TECHNICAL EFFICIENCY ON MAIZE PRODUCTION IN SELECTED AREAS OF BANGLADESH: A STOCHASTIC FRONTIER APPROACH

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*This is to certify that the thesis entitled, "**TECHNICAL EFFICIENCY ON MAIZE PRODUCTION IN SELECTED AREAS OF BANGLADESH: A STOCHASTIC FRONTIER APPROACH**" submitted to the Faculty of Agribusiness Management, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS**, embodies the result of a piece of bona fide study work carried out by **ASMA YEASMIN SAMPA** , bearing Registration No. **11-04511** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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DEDICATED TO MY BELOVED PARENTS

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ABSTRACT

The present study was designed to analyze technical efficiency and to estimate the profitability of maize production in six villages under Harirampur and four villages under Bagha upazila of Manikgonj and Rajshahi districts respectively. Primary data were collected through random sampling from 131 farmers. The main findings of the study reveal that maize production is a profitable enterprise. Total cost of production was Tk. 107012.19 per hectare. Gross returns, gross margin were Tk. 151323.72 per hectare, Tk. 69003.91 per hectare and net returns was Tk. 44311.53 per hectare. Per hectare yields of maize was found 8563.421 kg. Benefit Cost Ratio (BCR) was found to be 1.41 which implies that one taka investment in maize production generated Tk. 1.41 in the study area. BCR were found to be 1.26 and 1.59 at Harirampur and Bagha upazila respectively. The Cobb-Douglas stochastic frontier production function was used to measure technical efficiency of maize farmers. The coefficients of parameters e.g. land preparation cost, seed and irrigation were positive where seed and irrigation were highly significant and land preparation cost was significant at 5 percent level. Technical efficiency ranged from 0.71 to 0.99 with a mean of 0.93. In the technical inefficiency effect model, experience, extension service and farm size have negative coefficients indicating that this helps in reducing technical inefficiency of maize farmers. The value γ-parameter associated with the variance in the stochastic frontier model was 0.9531, indicates that inefficiency effects have a significant contribution in determining the level and variability of output of maize farms. Among various problems, high price of seeds, natural calamities and low price of grains ranked 1st, 2nd and 3rd respectively on the basis of magnitude of problem faced by farmers. Development of new varieties, reduction of price of seed, fair price of produced maize, adequate extension service, available credit and storage facility can improve the present production situation.

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ABBREVIATIONS AND ACRONYMS

BARI	: Bangladesh Agricultural Research Institute
AEZ	: Agro Ecological zone
BB	: Bangladesh Bank
BBS	: Bangladesh Bureau of Statistic
BCR	:Benefit Cost Ratio
BDT	: Bangladeshi Taka
BER	: Bangladesh Economic Review
DAE	: Department of Agricultural Extension
et al.	: and others (at elli)
GDP	: Gross Domestic Product
GR	: Gross Return
ha	: Hectare
HIES	: Household Income and Expenditure Survey
HSC	: Higher Secondary Certificate
HYV	: High Yielding Variety
IOC	: Interest on Operating Capital
kcal	: Kilocalorie
kg	: Kilogram
Ln	: Natural Logarithm
ML	: Maximum Likelihood
MoP	: Muriate of Potash
M.Ton	: Metric Ton
NGO	: Non Government Organization
No.	: Number
t	: Ton
TC	: Total Cost
TFC	: Total Fixed Cost
Tk.	: Taka
TSP	: Triple Super Phosphate
TVC	: Total Variable Cost
Govt.	: Government
IRRI	: International Rice Research Institute
US	: United States
USDA	: United States Department of Agriculture
$	: Dollar
%	: Percentage

CHAPTER 1

INTRODUCTION

1.1 Background to the Study

Bangladesh is a developing country with agriculture as the mainstay of the economy. Agriculture is the key driver of the growth of Bangladesh economy and has been playing a vital role in the socio-economic advancement and sustainable economic development of the country through gradual improvement of the rural as well as the whole economy by ensuring food security, generating employment, developing human resources and alleviating poverty. The targeted GDP growth rate was 7.86 percent in 2018-19, significantly higher than the growth of 7.28 percent in the preceding fiscal year (BER, 2018). Among the broad sectors of GDP, the contribution of agriculture to GDP slid down by 0.51 percentage point to 14.23 percent (BER, 2018).Being an agriculture based country, Bangladesh is recognized as one of the most vulnerable areas to the impacts of global warming and climate change its unique geographic location, dominance of floodplains, low elevation, high population density, and overwhelming dependence on nature for its resources and services are mainly responsible for this. The entire harvest can be wiped out in a matter of hours when cyclones hit the country. Bangladesh forms the largest delta in the world and is situated between $88^{o}10'$ and $92^{o}41'$ East longitudes and between $20^{o}34'$ and $26^{o}38'$ North latitudes. The great delta is flat throughout and stretches from near the foot-hills of the Himalayan Mountains in the north to the Bay of Bengal in the south.

