize the role of maize in agricultural development. For example, Abiola and Akinola (2021) employed time-series data along with vector error correction models (VECM) and found a significant positive long-run relationship between maize production and agricultural output in Nigeria. This suggests that improving maize productivity is essential for overall agricultural growth and sustainability.

At the farm level, two dominant methodological approaches are evident in the literature: stochastic frontier analysis (SFA) and cost–return analysis combined with production functions**.** Studies using stochastic frontier models mainly focus on estimating profit efficiency and identifying inefficiency factors. For instance, Asare et al. (2019) applied a translog stochastic frontier model and reported relatively low profit efficiency (48.4%) among maize farmers in Ghana, highlighting the importance of institutional factors such as access to credit, infrastructure, and extension services. Similarly, Anang and Shafiwui (2020) used a Cobb–Douglas stochastic frontier model and found higher efficiency (71%), emphasizing the role of education, experience, and farmer organizations. Comparable findings are reported by Ngeno (2020) and Ogunniyi (2011), who observed moderate to low efficiency levels in Kenya and Nigeria, respectively, indicating substantial scope for improving resource use and management practices.

In Bangladesh, several studies have examined maize production using cost–return analysis and production function approaches. Rahman and Rahman (2020) found maize farming to be highly profitable (BCR = 1.63) with high economic efficiency (87%), although cost inefficiencies persist. Similarly, Hassan et al. (2021) reported that maize cultivation in Rangpur district is profitable, particularly for larger farmers, but is constrained by issues such as low market prices, pest infestations, and limited resources. Biswas et al. (2023) also confirmed profitability (BCR = 1.40–1.72) using a Cobb–Douglas production function but highlighted constraints including high input costs, labor shortages, and declining soil fertility. These findings are consistent with Hajong et al. (2023), who reported positive net returns but identified rising input prices as a major challenge.

Some studies attempt to combine efficiency and profitability perspectives. Mohiuddin et al. (2007), using growth models, OLS regression, and frontier production functions, found maize cultivation to be both profitable and technically efficient, although resource misallocation remained a key issue. Similarly, Adnan et al. (2021) applied a profit frontier model and reported moderate efficiency (0.71), influenced by education, extension services, and non-farm income. These studies highlight the importance of both economic and institutional factors in determining farm performance.

Evidence from other developing countries further supports these findings. Dahala et al. (2024) found maize farming in Nepal to be profitable but inefficiently managed, with underutilization of key inputs such as machinery and fertilizers. Likewise, studies in Ghana and Nigeria consistently point to inefficiencies arising from poor input management, limited access to resources, and inadequate institutional support. In addition, Islam and Hossain (2022), using secondary data, emphasized that despite the profitability of maize production in Bangladesh, agronomic and infrastructural challenges continue to hinder productivity growth.

A comparative assessment of the literature reveals that studies using stochastic frontier models primarily estimate efficiency levels and identify determinants of inefficiency, while those using Cobb–Douglas production functions and cost–return analysis focus on profitability and input-output relationships. However, there is limited integration of these approaches within a single framework. Moreover, many studies are region-specific and often rely on small sample size, which restricts the generalizability of their findings.

Importantly, existing research in Bangladesh tends to analyze either profitability or efficiency separately, without explicitly examining how different input costs influence gross revenue at the farm level. This creates a significant research gap in understanding the combined effects of input utilization and cost structure on farm income.

Therefore, this study addresses this gap by integrating cost–return analysis with a Cobb–Douglas production function to simultaneously examine profitability and the determinants of gross revenue among maize farmers in Northern Bangladesh. This combined approach provides a more comprehensive understanding of maize production dynamics and offers important insights for improving resource allocation and policy formulation.

3. Methodology

Methodology denotes the structured framework that guides the overall approach and model employed to conduct a research study. It provides a comprehensive enlightenment of the selection of study region, data collection procedures, sample and sampling techniques, model specification, profitability analysis and different analytical elements employed to achieve the objectives of the research. In other words, methodology serves as the blueprint of the research by guiding how data are gathered, processed and analyzed to ensure consistency and validity of the result.

3.1 Selection of Study Area

The research was conducted in the northern region of Bangladesh, one of the country's major maize-producing zones. The districts of Nilphamari and Rajshahi were purposively selected due to their favorable agro-climatic conditions and dominance in maize cultivation. Moreover, the researcher possesses a thorough understanding of the local language, lifestyle, cultural beliefs and socio-economic characteristics of the selected Upazila within these districts. Additionally, to the best of the researcher's knowledge, no prior study of this nature has been conducted in these areas. These areas represent all types of farmers, like small, medium, and large-scale maize farmers using modern agricultural technologies. Dimla Upazila and Domar Upazila were selected from Nilphamari District, and Godagari Upazila and Tanor Upazila were selected from Rajshahi District as the study area.

