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Profitability Analysis and Input Use Efficiency of Maize Cultivation in Selected Areas of Bangladesh

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Abstract: Maize farmers in Bangladesh are unaware of the benefits of maize cultivation due to a lack of information and concept generation. The objectives of this study were to estimate the cost and return of maize cultivation; assess the input use efficiency of maize cultivation for marginal, small, and medium maize production to address the problems; and suggest policy recommendations. The study was conducted in six villages in the Chuadanga district in Bangladesh. Data were collected by using an interview schedule from the purposively selected 80 respondents during 1–30 June 2018. After analyzing the data, the total cost of production was Tk. 124,495, Tk. 134,335, and Tk. 140,579 for marginal, small, and medium maize production, respectively. Per hectare gross return was Tk. 213,997, Tk. 204,972, and Tk. 197,163, and per hectare gross margin was Tk. 120,478, Tk. 104,748, and Tk. 92,516. Net return was calculated by deducting the gross cost from the gross return, and these were Tk. 89,502, Tk. 70,637, and Tk. 56,584. The benefit–cost ratio was 1.72, 1.53, and 1.40 for marginal, small, and medium maize production, respectively. From Cobb–Douglas production function analysis, it was observed that the coefficients of land preparation cost, irrigation cost, urea, and MoP cost were significant at different levels of probability for marginal, small, and medium maize production, and the coefficients of human labor cost, seed and pesticide used was not significant while the coefficients of TSP was negative and significant. This study also identified some of the problems associated with maize production. The findings revealed that the high price of inputs was the most acute problem, followed by a lack of technical knowledge and shortage of human labor at the critical stage, and declining soil fertility was the last obstacle that stood in the way of maize production in the study area.

Keywords: maize production; profitability; cost estimation; input use; soil fertility

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1. Introduction

Bangladesh is the world's eighth-most populous country, with a total population of 161 million people, a population growth rate of 1.36 percent, and a population density of 1109 people per square kilometer [1]. Bangladesh is primarily an agricultural country constrained by crop production. More than 70% of the country's population and 45.10% of its labor force are directly or indirectly dependent on agriculture, which contributes 14.10% to GDP [2]. Bangladesh experiences a subtropical monsoon climate well-known for producing a wide range of tropical crops, including rice, wheat, maize, jute, pulses, oilseeds, sugarcane, and others. Maize is one of the most important cereal crops and one of the most important crops in the world. Although maize is a new crop, Bangladesh's fertile soils and subtropical monsoonal climate make it ideal for maize cultivation. Prior to Bangladesh's independence in 1971, maize was only grown in a few tribal areas of the Southeastern Chittagong Hill Tracts. It was planted on approximately 147,996.59 ha of land in the 2017–2018 cropping season, with national average yields of around 5.7 tons per ha, producing well over a million tons of maize grain annually [3].

In Bangladesh, maize is grown in two seasons: rabi and kharif-I. The best soil for maize cultivation is non-waterlogged soil, such as sandy loam or loamy soil. The ideal temperature range for maize cultivation is 28 °C to 34 °C [4,5]. Timely sowing is required for higher yields. Rice has traditionally been the most important carbohydrate source for most farm families in South Asia, but with rising affluence and preferences for fish and poultry protein in diets, maize production has increased from 20.51 to 35.47 Mt in the last decade, with grain sold primarily to the feed industry [6]. Maize adoption has been particularly high in Bangladesh, where it was cultivated on approximately 1500 ha in 1984, but the area rapidly increased to approximately 0.20 ha in 2007–2008 and 0.36 ha in 2012–2013, due largely to the replacement of pulses, oilseeds, and wheat [6]. Maize is a highly productive and nutritious crop that is used as human food, poultry feed, and livestock fodder [7]. In terms of protein, phosphorus, and carotene content, maize outperforms rice. The fat and mineral content are also higher. It contains a lot of vitamin B and trace elements [8].

Maize (*Zea mays*) is the world's most widely grown cereal crop and an important cash crop for the industry. Maize ranks second to wheat in production among the world's cereal crops. Nonetheless, maize ranks first in Latin America and Africa among developing countries but third in Asia after rice and wheat [9]. As the global demand for maize crops has shifted, particularly in developing countries, its requirement will rise from 282 million tons in 1995 to 504 million tons in 2020 [10]. According to a recent US Department of Agriculture (USDA) report, farmers in Bangladesh earn more than USD 2275 for every hectare of maize planted. Boro earns them USD 1081 for a USD 1319 investment, making it a loss-making project, according to the company. Wheat farming is also less profitable than maize farming. According to the USDA report "Bangladesh: Grain and Feed Annual 2016", farmers can earn slightly more than USD 823 per hectare of wheat farming with an investment of USD 663. "Maize sales have a 2.4 times higher gross margin per hectare than wheat or rice. Maize is also less susceptible to pests and diseases", according to a UN Food and Agriculture Organization (FAO) report [11].

In 2016–2017, total cereal production (rice, wheat, and maize) was 38.14 million tons, while total maize production was only 3.03 million tons. In Bangladesh, maize accounts for 8% of total cereal production. Maize production is expected to be 3.29 million tons in 2017–2018 [2]. In 2016–2017, the district of Chuadanga produced 474,828 M. tons of maize. During 2016–2017, the area under kharif maize cultivation was 108 thousand hectares, with a total production of 303 M. tons, and the area under rabi maize cultivation was 49,155 thousand hectares, with a total production of 474,525 M. tons [3]. As a result, rabi maize accounted for 99.9% of total maize production in the Chuadanga district. In 2016–2017, Bangladesh's total maize production was 3,025,392 (M. tons), with Chuadanga district accounting for approximately 16% of total maize production [3]. In Bangladesh, maize is the third most important grain crop. It can be grown throughout the year in all three seasons. Dinajpur, Chuadanga, Takurgaon, Lalmonirhat, Rajshahi, Kushtia, Rangpur, and Bogra have been identified as more progressive in maize production, with higher rates of growth. Rangpur division produced the most maize (1,378,913 M. tons), with the Khulna division coming in second (719,184 M. tons). Maize production in the Khulna division is approximately 24% of total country production (2,686,832 M. tons), with the Chuadanga district alone accounting for 66% (474,828 M. tons) of total Khulna division production. Winter maize (rabi maize) is found to be the most prevalent, accounting for 89% of total maize production in the country [2].

Maize is widely used as a primary ingredient in poultry and fish feed. Maize is also used directly for human consumption, as well as in industrially processed foods and non-food products such as starches, acids, and alcohol. Maize is an important crop in Bangladesh's rice-based cropping system. The maize industry is a promising one, and its expansion is linked to national GDP. It has a significant impact on the nationalized economy. A small number of socio-economic studies on maize cultivation in Bangladesh revealed that it is a more profitable crop than rice [12,13] and mustard [14]. According to Rahman et al. [15] and Rahman et al. [16], maize production is not only profitable, but maize farmers' technical and economic efficiency is much higher than that of rice and wheat farmers. Although Rahman et al. [16] stated that the gross return is the primary motivator for selecting winter maize production in Bangladesh, it is unknown whether maize production is internationally competitive. Traditionally, maize was imported into Bangladesh, depleting valuable foreign currency reserves in the process. As a result, if maize is globally competitive, increasing maize production can effectively substitute for imports and save foreign currency. Bangladesh's land is also suitable for maize production. In fact, the fifth five-year plan (1997–2002) emphasized specific goals for achieving self-sufficiency in food grain production and increased production of other nutritional crops, allotting 8.9% of the total agricultural allocation to promote crop diversification. Crop diversification was also emphasized in the Poverty Reduction Strategy Paper (2005) [17] and the sixth five-year plan (2011–2015) [18]. According to the seventh five-year plan (2016–2020) [19], agricultural growth will be modest at 3.5% in 2020, as its main component, cereal, and commercial crops, appears to have reached a plateau of 1.4% growth for several years.