Bangladesh is predominantly the ninth most populous agrarian country with a total population of 162.7 million in the world with an annual population growth rate and density of 1.37 and 1103, in 2017 (BER, 2018). About 26.40 percent of total population of this country lives in rural areas (BER, 2018). Agriculture provides employment to nearly about 40.06 percent of its total labor forces (BER, 2018).According to the final data, sector wise share of broad agriculture, industry and service stood at 14.23 percent, 33.66 percent and 52.11 percent respectively (Figure 1.1); which were 14.74 percent, 32.42 percent and 52.85 percent respectively in previous fiscal year.

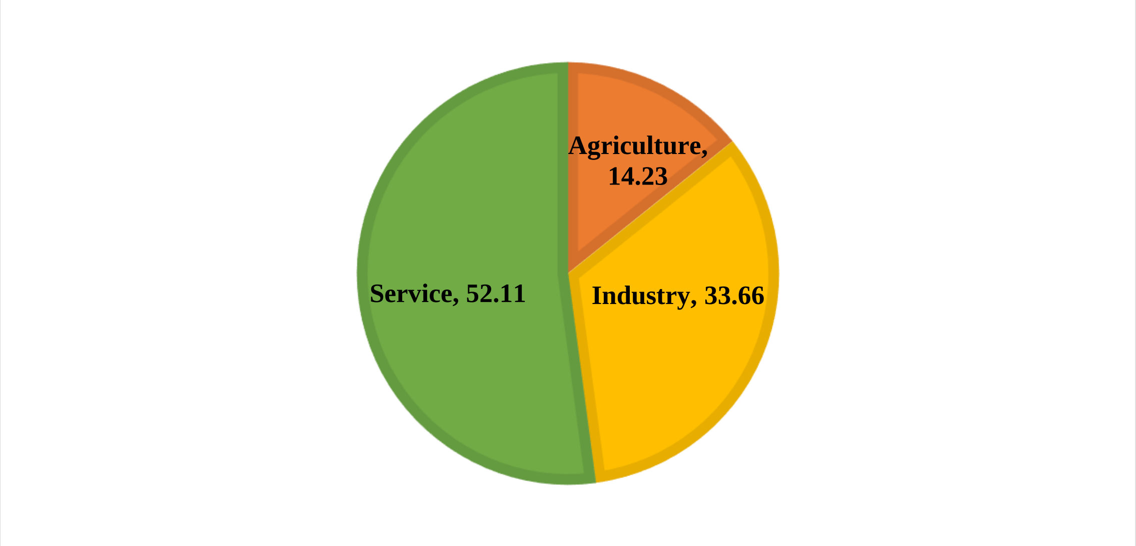


Figure 1.1: Contributions of Three Broad Sectors to the Country`s GDP
Source: BBS, 2018

Due to its very fertile land and favorable weather, varieties of crop grow abundantly in this country. The contributions of agriculture to GDP were 16 percent, 15.33 percent and 14.79 percent in fiscal year 2014-2015, 2015-2016 and 2016-2017 respectively. The decreasing trend of share of agriculture in GDP is represented in Figure 1.2 at constant prices (Base Year: 2005-06).