3.2 Sampling Technique

A multistage sampling technique was employed where maize-dominant Upazilas were selected purposively, followed by random selection of villages and farmers. At the first stage, maize-dominant Upazilas were selected from each district. At the second stage, two villages were chosen randomly from each Upazila. Finally, 100 maize farmers were selected proportionately for the interview. The sample size was considered adequate for statistical analysis and model estimation, as it satisfies commonly accepted requirements for econometric analysis.

3.3 Data Collection

For this research, primary and secondary data sources were employed. Primary data were acquired by a systematic and pre-tested questionnaire by performing face-to-face interviews during the 2024–2025 production seasons. Socioeconomic traits, land use, input costs, production and returns were all included in the data. Secondary data were gathered from pertinent reports of the Bangladesh Bureau of Statistics (BBS), Department of Agricultural Extension (DAE), journals and previous research works.

3.4 Specification of the Model

To quantify the profitability of maize production here we used descriptive statistics. The following are some definitions of the variables used:

Hired Labor Cost: Hired labor cost refers to payments made to external workers for agricultural activities when household labor is insufficient. These activities include land preparation, planting, weeding, fertilizer and pesticide application, irrigation, harvesting and post-harvest operations. It reflects the extent of dependence on hired labor and influences production efficiency and profitability.

Machinery Cost: Machinery cost represents expenses incurred for using agricultural machinery in maize production, including tractor or power tiller services for land preparation, threshers for shelling, and mechanical sprayers for pesticide application. It may also include fuel, lubricants and maintenance costs, indicating the level of mechanization in production.

Plowing Cost: Plowing cost refers to expenditures for land preparation activities such as initial tillage, deep and cross plowing, and leveling to ensure a suitable seedbed. Farmers typically pay tractor or power tiller operators on an hourly or per-acre basis. This cost is essential for proper soil preparation and crop establishment.

Seed Cost: The cost of buying maize seeds, whether local, hybrid, or high-yielding varieties (HYV) is included in the seed cost. It represents the quantity of seed used and the price per kilogram. Good yields require high-quality seeds, and farmers may also have to pay extra for transportation or treatment (such as fungicide coating). Seed cost has a significant impact on both crop yield and overall profitability.

Irrigation Cost: Irrigation cost consists of all expenditures connected to supplying appropriate water throughout the crop-growing period. This may include pump rental expenses, fuel or power for operating irrigation pumps, payment to irrigation water suppliers, and the cost of pipelines, hoses, and canal water fees.

Pesticides Cost: Pesticides cost comprises all spending on chemicals used to control insects, fungi, weeds, and other pests damaging maize. This incorporates insecticides, herbicides, fungicides, and spraying materials. The pricing also includes payment for spraying labor or machinery hire. This expenditure is crucial to preserving crop health since effective pest control is essential to avoid output losses.

Fertilizer Cost: Both chemical fertilizers (such as urea, DAP, TSP, mop, gypsum, zinc, etc.) and organic fertilizers (such as compost and manure) are integrated in fertilizer costs. Fertilizers are vital for promoting soil fertility and ensuring high yields. This variable is decisive in profitability analysis since changes in fertilizer application rate, type, and price have a direct impact on production costs and output.

Harvest and Transport Cost: All of the costs related to harvesting the maize crop and moving it to the homestead, storage facility, or neighborhood market are included in this cost category. It could comprise labor costs for manual harvesting, the price of loading and assembling produce, the cost of renting a car or van, and the cost of fuel for transportation.

Other Costs: Other production costs encompass incidental or indirect charges not covered in the other categories. These could contain the cost of renting or leasing land, the cost of small equipment (such as tarpaulins, baskets, and rope), interest on borrowed money, the cost of a mobile phone for market information, storage costs, and unforeseen costs (such as equipment repair or emergency pest control). These variable measures hidden or additional expenses that influence total production expenditure and overall profitability.