Bangladesh is one of the world's most populous countries. It is critical for Bangladesh to diversify crops in order to ensure food security as the population grows. Maize has a bright future in Bangladesh. It is one of our country's most important and fastest-growing cereals. The area under maize cultivation is also expanding. Agriculture employs a larger proportion of the population. As a result, crop diversification is critical for Bangladesh in order to ensure food security. However, farmers in Bangladesh are unaware of the benefits of maize production. They are also hesitant to invest in maize cultivation due to a lack of knowledge about maize production and marketing policy. In 2016–2017, Rabi maize accounted for 99.9% of total maize production in the Chuadanga district [3]. As a result, there were numerous research opportunities in the Chuadanga district for profitability analysis and input use efficiency in maize cultivation. Another justification for this study is to update information on maize profitability. It is critical to evaluate the alternative profitability of this investment in terms of 856 maize farming land and other resources. Additionally, maize is primarily consumed as poultry feed, though some dairy farms use maize as feed grains and its plants as green fodder for cattle. The country's demand for maize is increasing and is expected to rise further with the establishment of new poultry, dairy, and fish farms. Maize farmers, like other crop growers, are unaware of the input use efficiency of maize cultivation. Rural farmers are frequently subjected to risk and uncertainty.

Furthermore, maize accounts for more than 2.2% of the total cultivated land in Bangladesh [3]. Some studies [20,21] found that farmers could not achieve higher yields due to constraints that must be addressed urgently in the interest of farmers as well as the country. Although maize is one of Bangladesh's major grain crops, its production technologies have not been standardized in terms of science and economics. The nature of maize farmers' sensitivity to changes in input and output prices is unknown. This information is critical because Bangladeshi farmers must not only be more efficient in their production activities but also be responsive to market indicators in order to maximize productivity and profitability in order to ensure supply to the urban market [22] and increase farmers' welfare. Furthermore, the government of Bangladesh is attempting to diversify its agricultural sector beyond rice (i.e., wheat and maize) and noncereals (e.g., potatoes, vegetables, spices, etc.). The present study derived from the thesis of Rumana Biswas and the methods, results and discussion section also taken from the thesis work [23]. The current study on maize profitability and input use efficiency will be useful in developing appropriate policies to improve maize cultivation in Bangladesh. The objectives of this study were to estimate the cost and return of maize cultivation; assess the input use efficiency of maize cultivation for marginal, small, and medium maize production to address the problems; and suggest policy recommendations.

2. Materials and Methods

The survey method was used in the present study because it is assumed to have some advantages over the other methods. This method enables less time requirement and less cost, the result accomplished has wider applicability, and the method is usually more magnificent. However, the survey method also has some drawbacks.

2.1. Selection of the Study Area

Chuadanga district was selected as a study area because this district is one of the leading maize-producing areas of Bangladesh. Chuadanga Sadar Upazila and Damurhuda Upazila were selected from Chuadanga District as the study area. One union was selected from each upazila. A preliminary survey was conducted in three villages from each union. After a preliminary visit, six villages, namely Karpashdanga, Aramdanga, and Shubolpur from Karpashdanga union and Pirpur, Monirampur, and Rajapur from Alokdia union were selected as the locale of the study. Most of the farmers in these areas produced high-yielding varieties of maize and sold their products to different middlemen.

The main criteria behind the selection of the upazila were as follows:

- The selected upazila was a good maize-producing area;
- The researcher is familiar with the language, living, beliefs, and other socio-economic characteristics of the villages of this upazila;
- Previously such type of study was not conducted in this area.

2.2. Selection of the Sample and Sampling Techniques

A purposive sampling technique was applied for the study. It was not possible to conduct a farm business survey overlaying all farms. Here, sampling is taken for sample farms to cut down costs in terms of time and resources for the study. In total, 80 farmers were selected for the study. Among the 80 farmers, 10 were from Pirpur village, 15 were from Monirampur village, 15 were from Rajapur village, 10 were from Karpashdanga village, 15 were from Aramdanga village, and 15 were from Subolpur village, respectively (see Table 1; see Figure 1). Farm size was arbitrarily classified on the basis of the land where they produced maize and other crops. Farmers with 0.01–0.20 hectares of land were considered marginal farmers, 0.21–1.0 hectares were considered small farmers, and those with 1.01 hectares and above land were considered medium farmers [24].

Table 1. Distribution of sample farmers in the study area.

Upazila	Union	Villages	Maize Cultivars
Chuadanga Sadar	Alokdia	Pirpur	10
		Monirampur	15
		Rajapur	15
Damurhuda	Karpashdanga	Karpashdanga	10
		Aramdanga	15
		Subolpur	15
	Total		80

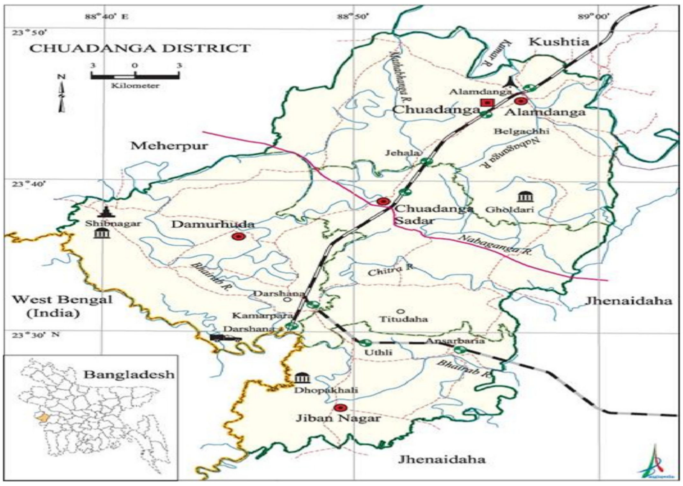

Figure 1. Map of Chuadanga District showing Chuadanga sadar and Damurhuda upazila in Bangladesh.

2.3. Period of Data Collection

Primary data are required for this study, and the researcher gathered the necessary information by interviewing the selected farmers. Data were collected using a structured questionnaire from 1 to 30 June 2018. Data were collected at that time because maize was harvested in April, and post-harvest management and selling were performed from April to May. Since the farmers of Bangladesh do not usually maintain records and accounts of their farm operations, they rely on their memory to give information.

Therefore, it is beneficial to collect information from respondents as early as possible after selling the maize.

2.4. Data Collecting Instruments

Both technical and socio-economic data were needed for this research.

The measures taken were:

- Built-in-check in the interview schedule;
- Field checking;
- Independent re-interviewing of the respondents.

2.5. Preparation of the Survey Schedule

The preparation of survey schedules is of crucial importance in this study. A comprehensive survey schedule was prepared to collect necessary information from the concerned respondent in such a way that all relevant information needed for maize cultivation could be easily obtained within the shortest possible time. The interview schedule was pretested to judge their suitability. After pretesting, the schedule was finalized. The final schedule included the following information:

- Identification of the farmer;
- Family size and composition, use of family labor, land holding pattern;
- Input and output-related information on maize cultivation at the farm level;
- Cost of human labor and material inputs for maize production;
- Problems of maize farmers;
- Suggestions according to the problems faced by the maize farmers.

2.6. Collection of Data

A farm management study usually involves the collection of information from individual farmers. There are various methods of collecting information from farmers. For the present study, the farm survey method was adopted for collecting data.

There are three main methods through which farm survey data can be gathered [25]. These are:

(1) Direct observation;
(2) Interviewing respondents;
(3) Records kept by the respondents.

In order to satisfy the objectives of the study, necessary data were collected by visiting each farm personally and by interviewing them with the help of a pretested interview schedule. Usually, most of the respondents do not keep records of their activities. Hence it is very difficult to collect actual data, and the researcher has to rely on the memory of the respondent. Before going to an actual interview, a brief introduction of the aims and objectives of the study was given to each respondent. It was narrated to the farmers that the study was purely academic. Farmers also stated the usefulness of the study in their farm business context. The question was asked systematically in a very simple manner, and the information was recorded on the interview schedule. When each interview was over, the interview schedule was checked and verified to be sure that the information on each of the items had been properly recorded. In order to minimize errors, data were collected in local units. These were subsequently converted into an appropriate standard unit.