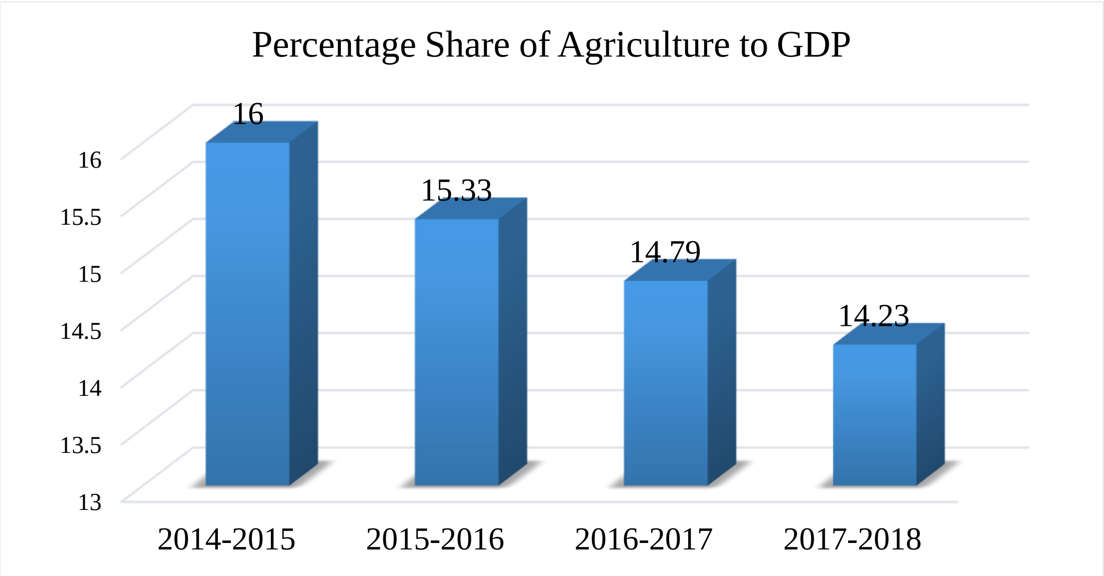
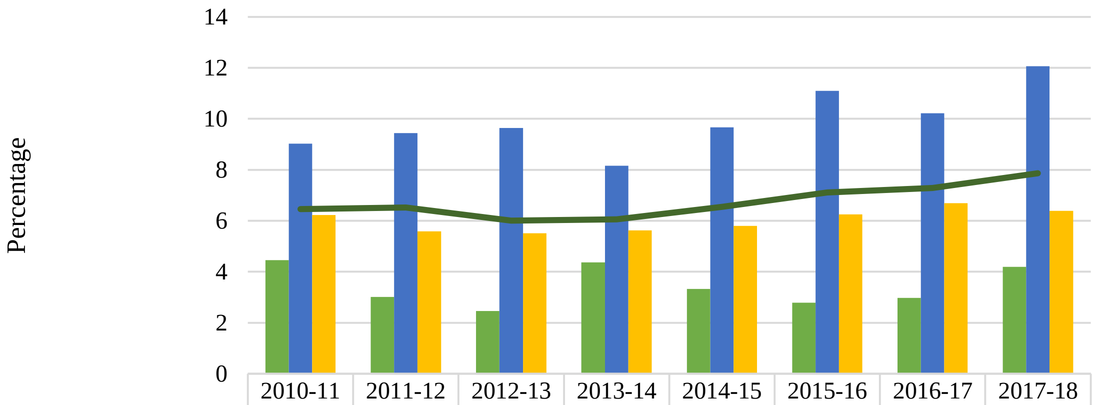


Figure 1.2: Contributions of Agriculture Sector to the Country`s GDP
Source: BBS, 2018

The GDP growth stood at 7.86 percent in FY2017-18, which were 6.46 percent, 6.52 percent, 6.01 percent, 6.06 percent, 6.55 percent, 7.11 percent and 7.28 percent in fiscal year 2010-11, 2011-12, 2012-13, 2013-14, 2014-15, 2015-16 and 2016-17 respectively. Growth rate of GDP, agriculture, industry and service sector are shown in figure 1.3.



	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Agriculture	4.46	3.01	2.46	4.37	3.33	2.79	2.97	4.19
Industry	9.02	9.44	9.64	8.16	9.67	11.09	10.22	12.06
Service	6.22	5.58	5.51	5.62	5.8	6.25	6.69	6.39
GDP growth rate	6.46	6.52	6.01	6.06	6.55	7.11	7.28	7.86

Figure 1.3: Growth Rate of GDP, Agriculture, Industry and Service Sectors
Source: BBS, 2018

Among the 3 broad sectors growth of agriculture sector increased to 4.19 percent of GDP, which was 2.97 percent in previous fiscal year. Growth of agriculture and forestry sector under broad agriculture sector rose to 3.47 percent of GDP. Growth of broad industry sector increased to 12.06 percent of GDP in FY2017-18; which was 10.22 percent in preceding fiscal year. Growth of broad service sector slightly decreased to 6.39 percent in FY2017-18 from 6.69 percent in FY2016-17 (Figure 1.4).