The Cobb-Douglas production function is used to illustrate the relationship between output and inputs utilized in maize production due to its strong theoretical foundation and extensive application in econometric studies (Kiron and Islam, 2023). The following is the study's empirical model:

$$Y_i = \beta_0 X_{1i}^{\beta_1} X_{2i}^{\beta_2} X_{3i}^{\beta_3} X_{4i}^{\beta_4} X_{5i}^{\beta_5} X_{6i}^{\beta_6} X_{7i}^{\beta_7} X_{8i}^{\beta_8} X_{9i}^{\beta_9} e^{u_i} \qquad (1)$$

This equation can be linearized in the logarithmic form as below:

$$lnY_i = ln\beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i} + \beta_4 lnX_{4i} + \beta_5 lnX_{5i} + \beta_6 lnX_{6i} + \beta_7 lnX_{7i} + \beta_8 lnX_{8i} + \beta_9 lnX_{9i} + u_i \qquad (2)$$

where,
$\boldsymbol{Y_i}$ = Gross revenue (GR) from maize farming (kg/acre) of the ith farmer;
$\boldsymbol{X_1}$ = Hired Labor Cost (Tk./Bigha);
$\boldsymbol{X_2}$ = Machinery Cost (Tk./Bigha);
$\boldsymbol{X_3}$ = Plowing Cost (Tk./Bigha);
$\boldsymbol{X_4}$ = Seed Cost (Tk./Bigha);
$\boldsymbol{X_5}$ = Irrigation Cost (Tk./Bigha);
$\boldsymbol{X_6}$ = Pesticides Cost (Tk./Bigha);
$\boldsymbol{X_7}$ = Fertilizer Cost (Tk./Bigha);
$\boldsymbol{X_8}$ = Harvest transport Cost (Tk./Bigha);
$\boldsymbol{X_9}$ = Other cost (Tk./Bigha);
$\boldsymbol{ln}$ = Natural logarithm;
$\boldsymbol{\beta_0}$ = Constant/Intercept term;
$\boldsymbol{\beta_1}, \boldsymbol{\beta_2}, \ldots, \boldsymbol{\beta_9}$ = Production coefficients of the respective variable
$\boldsymbol{u}$ = error term

We estimate the parameters of this model using the Ordinary Least Squares (OLS) approach.

3.5 Method of Profitability Analysis

The cost-benefit (cost-return) analysis is one of the common techniques for measuring and contrasting the profitability of various agricultural cultivation (Kiron and Islam, 2023). In our study, we used the following formula for estimating the profitability of maize farming:

$$\text{Profit}, \pi = \text{GR} - \text{TVC} - \text{TFC} \qquad (3)$$

where,
π = Profit from maize production (Tk/Bigha);
GR = Gross return from maize production (Tk/Bigha);
TVC = Total variable cost (Tk/Bigha);
TFC = Total fixed cost (Tk/Bigha).

Definitions of these variables are discussed below:

Gross Return (*GR*): The gross revenue is the sum of all maize revenue and straw revenue from producing maize.

Total Variable Cost (*TVC*): The cost of all variable factors used in production is referred to as the total variable cost. In our study, TVC encompasses the whole value of the costs connected with plow, irrigation, hired labor, machinery, seed, pesticides, fertilizer, harvest, transport, and other costs.

Total Fixed Cost (*TFC*): TFC includes both land use cost and family labor cost.

Land Use Cost: Land usage cost is the opportunity cost that happens because of planting maize on the land. This is mostly a rental expense, meaning that if a farmer did not cultivate the land and instead leased it to other farmers, he would earn a specific amount of rent.

Family Labor Cost: Family labor cost refers to the imputed value of labor contributed by household members in maize production on their own land. It represents the opportunity cost of family labor used in farming activities.

Total Cost (*TC*): In this study, the total cost is the sum of TVC and TFC. Mathematically-

$$TC = TVC + TFC \qquad (4)$$

4. Results and Discussion

4.1 Socioeconomic Characteristics

This section describes the study's conclusions and provides a thorough analysis of the data. It is divided into three main parts. The first section outlines the respondents' demographics and socioeconomic circumstances. The second part shows the estimated findings of the Cobb-Douglas production function study. The third component assesses the profitability of maize growing in the study area. The key conclusions and their consequences for the study are summarized in the section's conclusion.

Distribution by Age: Table 1 shows that the majority of farmers are within the working-age group, indicating active labor participation.

Table 1. Age Distribution of Maize Farmers

Age Group (Years)	Frequency	Percentage (%)
0–14	0	0.0
15–64	93	93.0
64+	7	7.0
Total	100	100.0

Source: Author’s Survey, 2025

Distribution by Gender: Table 2 demonstrates that all of the farmers in the study region are men (100%) in terms of gender. The study area consequently lacks any female farmers.