In order to obtain reliable data, the researcher initially visited several times to introduce herself to the people of the study areas during the season. Secondary data were collected through literature and different publications from the Bangladesh Bureau of Statistics, Ministry of Finance, Bangladesh Bank (BB), etc.

2.7. Editing and Tabulation of Data

After the collection of primary data, the filled schedules were edited for analysis. These data were verified to eliminate possible errors and inconsistencies. All the collected data were summarized and scrutinized carefully. For data entry and data analysis, Microsoft Excel programs v.10 and SPSS software v.23 were used. It might be observed here that information was collected initially in local units, and after checking the collected data, it was converted into standard units. Finally, a few relevant tables were prepared according to the necessity of analysis to meet the objectives of the study.

2.8. Procedure for Computation of Costs

Farmers growing maize had to pay for various inputs used in the production process. The input items were valued at the current market price and occasionally at the government price in the area during the survey period or at the price at which farmers purchased. Farmers occasionally purchased hired labor, seed, fertilizer, manure, and pesticides from the market, and pricing these items was simple. Farmers, on the other hand, did not pay cash for some inputs, such as family labor. As a result, calculating the cost of production of these inputs was extremely difficult. The opportunity cost principle was applied in this case. In this study area, the following cost components were considered when calculating the production cost:

- Human labor;
- Land preparation/mechanical power cost;
- Seed;
- Manure;
- Fertilizer;
- Irrigation;
- Pesticides cost;
- Interest in operating capital;
- Land use.

2.8.1. Cost of Human Labor

Human labor cost was one of the most important and largest cost items of maize production in the study area. It is required for different farm operations such as land preparation, weeding, application of fertilizer and insecticide, harvesting and carrying, etc. Mainly two types of human labor were used in the study area, such as family labor and hired labor. Family labor includes the operator himself; the adult male and female, as well as children of a farmer's family; and the permanently hired labor. In order to determine the costs of unpaid family labor, the opportunity cost concept was used. In this study, the opportunity cost of family labor was assumed to be the market wage rate, i.e., the wage rate that the farmers actually paid to the hired labor. The labor that was appointed permanently was considered family labor in this study. In computing the cost of hired labor, actual wages were paid and charged in the case where the hired laborers were provided with meals; the monetary value of such payment was added to the cash paid. The labor was measured in a man-day unit, which usually consisted of 8 h a day.

In producing maize, human labor was used for the following operations:

- Land preparation/plowing/laddering;
- Fertilizing, weeding, and irrigation;
- Pest control;
- Harvesting, storing, and marketing.

2.8.2. Cost of Power Tiller and Laddering

Human labor and mechanical power were jointly used for land preparation. Power tiller and laddering cost was the summation of hired draft power and human labor. Hired power tiller and laddering costs were calculated by the prevailing market prices that were actually paid by the farmers.

2.8.3. Cost of Seeds

The costs of seed were calculated at the actual price paid by the farmers. It may be marked here that there was a variation in the cost per kilogram (kg) seed in the study area.

2.8.4. Cost of Manure

Manure may be used through purchase. The value of purchased manure was calculated at the prevailing market price.

2.8.5. Cost of Fertilizer

It is very important for maize cultivation to use the fertilizer in the recommended dose. In the study area, farmers used mainly three types of chemical fertilizer, i.e., urea, TSP (Triple Super Phosphate), and MoP (Muriate of Potash) for growing maize cultivation. The fertilizer cost was calculated according to the actual price paid by the farmers.

2.8.6. Cost of Pesticide

Most of the sample farmers used Vittaku, Furadan, Sunforan, Rijent, Dithane M-45, Thiovit 80 wp, and Rovral 50 wp for maize. The cost of these pesticides was calculated by the prices paid by farmers.

2.8.7. Cost of Irrigation

The cost of irrigation included the rental charge of the machine plus the costs of fuel. Someone rents/borrows only water from the shallow tube well (STW) owners by paying some charge.

2.8.8. Interest on Operating Capital

Interest cost was computed at the rate of 10% per annum. It was assumed that if farmers took loans from a bank, they would have to pay interest at the above-mentioned rate. Since all expenses were not incurred at the beginning of the production process, rather they were spent throughout the whole production period. The interest on operating capital was calculated by using the following standard formula [26].

$$\text{Interest on operating capital (IOC)} = \frac{Operating\ Capital \times Rate\ of\ interest \times Time}{2}$$

This actually represented the average operating costs over the period because all costs were not incurred at the beginning or at any fixed time. The cost was charged for a period of 6 months at the rate of Tk. 10 per annum.

2.8.9. Land Use Cost

The price of land was different for different plots depending on the location and topography of the soil. The cost of land used was estimated by the cash rental value of the land. In calculating land use cost, the average rental value of land per hectare for a particular year. In computing the rental value of the land used cost (LUC), it was calculated according to the farmer's statement.

2.9. Analytical Techniques

Both tabular and statistical tools were used for analyzing the data. Tabular tools are used for calculating profitability, average, percentage, total, etc. For multiple regression analysis, the Cobb–Douglas production function was also used to estimate the effects of key variables (Dillion and Hardaker) [14]. In the Cobb–Douglas production function, the regression coefficient directly shows production elasticity, and the sum of the production elasticities indicates whether the production process is increasing, constant, or decreasing returns to scale.

The Cobb–Douglas production frontier model was used for estimating the profitability of maize production in the study areas, and the model is given below:

$$Y = aX_1^{b1} \times aX_2^{b2} \times aX_3^{b3} \times aX_4^{b4} \times aX_5^{b5} \times aX_6^{b6} \times aX_7^{b7} \times aX_8^{b8} \times e^{ui}$$

In order to identify the factors affecting the gross return on maize production, the Cobb–Douglas production function used:

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + \ldots + b_n \ln X_n + ui$$

where:

- ln = Natural logarithm, Y = Gross yield (kg/ha), and X_1 = Cost of animal labor and power tiller (Tk/ha);
- X_2 = No. of human labor (man-days/ha);
- X_3 = Quantity of seed (kg/ha);
- X_4 = Cost of irrigation (Tk/ha);
- X_5 = Quantity of urea (kg/ha);
- X_6 = Quantity of TSP (kg/ha);
- X_7 = Quantity of MoP (kg/ha);
- X_8 = Cost of pesticide (Tk/ha);
- a = Constant or intercept term;
- b1, b2, b3, b4, b5, b6, b7, b8 = production coefficient of the respective input variable to be estimated;
- u_i = error term.

2.10. Profitability Analysis

Cost and return analysis is the most common method of determining and comparing the profitability of different farm households. In the present study, the profitability of maize cultivation is calculated as described in Section 2.10.1.

2.10.1. Calculation of Gross Return

Per hectare gross return was calculated by multiplying the total amount of products by their respective per-unit prices.

$$\text{Gross return} = \text{Quantity of the product} \times \text{Average price of the product}$$

2.10.2. Calculation of Gross Margin

Gross margin is defined as the difference between gross return and variable costs. Generally, farmers want maximum return over the variable cost of production. The argument for using the gross margin analysis is that the farmers are interested in obtaining returns over variable cost. The gross margin was calculated on a TVC basis. Per hectare, gross margin was obtained by subtracting variable costs from gross return.