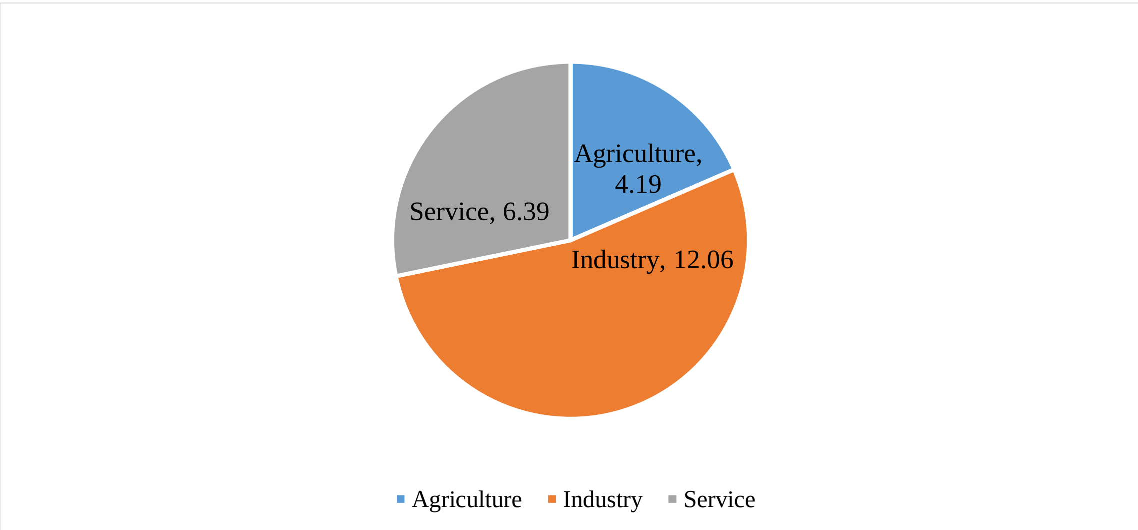


Figure 1.4: GDP Growth Rate of Broad Sectors.
Source: BBS, 2018

Despite increase in the shares of fisheries, livestock, and forestry, crop sub-sector alone accounts for 7.51 percent share of agricultural GDP (BER, 2018) (Table 1.1). Although the contribution of crop sub-sector in GDP marginally decreased from 9.49 percent in year 2012-13 to 7.51 percent in year 2013 -14.

Table 1.1: Contributions and Share of Agriculture Sub-sectors to the Country`s GDP

Sub-sectors	Contributions to GDP (%)	Percentage Share to GDP
Crops and horticulture	7.51	3.06
Animal farming	1.53	3.40
Forest	1.62	5.51
Fisheries	3.56	6.37

Source: BBS, 2018

Over the last few years, there has been an increasing trend in food production. Food grains production stood at around 413.25 lakh metric tons (MT) (BBS, 2018). Among total cropped area, only 2.20 percent land was utilized for maize production where largest share was under rice production and is was 74.85 percent land of total cultivated land (Figure 1.5).

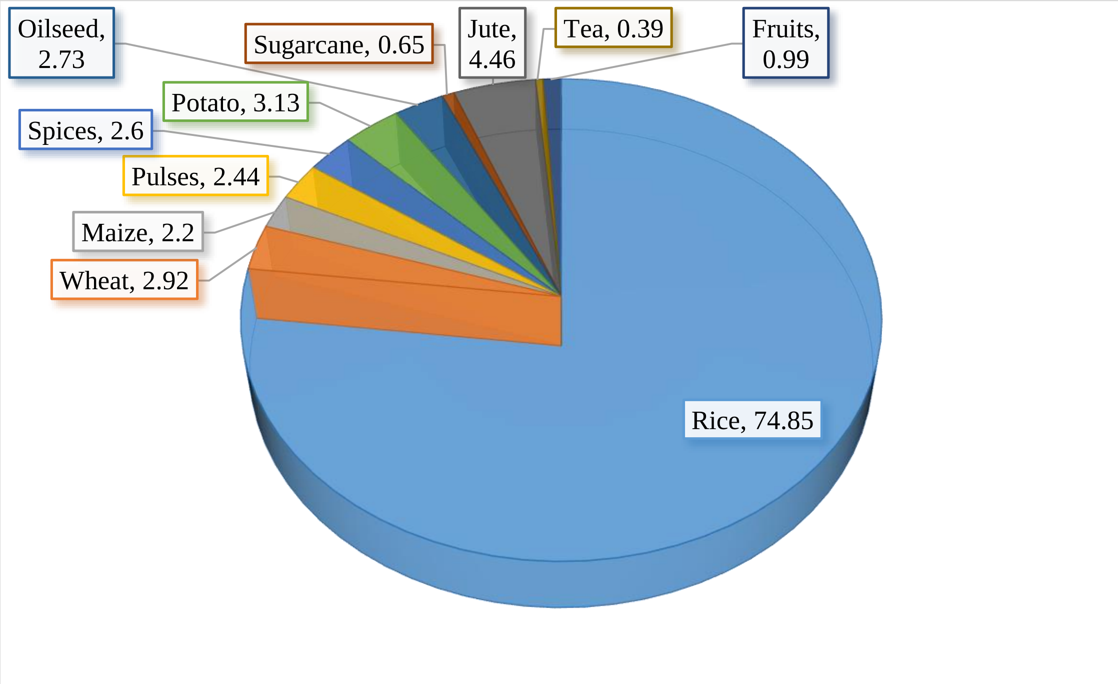


Figure 1.5: Area under Cultivation of Different Crops in Bangladesh, 2015-2016
Source: BBS, 2018

Bangladesh is also one of the most densely populated nations of the world (964 persons per km^2) with an estimated population of 142.3million, of which 75% live in rural areas (BBS, 2010). Poverty rate declined 15.7 percentage points within a decade (40% in 2005 reduced to 24.3% in 2016) (BBS, 2018).