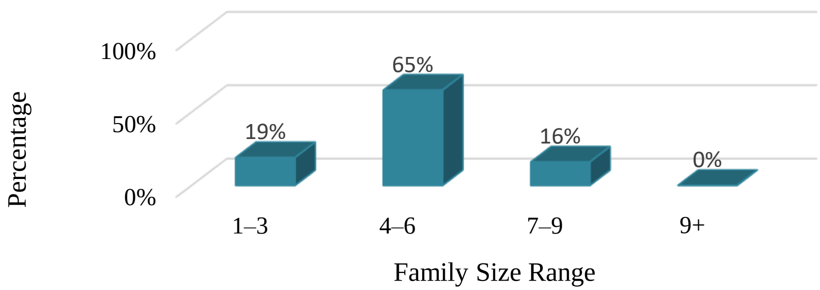
Table 2. Gender Distribution of the Farmers

Gender	Frequency	Percentage (%)
Male	100	100 .0
Female	0	0 .0
Total	100	100 .0

Source: Author's Survey, 2025

Distribution by family size: Figure 1 presents family size distribution among maize farmers in Northern Bangladesh. Most households (65%) have 4–6 members, followed by 1–3 members (19%) and 7–9 members (16%), with none exceeding nine. Family size affects profitability as medium-sized households can supply adequate family labor, reducing hired labor costs, while smaller or larger families may face labor or resource constraints.

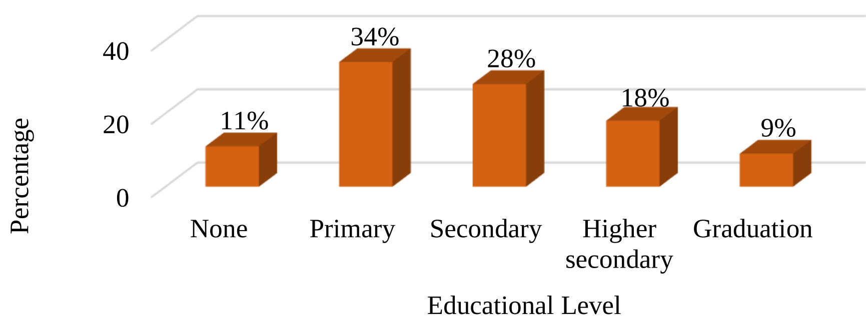
Figure 1. Family Size Distribution of Maize Farmers



Source: Author's Survey, 2025

Distribution by Educational Level: Figure 2 shows the educational profile of maize farmers. Most have at least basic literacy with 34% completing primary education, 28% secondary and 18% higher secondary. Only 9% hold a postsecondary degree while 11% have no formal schooling. Overall, the findings expresses that basic education is common likely supporting better adoption of farming strategy and informed management decisions.

Figure 2. Distribution of Respondents by Educational Level



Source: Author's Survey, 2025

Distribution by Farmer Type: Table 3 displays the distribution of farmers by landholding. Owner farmers, cultivating their own land, form the majority (67%) and typically have greater control over management and inputs.

Table 3. Farmer Type Distribution of Maize Farmers

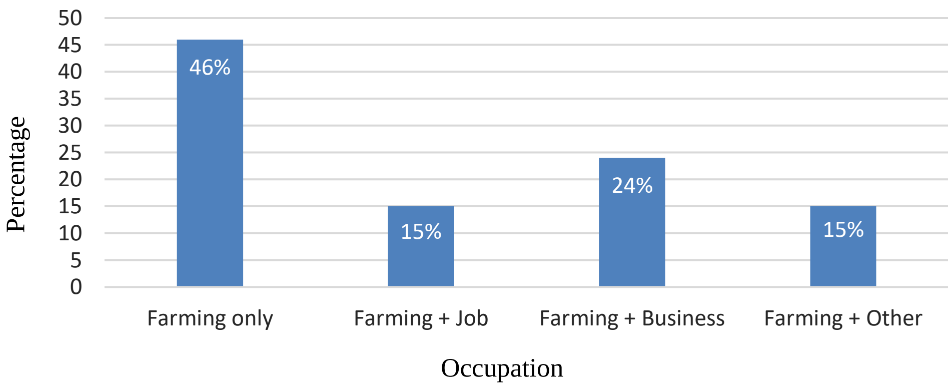
Farmer Type	Frequency	Percentage (%)
Owner Farmer	67	67
Owner-Tenant	25	25
Tenant Farmer	8	8
Total	100	100

Source: Author's Survey, 2025

Owner-tenant farmers (25%) cultivate both owned and leased land, expanding production but incurring rental costs. Tenant farmers (8%) rely solely on leased land, facing higher costs and limited decision-making, which may lessen profitability.