That is:

$$\text{Gross margin} = \text{Gross return} - \text{Total variable cost}$$

2.10.3. Calculation of Net Return

Net return or profit was calculated by deducting the total production cost from the total return or gross return. That is:

$$\text{Net return} = \text{Gross return} - \text{Total cost}$$

The following conventional profit equation was applied to examine farmers' profitability level of maize-producing farms in the study areas.

$$\text{Net profit, } \pi = \Sigma\, PmQm + \Sigma\, PfQf - \Sigma\, (Pxi\ Xi) - TFC$$

where:

- π = Net profit/Net return from maize cultivation (Tk./ha);
- Pm = Per unit price of maize (Tk./kg);
- Qm = Total quantity of maize cultivation (kg/ha);
- Pf = Per unit price of other relevant maize (Tk./kg);
- Qf = Total quantity of other relevant maize (kg/ha);
- Pxi = Per unit price of i-th inputs (Tk.);
- Xi = Quantity of the i-th inputs (kg/ha);
- TFC = Total fixed cost (Tk.);
- i = 1, 2, 3, . . . , n (number of inputs).

2.10.4. Undiscounted Benefit–Cost Ratio (BCR)

The average return to each taka spent on production is an important criterion for measuring profitability. Undiscounted BCR was estimated as the ratio of gross return to the total cost per hectare.

$$\text{BCR} = \frac{Gross\ Return}{Total\ Cost\ Per\ Hectare}$$

2.11. Measurement of Input Use Efficiency

In order to test the input use efficiency, the ratio of marginal value product (MVP) to the marginal factor cost (MFC) for each input was computed and tested for its equality to 1, i.e., MVP/MFC = 1.

The marginal productivity of a particular resource represents the additional gross returns in value terms caused by an additional one unit of that resource, while other inputs are held constant. When the marginal physical product (MPP) is multiplied by the product price per unit, MVP is obtained. The most reliable, perhaps the most useful estimate of MVP is obtained by taking resources (Xi) as well as gross return (Y) at their geometric means.

That is:

$$r = \frac{MVP}{MFC}$$

where:

- r = Efficiency ratio;
- MVP = value of change in output resulting from a unit change in variable input (BDT);
- MFC = price paid for the unit of the variable input (BDT).

Under this method, the decision rules are that when: r > 1, the level of resource use is below the optimum level, implying the under-utilization of resources. Increasing the rate of use of that resource will help increase productivity. r < 1, the level of resource use is above the optimum level, implying overutilization of resources. Reducing the rate of use of that resource will help improve productivity. r = 1, the level of resource use is at optimum implying efficient resource utilization.

The most reliable, perhaps the most useful estimate of MVP is obtained by taking all input resources (Xi) and gross return (Y) at their geometric means [27]. All the variables of the fitted model were calculated in monetary value. As a result, the slope coefficient of those independent variables in the model represents the MVPs, which were estimated by multiplying the production co-efficient of given resources with the ratio of the geometric mean (GM) of gross return to the geometric mean (GM) of the given resources, that is:

$$\text{MVP (Xi)} = \beta i\, \frac{\bar{Y}(GM)}{\ddot{X}i(GM)}$$

where:

- $\bar{Y}$ (GM) = Geometric mean of gross return (BDT);
- $\ddot{X}$i (GM) = Geometric mean of different independent variables (BDT);
- βi = Co-efficient of parameter i = 1, 2, . . . , *n*.

2.12. Limitations of the Study

- One of the key limitations of the current study is that the researcher had to depend on the memory of the farmers for data collection. Because the sample farmers did not keep records of their farm business, the possibility of errors cannot be fully ruled out.
- The study was completed in a limited area of the Chuadanga district, taking into account the limited number of samples due to limitations of resources and time. Therefore, the findings of the study are not out of the question, and it is not applicable to all maize-growing farmers.

3. Results

3.1. Pattern of Input Use for Maize Cultivation

Farmers in the study areas used various inputs for maize cultivation. Farmers used per hectare on average family labor was 33 man-days, and hired labor was 126 man-days. On average, they sowed 24.5 kg of seed per hectare of farms. They applied at the rate of urea 389 kg/ha, TSP 223 kg/ha, and MoP 105 kg/ha for maize production. It was observed that among the chemical fertilizer, farmers used the highest amount of urea for the farms. In the study areas, farmers also applied gypsum (37 kg/ha), zinc (7), and manure 1150 kg/ha for maize cultivation (see Table 2).

Table 2. Level of input use per hectare of maize cultivation.

Particulars	Farms				
	Marginal	Small	Medium	All Farms	Price Tk./Unit
Human labor (man-day)					
Family	27	34	38	33	400
Hired	120	125	132	126	400
Seed (kg)	21	25	27	24.5	250
Urea (kg)	402	395	369	389	16
TSP (kg)	208	220	242	223	27
MoP (kg)	90	110	115	105	30
Manure (kg)	1200	1300	950	1150	3
Gypsum (kg)	35	39	37	37	36
Zinc (kg)	4	7	9	7	200

Source: field survey, 2018

3.2. Profitability of Maize Production

In order to determine the profitability and compare it among the maize production farmers, the following costs and returns items were calculated.

3.2.1. Estimation of Costs

Costs are the expenses incurred in organizing and carrying out the production process. In the production process, farmers used two categories of cost, variable cost, and fixed cost. The variable costs of maize production include the cost of seed, hired labor, animal and power tiller cost for land preparation, fertilizer, manure, irrigation, and pesticide. In this study, the fixed costs include interest in operating capital, land lease value, and family labor. Farmers used both home-supplied and purchased inputs. The costs of purchased inputs were estimated on the basis of the actual payments made by the farmers, and for home-supplied inputs, the opportunity cost principle was applied to determine their value.

Cost of Human Labor

For maize production, human labor is the most important input. It was required for different operations such as land preparation, weeding, fertilizing, using pesticides, harvesting, carrying, threshing, drying, storing, etc. In this study, human labor was measured in man-days. One man-day was equivalent to 8 h of work for an adult man. For women and children, man equivalent day was estimated. This was computed by converting all women- and children-day into man-equivalent-day according to the following ratio: 1 man-day = 1.5 woman-day = 2 child-day [28].

The per hectare human labor cost of maize is shown in Table 3. The per hectare human labor costs were Tk. 48,000, Tk. 50,000 and Tk. 52,800 for marginal, small, and medium farmers, respectively, and their percentages of the total cost of production were 38.56, 37.22, and 37.56 percent, respectively.

Table 3. Per hectare costs of maize cultivation.

Particulars	Marginal		Small		Medium		All Farms
	(Tk./ha)	%	(Tk./ha)	%	(Tk./ha)	%	(Tk./ha)
Hired labor	48,000	38.56	50,000	37.22	52,800	37.56	50,400
Land preparation	8344	6.70	9520	7.09	9825	6.99	9229
Seed	5250	4.22	6250	4.65	6750	4.80	6125
Urea	6432	5.17	6320	4.70	5904	4.19	6224
TSP	5616	4.51	5940	4.42	6534	4.65	6021
MoP	2700	2.17	3300	2.46	3450	2.45	3150
Zinc sulfate	800	0.64	1400	1.04	1800	1.28	1400
Gypsum	1260	1.01	1404	1.05	1332	0.95	1332
Manure	3600	2.89	3900	2.90	2850	2.03	3450
Irrigation	8712	6.99	8940	6.66	9845	7.00	9165
Pesticide	2805	2.25	3250	2.42	3557	2.53	3204
A. Total variable cost	93,519	75.12	100,224	74.61	104,647	74.44	99,700
Lease value	15,500	12.45	15,500	11.54	15,500	11.03	15,500
Family labor	10,800	8.67	13,600	10.12	15,200	10.81	13,200
Interest in operating capital	4676	3.76	5011	3.73	5232	3.72	4985
B. Fixed costs	30,976	24.88	34,111	25.39	35,932	25.56	33,685
Total cost (A + B)	124,495	100	134,335	100	140,579	100	133,385

Source: field survey, 2018

Cost of Mechanical Power

In the study area, a power tiller was mainly used for land preparation. The power tiller was used on a contract basis. In the study area, farmers used purchased power tillers and animal labor for leveling their land. By adding the power tiller cost and animal labor cost total cost of animal labor and power tiller was found. Table 3 indicates that per hectare, animal labor and power tiller cost for maize production were Tk. 8344, Tk. 9520, and Tk. 9825 for marginal, small, and medium farmers, respectively, and their percentages of the total cost of production were 6.70, 7.09, and 6.99 percent, respectively.