1.2 Present Status of Maize in Bangladesh

Maize (*Zea mays*) belongs to the family Grammies a versatile photo insensitive crop. *Maize is* gaining importance in recent years as a promising crop aimed at boosting agricultural growth in Bangladesh (Rahman *et al*, 2014). Maize is one of the oldest crops and the third most important crop after rice and wheat among the cereals in Bangladesh for its versatile nature with highest grain yield and multiple uses. It is most commonly used in poultry and fish feed industries, for baking and other foods such as popcorn, fried corn for human consumption (Rahman *et al*, 2016). Bangladesh has the opportunity to increase the maize cultivation area and yield for its soil conditions, topography, and climate (Hossain *et. al* 2015).

Although the expansion of maize was not successful in Bangladesh during the 1960s due to the thrust of the government to promote a rice based Green Revolution technology, the production and yield of maize has experienced an explosive growth in recent years (Rahman *et al*, 2014).

The area under maize cultivation has increased to 963000 acres in 2016-17 from 804000 acres in 2014-15. Increasing trend was also noticeable in yield rate which was 2826 kg per acre in 2014-15, increased to 3141 kg per acre in 2016-17. Total volume of production of maize have was 3026000 M. Tons in 2016-17 (Table 1.2 and 1.3)

Table 1.2: Area, Productivity and Production of Maize from 2014-15 to 2016-17.

Crop	2014-15			2015-16			2016-17		
	Area '000' Acres	Per acre Yield (Kg)	Production '000' M.Tons	Area '000' Acres	Per acre Yield (Kg)	Production '000' M.Tons	Area '000' Acres	Per acre Yield (Kg)	Production '000' M.Tons
Maize	804	2826	2272	827	2956	2445	963	3141	3026

Source: BBS, 2018

Table 1.3: Indices of Area and Production of Maize (Base: 1984-85=100)

Crop	Area					Production				
	2012-13	2013-14	2014-15	2015-16	2016-17	2012-13	2013-14	2014-15	2015-16	2016-17
Maize	6220	8139	8624	8876	10332	47330	64941	69480	74788	92520

Source: BBS, 2018

Total area under production of kharif maize and rabi maize separately were 13886 acres and 35456 acres in Manikgonj district whereas total area under production of kharif maize and rabi maize were 27704acres and 84713acres in Rajshahi district in 2016-17. Total production were 27547 M. Ton and 60828 M. Ton for kharif maize in Manikgonj and Rajshahi district respectively in 2016-17. In case of rabi maize the amount were much more higher and these were 98910 M. Ton and 258853 M. Ton in Manikgonj and Rajshahi district respectively in same year (Table 1.4 and 1.5).

Table 1.4: Area and Production of Kharif Maize in Manikgonj and Rajshahi District.

Division	2014-15		2015-16		2016-17	
	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)
Manikganj	13894	27114	14190	30370	13886	27547
Rajshahi	32579	68984	28486	51537	27704	60828
Bangladesh	141941	310471	128659	284230	146014	338560

Source: BBS, 2018

Table 1.5: Area and Production of Rabi Maize in Manikgonj and Rajshahi District.

Division	2014-15		2015-16		2016-17	
	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)
Manikganj	27533	75853	32195	89573	35459	98910
Rajshahi	73866	174610	68808	181174	84713	258853
Bangladesh	661928	1961527	698728	2161348	816986	2686832

Source: BBS, 2018

Total area under production of kharif maize and rabi maize were 49345acres and 112417acres in Manikgonj and Rajshahi district district respectively whereas total production of kharif maize and rabi maize were 126457 M.Ton and 319681 M.Ton in Manikgonj and Rajshahi district respectively in 2016-17 (Table 1.6).

Table1.6: Area and Production of Maize (Rabi & Kharif) in Manikgonj and Rajshahi District.

Region	2014-15		2015-16		2016-17	
	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)
Manikganj	41427	102967	46385	119943	49345	126457
Rajshahi	106445	243594	97294	232711	112417	319681
Bangladesh	803869	2271998	827387	2445578	963000	3025392

Source: BBS, 2018

Intensity of Cropping in Dhaka and Rajshahi district in several years are represented in table 1.7 and table 1.8.

Table 1.7: Total Cultivated Area and Net Cropped Area.

Region	Total Area ('000' acres)					Net cropped area ('000' acres)				
	2011-12	2012-13	2013-14	2014-15	2015-16	2011-12	2012-13	2013-14	2014-15	2015-16
Dhaka	1838	1838	1851	1851	1851	948	950	960	1011	849
Rajshahi	2333	2333	2339	2339	2339	1735	1738	1747	1804	1821
Bangladesh	36669	36669	36465	36465	36465	19594	19543	19581	19596	19636

Source: BBS, 2017

Table 1.8: Gross Cropped Area and Intensity of Cropping.