Distribution by Occupation: As part of the socio-economic profile of the respondents, Figure 3 shows that 46% of the farmers depend solely on agriculture for their livelihood. This indicates a strong reliance on maize farming, where profitability directly influences their household income and overall well-being. The remaining farmers diversify their income: 15% engage in farming along with a job, 24% combine farming with business activities and another 15% pursue other forms of work. This diversification suggests that many households adopt multiple income sources to manage risk and stabilize their financial condition.

Figure 3. Occupational Distribution of Respondents



Source: Author's Survey, 2025

Distribution by Farming Experience: Approximately half of the farmers (48%) are relatively new cultivators with one to five years of experience, 36% of farmers have six to ten years of experience (Table 4).

Table 4. Distribution of Farmers by Farming Experience

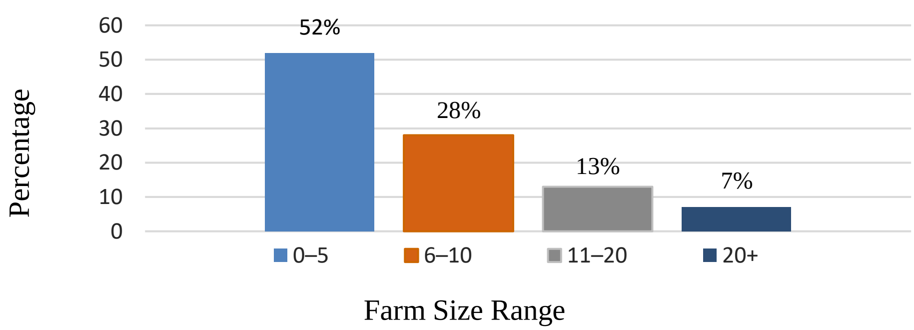
Experience Range (years)	Frequency	Percentage
1–5	48	48
6–10	36	36
10+	16	16
Total	100	100

Source: Author's Survey, 2025

Just 16% of farmers have more than ten years of experience, which indicates that they are highly skilled and knowledgeable about marketing tactics, input management, and maize cultivation. This variation in experience draws attention to its possible impact on labor usage, farm management techniques, and overall profitability.

Distribution by Farm Size: The distribution of maize farmers in Northern Bangladesh by farm size is shown in Figure 4. Smallholder farming predominates in the area evidenced by the majority of farmers (52%) operating 0–5 Bigha, 28% of farmers have medium-sized farms with 6–10 Bigha, while 13% have larger, more resource-intensive farms with 11–20 Bigha. Just 7% run farms of more than 20 Bigha. This distribution depicts that small and medium-sized farmers produce the majority of the maize which directly affects labor allocation, input utilization and profitability.

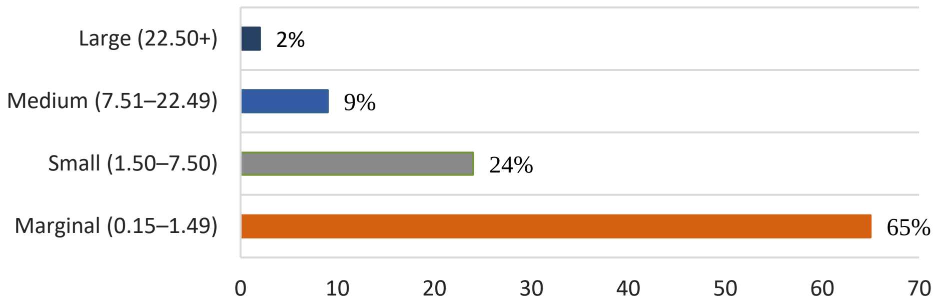
Figure 4. Distribution of Farmers by Farm Size



Source: Author's Survey, 2025

Distribution by Maize Land Size: The distribution of maize producers by landholding size in Northern Bangladesh is displayed in Figure 5. The majority (65%) grow marginal plots (0.15–1.49 Bigha), demonstrating the preponderance of small-scale maize agriculture (Kiron & Islam, 2023). 24% of farms are small (1.50–7.50 Bigha), while 9% are medium (7.51–22.49 Bigha). Merely 2% run huge farms (≥22.50 Bigha). This distribution represents that smallholders dominate maize production, which has a big impact on labor allocation, input utilization and profitability.