Cost of Seed

In the study area, farmers used mainly purchased seeds. Seeds used by the farmers in the study area were Pioneer V-92, Balaji, Boloban, 63-Kaveri, Chhokkavutta, etc. The costs of purchased seeds were calculated on the basis of actual prices paid by the farmers in the study area. Per hectare costs of seeds of maize production was Tk. 5250, Tk. 6250 and Tk. 6750 for marginal, small, and medium farmers, respectively, and their percentages of the total cost of production were 4.22, 4.65, and 4.80 percent, respectively (see Table 3).

Cost of Fertilizer

In the study area, farmers used five types of chemical fertilizer, namely, urea, triple supper phosphate (TSP), muriate of potash (MoP), gypsum, and zinc sulfate ($ZnSo_4$). These chemical fertilizers were charged at the rate of the price paid by the farmers. Per hectare costs of urea was Tk. 6432, 6320, and 5904 for the marginal, small, and medium farmers, respectively, and their percentages of the total cost of production were 5.17, 4.70, and 4.19 percent, respectively (see Table 3).

Per hectare costs of TSP was Tk. 5616, 5940, and 6534 for the marginal, small, and medium farmers, respectively, and their percentages of the total cost of production were 4.51, 4.42, and 4.65 percent, respectively (see Table 3).

Per hectare costs of MP was Tk. 2700, 3300, and 3450 for the marginal, small, and medium farmers, respectively, and their percentages of the total cost of production were 2.17, 2.46, and 2.45 percent, respectively (see Table 3).

Per hectare costs of Zinc Sulphate were Tk. 800, 1400, and 1800 for the marginal, small, and medium farmers, respectively, and their percentages of the total cost of production were 0.64, 1.04, and 1.28 percent, respectively (see Table 3).

Per hectare costs of gypsum were Tk. 1260, 1404, and 1332 for the marginal, small, and medium farmers, respectively, and their percentages of the total cost of production were 1.01, 1.05, and 0.95 percent, respectively (see Table 3).

Using various kinds of fertilizer plays an important role in maize cultivation. In the study area, farmers used urea, TSP, MoP, zinc sulfate, and gypsum for maize cultivation. Per hectare costs of fertilizers were Tk. 16,808, Tk. 18,364, and Tk. 19,020 for marginal, small, and medium farmers, respectively. It is clear to see that the fertilization cost of a medium farmer is higher than marginal and small farmers (see Table 3).

Manure Cost

Per hectare cost of manure for marginal, small and medium farmers was Tk. 3600, 3900, and 2850, respectively, and their percentages of the total cost of production were 2.89, 2.90, and 2.03 percent, respectively. Manure cost is higher for small farmers than for marginal and medium farmers (see Table 3). Most of the small farmers are fully involved in their farm business. Because of the dearth of cash, they are not always capable of purchasing fertilizer. Fertilizer dealers sometimes provide fertilizer to the farmer. In that case, the farmers are obligated to sell their products to that particular fertilizer seller below the actual market price. Family labor is also involved in managing small farms. Therefore, small farmers have more interest in the application of manure on their farms. Thus, their manure cost is also higher.

Cost of Irrigation

Maize production needs a huge amount of water. In the study area, farmers had to depend on shallow tube well (STW) and deep tube-well (DTW). These tube wells were diesel operated and/or electricity operated. The cost of irrigation water was charged at a fixed rate per unit area of irrigated land. All irrigation water charges were paid in cash. Per hectare costs of irrigation cost were Tk. 8712, Tk. 8940 and Tk. 9845 for marginal, small, and medium farmers, respectively, and their percentages of the total cost of production were 6.99, 6.66, and 7.00 percent, respectively (see Table 3).

Cost of Pesticides

The pesticides used by the farmers in the study area were Vittaku, Sunforan, Rijent, Dithane M-45, Thiovit 80 wp, and Rovral 50 wp, etc. Table 3 reveals that per hectare costs of pesticides were Tk. 2805, Tk. 3250 and Tk. 3557 for marginal, small, and medium farmers, respectively, and their percentages of the total cost of production were 2.25, 2.42, and 2.53 percent, respectively (see Table 3).

3.2.2. Total Variable Cost

In the study area, the total variable costs varied from year to year. It was observed that the total variable costs per hectare were Tk. 93,519, Tk. 100,224 and Tk. 104,647 for marginal, small, and medium farmers, respectively, and their percentages of the total cost of production were 76.56, 72.72, and 71.70 percent, respectively (see Table 3).

3.2.3. Fixed Costs

The farmers used the land as per the conditions of the leasing arrangement. The term leasing cost means the cost was required for maize farmers to take a land lease that would be used for maize production for a particular period of time. Leasing cost varies from one place to another depending on the location, soil fertility, topography of the soil and distance from the sources of water, etc. Leasing cost was the single highest cost item in the study areas. The value of own land was calculated as opportunity cost. Land use cost for maize production was estimated at the prevailing rental value per hectare in the study area.

Land rental values per hectare were estimated at Tk. 15,500, Tk. 15,500, and Tk. 15,500 for marginal, small, and medium farmers, and their percentages of the total cost of production were 12.45, 11.54, and 11.03 percent (see Table 3).

3.2.4. Family Labor

In the study area, family labor costs per hectare for maize cultivation were Tk. 10,800, Tk. 13,600, and Tk. 15,200 for marginal, small, and medium farmers, and their percentages of the total cost of production were 8.67, 10.12, and 10.81 percent. The family labor cost of medium farmers is higher than marginal and small farmers. The farm size of marginal farmers is smaller than small and medium farmers. Again, most of the marginal farmers are day laborers and possess other off-farm activities. Thereat, they are less interested in fully involving their family labor in maize cultivation (see Table 3).

3.2.5. Interest on Operating Capital

Interest on operating capital per hectare was Tk. 4676, 5011, and 5232 for marginal, small, and medium farmers, which covered 3.76, 3.73, and 3.72 percent of the total cost (see Table 3).

3.2.6. Total Fixed Cost

In the study area, it was estimated that per hectare total fixed cost for maize cultivation was Tk. 30,976, 34,111, and 35,932 for marginal, small, and medium farmers, which comprised 23.44, 27.28, and 28.30 percent of the total cost (see Table 3).

3.3. Total Cost

The total costs were calculated by adding up the total variable cost and total fixed cost. In the study, per hectare total cost of maize cultivation was calculated at Tk. 124,495, Tk. 134,335, and Tk. 140,579 for marginal, small, and medium farmers. It was found that the highest and lowest costs per hectare appeared in medium and marginal farms, respectively (see Table 3).

3.4. Return of Maize Production

3.4.1. Gross Return

Per hectare gross return of maize production under marginal, small, and medium farms are shown in Table 4. Gross return per hectare consisted of the value of the main product. Per hectare return was calculated by multiplying the total amount of products by their respective average market price. The average market price of maize was Tk. 19 per kg. Per hectare gross returns under marginal, small, and medium farms were Tk. 213,997, Tk. 204,972, and Tk. 197,163, respectively, which indicates that per hectare gross return of marginal farms was higher than small and medium farms.

Table 4. Per hectare cost and return of maize production.

Particulars	Marginal Farm	Small Farm	Medium Farm	All Farm
Total Production (kg/ha)	11,263	10,788	10,377	10,809
Price of maize (Tk./kg)	19	19	19	19
Gross Return (Tk./ha)	213,997	204,972	197,163	205,371
Total variable cost (Tk./ha)	93,519	100,224	104,647	99,700
Gross Margin (Tk./ha)	120,478	104,748	92,516	105,671
Total cost (Tk./ha)	124,495	134,335	140,579	133,385
Net Return (Tk./ha)	89,502	70,637	56,584	71,986
BCR (Total cost basis)	1.72	1.53	1.40	1.53
BCR (Variable cost basis)	2.29	2.04	1.88	2.06

Source: field survey, 2018

3.4.2. Gross Margin

Gross margin is the gross return over variable cost. The gross margin was calculated by deducting the total variable cost from the gross return. On the basis of the data, gross margins were found to be Tk. 120,478, Tk. 104,748, and Tk. 92,516 per hectare for marginal, small, and medium maize farms, respectively (see Table 4).