Region	Gross Cropped Area ('000' acres)					Intensity of Cropping				
	2011-12	2012-13	2013-14	2014-15	2015-16	2011-12	2012-13	2013-14	2014-15	2015-16
Dhaka	1594	1598	1572	1830	1906	168	168	164	181	184
Rajshahi	3289	3301	3458	3591	3675	190	190	198	199	202
Bangladesh	37261	37150	37573	37674	38148	190	190	192	192	194

Source: BBS, 2017

1.3 Origin and Status of Maize

Maize (Zea mays ssp. mays) belongs to the tribe Maydae, family Poaceae and was originated in Mexico and Central America. Maize also known as corn, is a cereal grain first domesticated by indigenous peoples in southern Mexico about 10,000 years ago. Most historians believe maize was domesticated in the Tehuacán Valley of Mexico. According to a genetic study by Embrapa, corn cultivation was introduced in South America from Mexico, in two great waves: the first, more than 6000 years ago, spread through the Andes. Evidence of cultivation in Peru has been found dating to about 6700 years ago. The second wave, about 2000 years ago, through the lowlands of South America. In Bangladesh, maize cultivation started in the early 9th century (1809) in the districts of Rangpur and Dinajpur (Begum and Khatun, 2006).

Maize has become a staple food in many parts of the world, with the total production of maize surpassing that of wheat or rice. However, little of this maize is consumed directly by humans: most is used for corn ethanol, animal feed and other maize products, such as corn starch and corn syrup. The six major types of maize are dent corn, flint corn, pod corn, popcorn, flour corn, and sweet corn ("Maize," n. d.).

1.4 Nutritive Value of Maize

Maize and cornmeal (ground dried maize) constitute a staple food in many regions of the world. Raw, yellow, sweet maize kernels are composed of 76 percent water, 19 percent carbohydrates, 3 percent protein, and 1 percent fat which provide 360 kJ (86 kcal) energy. In a 100-gram serving, maize kernels provide 86 calories and are a good source (10-19 percent of the Daily Value) of the B vitamins, thiamin, niacin, pantothenic acid (B5) and folate. In moderate amounts, they also supply dietary fiber and the essential minerals, magnesium and phosphorus whereas other nutrients are in low amounts. Maize has suboptimal amounts of the essential amino acids tryptophan and lysine, which accounts for its lower status as a protein source. The indigenous Americans overcame this deficiency with the inclusion of beans in their diet ("Maize," n. d.).

1.5 Uses

1.5.1 Human Food

Maize has become a staple food in many parts of the world, with the total production of maize surpassing that of wheat or rice. However, little of this maize is consumed directly by humans: most is used for corn ethanol, animal feed and other maize products, such as corn starch and corn syrup. The six major types of maize are dent corn, flint corn, pod corn, popcorn, flour corn, and sweet corn. Maize is a major source of starch. Maize flour is a major ingredient in home cooking and in many industrialized food products. Maize is also a major source of cooking oil (corn oil) and of maize gluten. Popcorn, Corn flakes ("Maize," n. d.).

1.5.2 Feed and Fodder for Livestock

Maize is a major source of both grain feed and fodder for livestock. It is fed to the livestock in various ways. When it is used as a grain crop, the dried kernels are used as feed. They are often kept on the cob for storage in a corn crib, or they may be shelled off for storage in a grain bin. When the grain is used for feed, the rest of the plant (the corn stover) can be used later as fodder, bedding (litter), or soil amendment. When the whole maize plant (grain plus stalks and leaves) is used for fodder, it is usually chopped all at once and ensilaged, as digestibility and palatability are higher in the ensilaged form than in the dried form. Maize silage is one of the most valuable forages for ruminants. Before the advent of widespread ensilaging, it was traditional to gather the corn into shocks after harvesting, where it dried further. With or without a subsequent move to the cover of a barn, it was then stored for weeks to several months until fed to the livestock ("Maize," n. d.).

1.5.3 Chemicals

Starch from maize can also be made into plastics, fabrics, adhesives, and many other chemical products. The corn steep liquor, a plentiful watery byproduct of maize wet milling process, is widely used in the biochemical industry and research as a culture medium to grow many kinds of microorganisms. Chrysanthemin is found in purple corn and is used as a food coloring ("Maize," n. d.).

1.6 Statement of the Problem

Maize is the third most important grain crop in the world. Every year approximately 1.2 million ton maize is utilized of which only 42 percent is produced by the country and remaining is imported from other countries (BBS, 2005). More than 90 percent of maize is used as poultry feed and the remaining in fish sector and as human food products. The country has a great potentiality to improve and expand the maize production. Maize is a relatively new crop in Bangladesh and it has an enormous market potential. The country's poultry industry continues to grow and so there is also a growing demand for maize. Farmers cultivating maize are not completely aware of the benefits of maize cultivation. They are not interested to invest for maize cultivation as they do not have proper information on maize farming and marketing techniques. Bangladesh is facing a problem of malnutrition due to her high population growth and low productivity of crops. The traditional crop including rice and wheat seems quite unable to meet up the nutritional requirements to the increasing population. So, it is a time demand to introduce a new crop like maize to the existing cropping pattern of the country. Maize can be a potential grain crop for nutritional support to the country population. Moreover, the country environment is more suitable for cultivation of this crop. The economics related to maize cultivation need to be exposed among the farmers for its proper diffusion.