Figure 5. Distribution of Farmers by Maize Land Size



Source: Author’s Survey, 2025

Distribution by Loan: The distribution of maize farmers in Northern Bangladesh according to loan status is shown in Table 5. The overwhelming majority of farmers (89%) did not take out a loan, suggesting that the majority of maize growers rely on their own savings or family resources to produce their crop. Just 11% of respondents said they had taken out loans, indicating either a lack of formal credit availability or a reluctance to take on debt. The use of inputs, investments in agricultural technologies, and overall productivity may all be directly impacted by this financial behavior.

Table 5. Distribution of Farmers by Loan Status (n = 100)

Loan Status	Frequency	Percentage (%)
No	89	89
Yes	11	11
Total	100	100

Source: Author’s Survey, 2025

Distribution by Loan Interest: The distribution of maize farmers in Northern Bangladesh according to loan interest payments is exposed in Table 6.

Table 6. Distribution of Farmers by Amount of Interest Paid on Loans (BDT)

Interest Amount (BDT)	Frequency	Percentage (%)
0	89	89
3,000	4	4
4,000	1	1
5,000	6	6
Total	100	100

Source: Author’s Survey, 2025

The majority of farmers (89%) did not receive loans or relied on interest free sources of finance and therefore incurred no interest cost. A small percentage of farmers (11%) paid interest between 3,000 and 5,000 BDT suggesting that they borrowed little money with interest from official or unofficial sources. This pattern present that most maize farmers have relatively easy entrance to credit and low borrowing costs, which may limit their ability to invest in technologies and inputs for maize farming.

Distribution by Extension Services: The distribution of maize farmers in Northern Bangladesh according to their access to agricultural extension services is represented in Table 7. Just 34% of farmers reported receiving extension support compared to 66% who said they had no access. This suggests that a sizable percentage of farmers are not adopting modern maize cultivation techniques, technical advice, or training.

Table 7. Distribution of Farmers by Access to Extension Services

Access to Extension Services	Frequency	Percentage (%)
No	66	66
Yes	34	34
Total	100	100

Source: Author's Survey, 2025

4.2 Profitability Analysis of Maize Cultivation

This section explains how much farmers earn from maize after covering all production costs.

Total variable cost (*TVC*): In northern Bangladesh, the average Total Variable Cost (TVC) of growing maize was Tk. 19,406.6 per Bigha and it accounts for the majority of production costs. TVC comprises expenditures like hired labor, operating machinery, plowing, buying seeds, irrigation, applying fertilizer and pesticides, harvesting and transportation that are directly correlated with output levels.

Total Fixed Cost (*TFC*): A Total Fixed Cost (TFC) of Tk. 7,716.8 per Bigha is incurred by maize producers in addition to variable costs. Fixed costs included land usage fees and the imputed value of family work is not affected by the volume of production in contrast to variable costs. Regardless of the size of cultivation or the actual output attained, these expenses reflect the initial cash outlay required to run the farm. The structural obligations of maize farming, such as labor resources and land availability serves as the cornerstone of production activities are decorated by the existence of fixed costs.

Total Gross Revenue (*GR*): The sale of both maize grain and straw results in a significant Gross Revenue (GR) for maize production averaging Tk. 44,185.7 per Bigha. This revenue is an outcome of both robust market demand and acceptable yields. The region's farmers find maize to be an economically appealing crop due to its high GR, and it encourages them to invest in productivity-boosting inputs and sophisticated production techniques in addition to generating income.

Profit: The average profit per Bigha is Tk. 14,462.6 after subtracting the entire production cost (TVC + TFC) from the gross revenue. With returns that cover all costs and leave a surplus for household consumption or reinvestment, the positive profit margin attests to the financial viability of maize cultivation. The profit level further supports maize's status as a dependable source of income for farmers by representing resilience despite modest changes in input costs or market prices.

The findings show that maize gives good returns because farmers get high yields while spending less on inputs. Overall, the investigation proves that maize farming is a profitable and dependable source of income for most farmers in the study area. The following Table 8 shows the profit quantity from maize production.