3.4.3. Net Return

Net return or profit was calculated by deducting the total production cost from the gross return. On the basis of the data, the net returns were estimated as Tk. 89,502, Tk. 70,637, and Tk. 56,584 for marginal, small, and medium maize farms per hectare (see Table 4). As the farm size of a marginal farmer is very small, the farmer handles the farm by themselves. Therefore, their production is higher, and the cost is also lower than small and medium farmers. As a result, their net return is higher than small and medium farmers.

3.4.4. Benefit–Cost Ratio (Undiscounted)

The benefit–cost ratio (BCR) is a relative measure that is used to compare benefits per unit of cost. The benefit–cost ratio (BCR) was found to be 1.72, 1.53, and 1.40 for marginal, small, and medium maize farms, respectively, which implies that one taka investment in maize production generated Tk. 1.72, 1.53, and 1.40, respectively (see Table 4). From the above calculation, it was found that maize production is profitable in the study area, but there is a difference in profitability among individual farm groups. It can be seen from Table 4 that marginal farmers are making the highest amount of profit while the medium farmers are earning the lowest amount of profit from their maize production.

3.5. Input Use Efficiency of Maize Cultivation

3.5.1. Factors Affecting Production of Maize

For producing maize production, different kinds of inputs, such as human labor, power tiller, seed, fertilizer, manure, irrigation, and insecticides, were employed, which were considered as a priori explanatory variables responsible for variation in maize production. Multiple regression analysis was employed to understand the possible relationships between the production of maize and the inputs used.

3.5.2. Interpretation of Results

Interpretation of the estimated co-efficient and related statistics of Cobb–Douglas production function of the farms from which maize production is shown in Table 5. The following features were noted:

- Cobb–Douglas production function fitted well for maize production farms as indicated by F-values and R^2.
- The relative contribution of individual key variables affecting the productivity of maize production farmers can be seen from the estimates of a regression equation. The results showed that most of the co-efficient had expected signs. However, the explanatory variables such as land preparation (X_1), irrigation (X_4), urea (X_5), TSP (X_6), and MoP (X_7) were found to have a significant effect on production in maize farms, but human labor (X_2), seed (X_3) and pesticide (X_8) was found to have an insignificant effect on the production of maize.

Table 5. Estimated values of coefficients and related statistics of Cobb–Douglas production function.

Explanatory Variables	Coefficient	Standard Error	*p*-Value
Intercept	2.908	0.298	0.000
Cost of land preparation (X_1)	0.425	0.104	0.000 ***
human labor (X_2)	0.061	0.062	0.323
seed (X_3)	0.116	0.104	0.196
Cost of irrigation (X_4)	0.305	0.118	0.007 ***
urea (X_5)	0.175	0.081	0.048 *
TSP (X_6)	−0.076	0.049	0.000 ***
MoP (X_7)	0.131	0.062	0.044 *
Cost of pesticide (X_8)	0.027	0.053	0.652
R^2		0.852	
Adjusted R^2		0.846	
Return to scale		1.164	
F-value		175.495 ***	

Source: field survey, 2018. Note: *** significant at 1 percent level; * significant at 5 percent level and NS: not significant.

Maize Production

Land preparation (X_1)

The coefficient of land preparation cost was 0.425, which was significant at 1 percent level (see Table 5). That means 1 percent in the cost of this input, keeping other factors constant, would result in an increase in gross yield by 0.425 percent.

Human labor (X_2)

The coefficient for human labor was 0.061 and was insignificant (see Table 5).

Seed (X_3)

The estimated coefficient of seed was 0.116, which was insignificant (see Table 5).

Irrigation (X_4)

The coefficient of the variable was 0.305 and significant at 1 percent level. This suggests that by holding other factors constant, additional spending of 1 percent on irrigation water would enable the farmers to increase the yield by 0.305 percent (see Table 5).

Urea (X_5)

The estimated value of the coefficient of urea fertilizer was 0.175 and was significant at 5 percent level, which indicates that 1 percent increase in urea, keeping other factors constant, would increase the gross yield by 0.175 percent (see Table 5).

TSP (X_6)

The estimated value of the coefficient of TSP fertilizer was −0.076 for maize farmers. The co-efficient of TSP was negative and significant at 1 percent level. It can be said that 1 percent increase in TSP, keeping other factors constant, would decrease the yield by 0.076 percent (see Table 5). For farmers, it also can be stated that the use of additional TSP would harm the output.

MoP (X_7)

The estimated value of the coefficient of MoP fertilizer was 0.131 and was significant at 5 percent level, indicating that 1 percent increase in MoP fertilizer, keeping other factors constant, would increase the yield by 0.131 percent (see Table 5).

Pesticide (X_8)

The coefficient of the variable was 0.027 and insignificant (see Table 5).

Value of R^2

The coefficient of multiple determinations, $R^{2,}$ was 0.852 for the owner farmer, which indicates that about 85 percent of the total variation in return of maize production is explained by the variables included in the model. In other words, the excluded variables accounted for 15 percent of the total variation in return for maize (see Table 5).

F-Value

The F-value of the equation was highly significant, and it implies that the included variables are important for explaining the variation in returns of maize production (see Table 5).

Returns to Scale

The summation of all the production coefficients indicates returns to scale. For maize production in farmers, the summation of the coefficients was 1.164. This indicated that the production function showed increasing returns to scale (see Table 5).

3.6. Input Use Efficiency in Maize Production

In order to identify the status of resource use efficiency, it was considered that a ratio equal to unity indicated the optimum use of that factor, and a ratio more than unity indicated that the yield could be increased by using more of the resources. A value of less than unity indicated the unprofitable level of resource use, which should be decreased to minimize the losses because farmers overused this variable. The negative value of MVP indicates the indiscriminate and inefficient use of resources [24].

The ratio of MVP and MFC of land preparation cost (9.44) for maize production was positive and more than one, which indicated that in the study area, land preparation was underused (see Table 6). Therefore, farmers should increase the optimum use of land preparation to attain efficiency considerably.

Table 6. Estimated input use efficiency in maize production.

Variable	Geometric Mean (GM)	$\bar{Y}$ = (GM)/$\ddot{x}_i$ (GM)	Co-Efficient	MVP (Xi)	r = MVP/MFC	Decision Rule
Yield (Y)	40,710.07					
Land preparation cost (X_1)	1831.93	22.22	0.425	9.44	9.44	Under-utilization
Human labor cost (X_2)	7686.39	5.29	0.061	0.32	0.32	Over-utilization
Seed cost (X_3)	2239.44	18.17	0.116	2.11	2.11	Under-utilization
Irrigation cost (X_4)	2818.74	14.15	0.305	4.41	4.41	Under-utilization
Urea cost (X_5)	1434.60	28.38	0.175	4.97	4.97	Under-utilization
TSP cost (X_6)	1043.37	39.02	−0.076	−2.96	−2.96	Over-utilization
MoP (X_7)	660.07	61.68	0.131	8.08	8.08	Under-utilization
Pesticide cost (X_8)	471.59	86.33	0.027	2.33	2.33	Under-utilization

Source: field survey, 2018

Table 6 showed that the ratio of MVP and MFC of human labor (0.32) for maize cultivation was positive and less than one, which indicated that in the study area, human labor for maize cultivation was over-utilization. Therefore, farmers should decrease the use of human labor to attain an efficiency level.