Maize production and yield has experienced an explosive growth in Bangladesh in recent years. The cropped area of maize has increased from only 2,654 ha in 1972 to 385200 ha in 2017; production from 2,249 ton to 3025392 M.ton; and yield from 0.85 t/acre to 7.76 t/ha during the same period. Maize has now positioned itself as the 1st among the cereals in terms of yield rate (7.76 t/ha) as compared to Boro rice (4.02 t/ha) and wheat (3.158 t/ha) (BBS, 2018). Maize possesses a wide genetic variability enabling it to grow successfully in any environment and in Bangladesh it is grown both in winter and summer time, although the former is the dominant pattern. Demand for maize is increasing worldwide and in Bangladesh and its production has crossed 92520 M. ton by 2017.

Several studies have also indicated that there may be significant efficiency differentials between different groups of farms and between different regions among all farms and it should be possible to improve the performance of the less efficient farms or regions without major investment from outside at least in the short run. The process of increasing output only by improving efficiency cannot continue indefinitely, since under perfect technically efficient conditions the frontier output level will be reached. A sound and realistic agricultural policy is one of the most important instruments through which agricultural production can be increased.

1.7 Objectives of the Study

The present study was undertaken to achieve the following objectives:

1. To identify the socio-demographic profile of maize farmers
2. To calculate the technical efficiency of maize cultivation.
3. To estimate the profitability from maize cultivation.
4. To address the problems facing by maize farmers and to suggest policy options to overcome these problems.

1.8 Justification of the Study

As an agro-based country, the overall economic growth of Bangladesh predominantly depends on the development of agriculture sector. The agro-climatic conditions of Bangladesh are conducive for the cultivation of a wide variety of crops but 74.85 percent of the gross cropped areas are at present confined to the production of rice. Due to increasing population, demand for other cereal crops increased significantly. Maize is an important cereal crop of Bangladesh widely grown in al the year round more or less.

The area of cultivable land for crop production decreasing but the area for maize production is increasing day by day though the rate of increasing is not satisfactory at all. The demand for maize is increasing as well as the production. Recently due to expand of dairy and poultry sector in our country the existing production of maize can unable to meet up the existing demand for maize. To lessen this gap between demand and supply of maize, the production must be increased. Huge foreign currency can be earned through the export of this potential cereal crop.

Prior to giving emphasis on the production of maize, it requires relevant and adequate information on different aspects of production at the farm level. Such knowledge of production is also necessary to make appropriate decision by the growers as they have to select enterprises within scarce resources.

Production of maize can be increased by increasing the technical efficiency of maize using existing technology. It is generally assumed that farmers are inefficient at producing maize crop and there are significance inefficiency differences among farm groups. Agriculture production policy in Bangladesh is concerned by lack of information about the relative profitability of different agricultural production. Though few investigation were conducted on maize in different areas of Bangladesh, there were no study on the technical efficiency or inefficiency as well as factors affecting the level of technical efficiency or inefficiency of maize producers in the areas selected by author. For this reason, the present study makes an attempt to analyze the profitability of maize production and to estimate the technical efficiency of maize producing farmers which depends on the different socio-economic variables.

Future policies to be taken by policy makers, research managers, NGOs and extension agents for the development of maize obviously benefit the farmers in terms of higher production, higher income, and creation of self-employment opportunity. So, further investigations were necessary to help the policy makers in coming to right conclusion and formulating appropriate policies.

1.9 Organization of the Study

This thesis contains a total of eleven chapters which have been organized in the following sequence. Chapter 1 reveals introduction of the study. The review of literature is presented in Chapter 2. Methodology of the relevant study is discussed in Chapter 3. A brief description of the study area is presented in chapter 4. Chapter 5 presents socio-demographic profile of maize farmers. Technical efficiency of maize farmers are estimated in chapter 6. Chapter 7 deals with profitability analysis of maize production. Chapter 8 presents findings of constrains to maize cultivation. Finally, Chapter 9 presents summary, conclusion and recommendations to increase productivity of maize in Bangladesh.