Table 8: Profitability Analysis of Per Bigha Maize Farming in Northern Bangladesh

Variable	Mean	Std. Dev.	Min	Max
Hired Labor	1967.5	778.479	0	3500
Machinery	669.3	100.717	500	900
Plowing	1508.3	106.44	1250	1900
Seed	1499.2	122.925	1200	1900
Irrigation	1453.7	241.969	1100	2000
Pesticides	1275.4	484.629	750	2100
Fertilizer cost	7547.6	336.815	6730	8190
Harvest transport	3230.7	335.882	2500	3900
Other cost	254.9	71.131	100	500
TVC	19406.6	1498.487	15400	21980
Family Labor	1533.8	922.738	0	5300
Land use	6183	758.661	5000	8000
TFC	7716.8	857.558	5900	10400
Maize Revenue	41996.3	3643.418	33600	48300
Straw Revenue	2189.4	120.209	1900	2400
GR	44185.7	3565.474	35850	50300
Profit	14462.6	2144.018	8680	20200

4.3 Determinants of Gross Revenue (Cobb–Douglas Results)

Understanding how various production costs influence maize producers' gross income is made easy using regression analysis. The model explains 84.6% of the variation in farmers' gross revenue ($R^2 = 0.846$), indicating that the selected cost variables effectively account for the key determinants of revenue variability.

The estimation is statistically reliable with 100 observations and the F-value of 55.123 with a p-value of 0.000 validates the overall model significance, demonstrating that the variables collectively have a significant impact on gross sales. Additionally, the BIC (1777.28) and AIC (1751.22) point out that the model is well-fitted with no unnecessary complexity.

Table 9. Regression Results of Cobb-Douglas Production Function

GR	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Hired Labor	0.657	0.272	2.42	0.018	0.117	1.197	**
Machinery	1.439	0.704	2.04	0.001	6.655	14.222	***
Plowing	-2.775	1.53	-1.81	0.073	-5.815	0.265	*
Seed	9.674	1.395	6.93	0.000	6.902	12.445	***
Irrigation	0.889	1.049	0.85	0.399	-1.196	2.973	
Pesticides	4.135	0.641	6.45	0.002	2.861	5.408	***
Fertilizer cost	0.492	0.474	1.04	0.303	-0.45	1.434	
Harvest transport	-0.287	0.461	-0.62	0.534	-1.202	0.628	
Other cost	-1.361	2.352	-0.58	0.564	-6.034	3.313	

Mean dependent var	44185.700	SD dependent var	3565.474
R-squared	0.846	Number of obs	100
F-test	55.123	Prob > F	0.000
Akaike crit. (AIC)	1751.224	Bayesian crit. (BIC)	1777.276

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Starting with hired labor cost, the coefficient is 0.657 and its significance at the 5% level (p = 0.018) expresses that labor plays a consequential role in improving farm output. In practical terms, every 1-unit increase in hired labor cost is associated with about a 0.66-unit increase in revenue consistent with the idea that timely and adequate labor helps producers to manage their fields more effectively. Machinery cost stands out as one of the most influential variables with a large coefficient of 10.439 supported by a very high t-value (5.48) and a p-value of 0.000. This indicates that investment in machinery positively contributes to revenue generation, underscoring the importance of mechanization in modern maize production.

Pesticide cost also significantly contributes to revenue with a coefficient of 4.135 and a very strong t-value (6.45). This implies that better pest management leads to healthier crops and less yield damage, ultimately raising gross revenue. On the other hand, irrigation cost has a small and statistically insignificant coefficient of 0.889 (p = 0.399). This suggests that irrigation practices or expenditures may be similar across farms, making it difficult for irrigation cost differences to translate into revenue variations. Fertilizer cost also indicates no significant effect with a coefficient of 0.492 and a p-value of 0.303, which may reflect inefficiencies arising from inappropriate application, imbalanced nutrient use, or diminishing returns associated with excessive fertilizer input. Moreover, Harvest transport cost has a negative but insignificant coefficient (–0.287; p = 0.534), suggesting that transport-related expenses are not directly tied to crop productivity. Likewise, the “other costs” category has a coefficient of –1.361 with no statistical significance (p = 0.564) because this category contains diverse operating expenses that do not consistently contribute to revenue generation.

4.3.1 Diagnostic Tests and Model Validation

To validate the reliability of the estimated model, diagnostic tests for multicollinearity and heteroscedasticity were performed. The results of the Variance Inflation Factor (VIF) analysis (see Table 10) indicate that all VIF values are well below the critical threshold of 10, with a mean VIF of 1.925. This confirms that multicollinearity is not a serious concern in the model.