The ratio of MVP and MFC of seed was found to be 2.11 for maize cultivation, positive, and more than one, which indicated that in the study area, the use of seed for maize production was under-utilization (see Table 6). Therefore, farmers should increase the use of seed for maize production to attain efficiency considerably.

Table 6 revealed that the ratios of MVP and MFC of irrigation used for maize cultivation were positive and more than one (4.41), which indicated that irrigation application was underutilized. Therefore, farmers should increase the use of irrigation to attain efficiency in maize cultivation.

It was evident from Table 6 that the ratio of MVP and MFC of urea (4.97) for maize cultivation was positive and more than one, which indicated that in the study area, the use of urea for maize cultivation was underused. Therefore, farmers should increase the use of urea to attain efficiency in maize cultivation.

The ratio of MVP and MFC of TSP (−2.96) for maize cultivation was negative and less than one, which indicated that in the study areas, the use of TSP for maize cultivation was overused (see Table 6). Therefore, farmers should decrease the use of TSP to attain efficiency considerably.

It was evident from Table 6 that the ratio of MVP and MFC of MoP (8.08) for maize cultivation was positive and more than one, which indicated that in the study area, the use of MoP for maize cultivation was underused. Therefore, farmers should increase the use of MoP to attain efficiency in maize cultivation.

It was evident from Table 6 that the ratio of MVP and MFC of pesticide (2.33) for maize cultivation was positive and more than one, which indicated that in the study area, the use of pesticide for maize cultivation was underused. Therefore, farmers should increase the use of pesticides to attain efficiency in maize cultivation.

4. Discussion

Agriculture is the most important source of income in Bangladesh. Farmers in this country first grow crops to meet their families' needs, and then they show an interest in growing cash crops such as cotton, jute, tea, maize, coffee, etc., which are mostly expected to deal with domestic demand and sell abroad in foreign currency. The nationalized economy is heavily reliant on maize. A small amount of effort was expended in order to investigate the economics of maize production. Determining the cost of production and profitability, by the way, should be planned. This research may provide a variety of detailed benefits to individual farmers for efficient farm operation and management, as well as research personnel for supplementary studies of related natural history and planners and policymakers who provide farmers centrally for macro-level strategy assessment. Islam conducted a study on the impact of maize production on farmer income and livelihood in a specific area of the Lalmonirhat district [29]. He stated that maize production has resulted in positive changes in various aspects of livelihood, such as capital, food intake, etc. According to the study, maize production resulted in a positive change in income. He also stated that the average annual income increase for maize growers was 63%, while it was 37% for non-maize growers. According to the study, maize production should be encouraged, irrigation facilities should be expanded, and low-cost post-harvest technologies should be provided. Shohag conducted research on maize production and marketing in a specific area of the Gaibandha district [30]. The study found that the rate of change in maize area, production, and yield increased dramatically as potential demand increased in various sectors. Tk. 36,425 and Tk. 29,591 were also calculated as gross margin and net return. He also recommended that inputs be available at reasonable prices, credit be available at low interest rates, adequate fertilizer be available during the production period, good quality seed be available, market demand be increased, storage and market facilities be improved, and post-harvest technology and pesticides be made available as important measures to encourage maize production.

Ahmed and Jahan experimented with maize/pea (*Pisum sativum*) intercropping during the rabi season to determine the best planting system for higher productivity and economic return [31]. The results showed that growing peas as an intercrop with maize is more profitable than growing maize alone. The results also indicated that four rows of BARI motorshuti-1 intercropped with maize are the best intercrop combination for maximum economic benefit. Hasan completed a study on the economic efficiency and constraints of maize production in Bangladesh's northern region [32]. He reported that all of the farmers used hybrid seeds for maize cultivation, with an average yield of 6.27 tons per hectare, which is higher in Dinajpur (6.35 tons per hectare) than in Panchagarh (6.18 tons per hectare). For Dinajpur and Panchagarh, the returns to scale of the selected inputs were 0.72 and 0.68, respectively. Technical efficiency was found to be 0.84 on average in Dinajpur and 0.80 in Panchagarh. It was also discovered that farmers in the study area had the potential to increase maize productivity by achieving full efficiency through resource reallocation. Economic analysis of maize production and maize-based cropping pattern in comparison to Boro rice and Boro-based cropping pattern shows that the maize production system is more profitable than Boro rice. Uddin et al. carried out an economic study on maize production in various farm-size groups in a specific area of Bangladesh [20]. He calculated the profitability, productivity, and resource use efficiency of various farm-size groups. According to this study, the average net returns on maize per hectare were estimated to be Tk. 31,583, Tk. 47,823, and Tk. 41,648 for small, medium, and large farmers, respectively. The study found that certain explanatory variables had an effect on maize production across all farmer groups. According to the study's findings, medium farmers earned more profit than small and large farmers. Finally, some recommendations for the development of maize production in Bangladesh were made. Haque conducted a comparative economic study of hybrid maize Uttaran and 900 M cultivation in the Bogra district's Sherpur Upazilla [33]. The study's major findings revealed that the average total costs per hectare for Uttaran and 900 M maize growers were Tk. 39,035.49 and Tk. 42,807.92, respectively. Average net returns per hectare from Uttaran and 900 M maize were Tk. 48,911.40 and Tk. 55,906.09, respectively. According to the study, 900 M maize growers earned higher per-hectare profits than Uttaran maize growers.

Alam et al. investigated the economics of hybrid maize production in a few areas of Bangladesh [34]. The current study aimed to evaluate the existing agronomic practices of hybrid maize cultivation, as well as its profitability, constraints, and factors influencing hybrid maize production. During the first week of December, the majority of farmers sowed seeds. The average seed rate per hectare was discovered to be 20.94 kg. Farmers discovered about 16 cultivable varieties, the majority of which were NK-40 and Pacific-II. Farmers used all types of fertilizer that were below the recommended level. Human labor and chemical fertilizer accounted for approximately 33 and 28 percent of the total variable cost, respectively. The hybrid maize yield was found to be higher than the national average. On a total variable cost basis, the average gross margin was Tk. 28,456. The cost of maize cultivation per kilogram was Tk. 4.12, and the return on one kilogram of maize production was Tk. 7.80. The coefficients of human labor, land preparation, irrigation, urea, and borax have been found to have a significant impact on gross return. The main issues for hybrid maize production were a lack of timely availability of seeds, high fertilizer prices, and a low yield price. Farmers grew hybrid maize because of its higher yield, higher income, and ease of cultivation. Alam et al. conducted a survey on four major maize-growing areas in Bangladesh, namely Chuadanga, Dinajpur, Bogra, and Lalmonirhat, from 2006 to 2007 [35]. A pre-planned interview schedule was used to collect data from 200 randomly selected maize growers, with 50 farmers in each location. The average yield was discovered to be 8.00 tons per acre. Maize production costs averaged Tk. 44,197, Tk. 33,195, and Tk. 24,441 per hectare on a total cost, variable cost, and cash cost basis, with a gross return of Tk. 69,773 per hectare. On a total variable cost (TVC) basis, the gross margin was Tk. 36,578/ha, and on a cash cost basis, it was Tk. 45,332/ha. The net return per hectare was determined to be Tk. 25,575. On a total cost, variable cost, and cash cost basis, the benefit–cost ratios were calculated as 1.58, 2.10, and 2.85, respectively. As a result, maize farming was extremely profitable. The main constraints to increased production were a lack of capital and the high price of TSP.

Paul conducted a study in the Lalmonirhat district of northern Bangladesh, a maize-producing area, to gain an understanding of maize productivity [36]. He discovered that the gross return per hectare for small, medium, and large crops was calculated to be Tk. 85,100, Tk. 97,280, and Tk. 112,853, respectively. The undiscounted BCR was 2.04, 1.70, and 1.88, respectively. The results showed that maize production was profitable in that area, with an average net return of Tk. 45,459 per hectare and a BCR of 1.86. Hossain conducted this research in light of the recent increase in demand for maize as a feed for livestock and poultry [37]. The study used stratified random sampling to estimate profitability, productivity, factors affecting profitability, problems, and constraints of maize farmers in Nulsundha, Kajolgram, and Rupsha from pingna union of Sarishabari Upazilla of Jamalpur district. The descriptive statistic, benefit–cost ratio (BCR), and Cobb–Douglas production functional model were used to achieve the study's objectives. On this basis, large farmers earn a higher net return (Tk. 65,033) than small and medium farmers, who earn Tk. 54,697 and Tk. 44,488, respectively. The undiscounted BCR for small, medium, and large farmers used to be 1.77, 1.88, and 2.02, respectively. The study found that the primary constraints of maize farming in the study field were a lack of quality seeds, a high input rate, and a high transportation cost. Regardless of the constraints, maize farming has a high potential for profitability in the study area.

Sadiq et al. conducted a study on the Profitability and Production Efficiency of Small-Scale Maize Production in Niger State, Nigeria, and discovered that maize production was profitable, with an average net farm income of N48, 109.00/hectare and a gross ratio of 0.39; a production efficiency index (2.50) per farmer further adjudged the enterprise's profitability, that is, the returns cover the cost of production almost entirely [38]. Ferdausi et al. conducted an economic study on maize production in some selected areas of the Bogura district and discovered that maize is a profitable crop for all types of farmers based on cost and return analysis [21]. The total cost of maize production was estimated to be Tk per hectare on average. For all farmers and Tk, dial 46,278. For small, medium, and large farmers, the numbers are 41,263, 53,554, and 48,715, respectively. Again, maize production gross margins were estimated at Tk. For small, medium, and large farmers, the numbers are 67,592, 64,694, and 74,089, respectively. Net returns for the farm size groups of the small, medium, and large, on the other hand, were calculated at Tk. 57,823, 53,895, and 64,138 per hectare, in that order. Small farmers had the highest BCR (2.40), followed by medium (2.01) and large (2.32) farmers. According to the Cobb–Douglas production function analysis, the effects of seed, manure, fertilizer, irrigation, and insecticide use had a significant impact on the gross return from maize production for all farmers. According to the efficiency analysis, the majority of the farmers used their inputs inefficiently. According to the study's findings, large farmers earned more profit than small and medium farmers.

Rahman used survey data from 300 farmers from three regions to investigate the potential of maize expansion by examining its profitability and economic efficiency [15]. When compared to rice and wheat, maize has the highest yield (7.98 t/ha) and return (BCR = 1.63). The economic efficiency of maize production is estimated to be 87%, though a 15% (100−87)/87) cost reduction is still possible while maintaining current output levels by eliminating technical and allocative inefficiency. Education helps to increase efficiency, whereas large farmers are relatively inefficient. Geography is important. In comparison to Dinajpur and Kushtia, efficiency is lower in the Bogra region. Policy implications include education investment, the implementation of appropriate price policies to stabilize prices, and the facilitation of input markets to ensure the timely delivery of required inputs. Dhakal et al. conducted a study on the productivity and profitability of maize–pumpkin mix cropping in Chitwan, Nepal, and discovered that the benefit–cost ratio (1.58) indicates that maize–pumpkin mix cropping is profitable, with a productivity of 2.83 tons per ha on a maize main product equivalent basis [39]. The magnitude of the regression coefficients for maize–pumpkin mix cropping implied that seed, fertilizer, and irrigation expenditure had a significant positive effect on gross return, with an estimated decreasing return to scale (0.85). According to estimated allocative efficiency indices, it is recommended to increase seed and fertilizer cum irrigation expenditure by approximately 90% and 55%, respectively.

Rahman conducted an economic study on maize production in various farm-size groups in some selected areas of Bangladesh's Thakurgoan district [40]. He discovered that maize production is a lucrative business. According to the study, the net returns on maize per acre were calculated to be Tk. 23,259.61, Tk. 25,380.21, and Tk. 27,944.97 for small, medium, and large farmers, respectively. The average net return for all farmer classes was Tk. 24,173.47. According to the study, large farmers earned the highest gross return per acre. For this study, the Cobb–Douglas production functions were used to assess the individual effect of input use on maize production. Human labor, urea cost, gypsum cost, seed cost, and tillage cost were all significant and had a positive effect on maize production. Finally, some of the problems that maize farmers face were identified, such as a lack of capital, high input costs, a lack of quality seeds, etc., and some recommendations to improve the current production situation were made. Masudul et al. conducted a study on farmer profitability of maize cultivation in the Rangpur district of Bangladesh's socio-economic context: an empirical analysis revealed that the cost of maize cultivation per acre for small, medium, and large farmers is exposed [11]. Total variable cost included total cost, which was calculated by adding total variable cost and total fixed cost. Large farmers (Tk. 1,324,536.) had the highest total cost, followed by medium farmers (Tk. 1,134,342.) and small farmers (Tk. (Tk. 363,813.6). Large farmers have the highest productivity (549.6 + 274.8 = 824.4 mon), followed by medium farmers (470.64 + 235.32 = 705.96 mon) and small farmers (150.96 + 75.48 = 226.44 mon). Profitability is also highest for large farmers (Tk. 397,086), medium farmers (Tk. 329,448), and small farmers (Tk. 329,448) (Tk. 105,672), because most large farmers have more land and produce more.

Profitability depends on the costs involved in production and returns from its product and by-product. In calculating cost, both cash cost and non-cash cost were considered. The cost items were the cost of human labor, mechanical power, seed, manure, fertilizer, pesticide, irrigation, land rent, and interest in operating capital. The variable costs were estimated at Tk. 93,519, Tk. 100,224 and Tk. 104,647 for a marginal, small, and medium group of farmers for maize production, respectively. Total fixed costs were estimated at Tk. 30,976, Tk. 34,111, and Tk. 35,932 for marginal, small, and medium maize production, respectively. Thus, the total cost of production was Tk. 124,495, Tk. 134,335, and Tk. 140,579 for marginal, small, and medium maize production, respectively. Per hectare gross return was Tk. 213,997, Tk. 204,972, and Tk. 197,163 for marginal, small, and medium maize production, respectively. Per hectare gross margin was Tk. 120,478, Tk. 104,748, and Tk. 92,516 for marginal, small, and medium maize production, respectively. Net return was calculated by deducting the gross cost from a gross return, and these were Tk. 89,502, Tk. 70,637, and Tk. 56,584 for marginal, small, and medium maize production, respectively. The benefit–cost ratio was 1.72, 1.53, and 1.40 for marginal, small, and medium maize production, respectively. From Cobb–Douglas production function analysis, it was observed that the coefficients of land preparation cost, irrigation cost, urea, and MoP cost were significant at different levels of probability for marginal, small, and medium maize production, respectively, and the coefficients of human labor cost, seed, and pesticide used were not significant while the coefficients of TSP was negative and significant for marginal, small, and medium maize farms, respectively.

Finally, it was observed that most of the MVPs of inputs were positive or more than one, which indicates that more profit can be obtained by increasing most of the input included in the production function. Input use efficiency indicated that all of the resources were underused for maize production except for overutilization of human labor cost and TSP cost. Therefore, there was a positive effect of key factors in the production process of maize cultivation. This study also identified some of the problems associated with maize production. The findings revealed that lack of good quality seed, low yield, and unstable price, lack of suitable land, disease infestation, the high price of inputs, lack of sufficient funds, shortage of human labor at the critical stage, declining soil fertility, etc., were the major obstacles that stood in the way of maize production in the study area.

5. Conclusions

The study showed that maize production is profitable in the study area. Marginal farmers received higher profits than small and medium farmers. However, maize production was profitable as other crop cultivation. The Cobb–Douglas production function model demonstrates that the included key variables had a significant and positive effect on maize production, with the exception of the positive and insignificant effects of human labor cost, seed cost, and pesticide cost. Except for human labor and TSP costs, resource use efficiency revealed that all resources were underutilized for maize production. As a result, key factors in the maize production process have a positive effect.

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