Table 10. Multicollinearity Test

	VIF	1/VIF
Pestisides	4.446	.225
Irrigation	2.971	.337
Hired Labor	2.063	.485
Machinery	1.696	.59
Seed	1.356	.738
Other cost	1.291	.775
Plowing	1.223	.818
Fertilizer cost	1.176	.85
Harvest transport	1.103	.906
Mean VIF	1.925	

Furthermore, the Breusch–Pagan/Cook–Weisberg test for heteroscedasticity was conducted. The test result ($\chi^2 = 2.79$; $p = 0.095$) fails to reject the null hypothesis of constant variance at the 5% significance level, indicating that heteroscedasticity is not a major issue. Therefore, the estimated coefficients can be considered reliable and efficient for interpretation.

5. Conclusions and Policy Recommendations

The study provides a comprehensive understanding of the socio-economic characteristics, production efficiency and profitability of maize cultivators in Northern Bangladesh. The findings expose that maize cultivation is predominantly carried out by small and marginal farmers who operate limited landholdings and rely heavily on family labor. Although maize cultivation generates substantial gross revenue and ensures a profitable return, with an average profit of Tk. 14,462.6 per Bigha—farmers continue to face several structural and operational challenges.The Cobb-Douglas production function results underline that key inputs such as machinery, seeds, pesticides, and hired labor significantly influence gross revenue, emphasizing the importance of quality inputs and modern production practices. However, inefficient use of plowing and fertilizers, along with high production costs, limits potential yield gains. The study also identifies major constraints, including limited access to credit, inadequate extension services, high input prices, pest prevalence, and labor shortages, all of which hinder productivity and reduce the economic stability of maize farmers.

The socio-economic profile of the households in the study area reflects a favorable demographic structure with 93% belonging to the productive age group (15–64 years). Most farmers live in medium-sized households of 4–6 members and possess primary to secondary levels of education while only a small proportion have completed higher studies. The farming structure is dominated by smallholders as the majority cultivates 0–5 Bigha of land and 65% operate marginal maize plots. Owner farmers constitute the largest share (67%) whereas owner-tenants and tenants represent smaller proportions. Farming experience is generally modest with nearly half of the respondents having 1–5 years of exposure to maize cultivation and only 16% having more than ten years. Access to institutional credit remains limited evidenced by the fact that 89% did not pay any loan interest during the production period. Similarly, agricultural extension support is inadequate with 66% of farmers reporting no access to technical advice or training. Most households rely primarily on family labor that is supplemented by hired labor when necessary. The Cobb–Douglas production function exhibits that hired labor, machinery, seed and pesticide costs significantly enhance gross revenue while irrigation, fertilizer, plowing and harvest-transport costs express non-significant or negative effects. The model demonstrates strong explanatory power and it is accounting for 84.6% of the variation in gross revenue. Profitability analysis indicates that maize cultivation is economically viable generating an average profit of Tk. 14,462.6 per Bigha under prevailing production conditions. Despite this profitability, challenges such as limited extension contact, low credit availability and prevalence of small landholdings continue to constrain the potential for greater productivity and income generation in the study area.

The following policy changes are suggested to boost profitability, increase production efficiency and fortify farmers' economic resilience in light of the major obstacles and difficulties experienced by maize farmers in Northern Bangladesh:

I. Ensuring Fair and Stable Maize Prices: The government should augment procurement efforts and set guaranteed minimum support prices for maize to avoid distress sales during the harvest season. Farmers would earn more stable and equitable pricing if they relied less on middlemen gratitude to village-level collecting centers, digital trading platforms, and enhanced market intelligence systems.

II. Reducing Production Costs through Targeted Input Subsidies: Rising fertilizer, insecticide, labor and irrigation operating cost are a common problem for maize growers. It would greatly lower production costs and increase profitability to implement targeted subsidy programs, particularly for tiny and marginal farmers, together with transparent and monitored input distribution.

III. Enhancing Climate Resilience and Risk Management: Droughts, storms and erratic rainfall are familiar in northern Bangladesh and have a detrimental force on maize production. Farmers might lower climate-related risks by rising weather advisory systems, encouraging drought-tolerant cultivars and creating climate-smart farming methods. Crop insurance particularly designed for maize growers can help protect their earnings.

IV. Expanding Access to Affordable Credit: For maize growers a significant hindrance is still a lack of capital. Access to credit would be enhanced via streamlined loan application processes, lower collateral requirements and greater participation from agricultural banks and microfinance organizations. Digital loan distribution and mobile banking could modernize and improve the procedure for farmers.

V. Strengthening Training and Extension Services: It is crucial to receive regular training on maize cultivation techniques including insect control, effective fertilizer use, soil fertility management and contemporary planting procedures. Increasing cooperation between extension agents, agricultural colleges and non-governmental organizations would increase farmers' technical expertise and boost output.

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