CHAPTER 2

REVIEW OF LITERATURE

This chapter reveals review of some related studies in connection with the present study. A limited number of socio-economic investigations were conducted on maize cultivation in Bangladesh, which revealed that it is a more profitable crop than rice (Hussain *et al*.1995), (Fokhrul, 1995) and mustard (Haque, 1999). Only a few studies were related to technical efficiency of Maize production in Bangladesh. Again, some of these studies may not entirely relevant to the present study, but their findings, methodology of analysis and suggestions have a great influence on the present study. Review of some research works relevant to the present studies, which have been conducted in the recent past, are discussed below.

Abawiera *et al.* (2016) examined the technical efficiency of maize production in Ghana using cross-sectional data collected from 576 maize farmers in the four main agro ecological zones of Ghana using structured questionnaire. Multi-stage sampling technique was employed in this study. Descriptive statistics and the stochastic frontier analysis were used for the analysis. The mean technical efficiency estimate for maize farmers in Ghana was 58.1 percent. The study also revealed that an increase in educational level, maize farming experience, extension contact as well as uses of fertilizer and improved seeds would increase the technical efficiency of maize producers in Ghana. Similarly, male Ghanaian maize farmers were technically more efficient than female farmers. Furthermore, membership of a farmer association had a statistical effect in increasing technical efficiencies. With an increase in farm size and land fragmentation decreased technical efficiency of the maize farmers.

Alam *et al.* (2012) estimated levels and determinants of farm-level technical efficiency of tilapia farmers of Bangladesh using stochastic frontier production function involving a model for technical inefficiency effects. Primary data from fifty tilapia farmers of Jessore district were used. The mean technical efficiency level of the tilapia farmers was 78 percent, and thus, the farmers operated 22 percent below the frontier production. Inefficiency effect was significant, and age, education, income, culture length, pond age, pond depth, water colour and pond tenure, as a group, were significant determinants of technical inefficiency. Tilapia yield can be improved from the current level of 7.36–8.96 tons per hectare by operating at full technical efficiency levels.

Ali *et al.* (2009) conducted the study on Maize-rice cropping systems in Bangladesh: Status and research needs. According to the study, Hybrid maize was an emerging high value cereal crop in Bangladesh, grown in intensive M-R cropping systems, and having among the highest average farm yields (5.7 t·ha-1) found in Asia. It was predicted that over the near future its expansion would continue to increase at about 15 percent per year. Maize-*T.* Aman rice is the major cropping system; however it is now becoming diversified with many other crops, including potato. Maize-rice cropping systems are expanding in Bangladesh. Bangladesh maize yields (with average farm yields around 5.7 t·ha-1) are among the highest found in Asia.

Baree (2012) measured the technical efficiency of onion (*Allium cepa* L.) farms in Bangladesh. A total of 225 sample farmers were selected, covering the 15 villages of Santhia Upazila of Pabna district. The elasticity of output with respect to land, labour, and capital cost were estimated to be positive values of 0.3026, 0.0718, and 0.0442, respectively, and also significant. With respect to seed and irrigation, it was found to be insignificant with negative values of 0.0045 and 0.0007. The coefficients of age, experience, and farm size were significant with expected negative signs, which means that the inefficiency effects in onion production decreases with increase in age, experience, and farm size. The technical efficiency of onion farms varied from 58 percent to 99 percent with mean value of 83 percent. It denotes that there is a scope to increase output per hectare of onion farm by 17 percent through the efficient use of production technology without incurring any additional costs.

Baree *et al.* (2011) assessed the technical efficiency of onion producing farms in Bangladesh. The coefficients of experience were significant with negative sign in small and medium farms. The coefficients of education were negative in small and medium farms and it was positive for large farm. The farm-specific technical efficiencies of onion producing small, medium and large farms varied from 55 percent to 99 percent, 57 percent to 99 percent and 56 percent to 99 percent with a mean technical efficiency of 77 percent, 87 percent and 84 percent respectively, which meant that without incurring any additional costs there was a scope to increase output per hectare of onion by 23 percent, 13 percent and 16 percent for small, medium and large farms respectively through the efficient use of existing production technology.

Begum *et al.* (2016) estimated a translog stochastic production function to examine the determinants of technical efficiency of freshwater prawn farming in Bangladesh. A total of90 farmers of three villages in southwestern (Fakirhat upazila in Bagerhat district) Bangladesh were selected randomly. Technical efficiency ranged from 9.50 to 99.94 percent with mean technical efficiency of 65 percent, which suggested a substantial 35 percent of potential output can be recovered by removing inefficiency.

Begum *et al.* (2010) analyzed the productivity of potato production. The per hectare potato production of the farmers of Lalmonirhat Sadar and Aditmari Upazila were 19897.88 and 21208.47 kg respectively. The benefit-cost ratio in Lalmonirhat Sadar and Aditmari Upazila were 1.52 and 1.56 respectively. The economic efficiency ranged from 81 to 99 percent at aggregate level, 97 to 99 percent in Lalmonirhat Sadar and 72 to 99 percent in Aditmari Upazila. The mean economic efficiencies were 98, 97 and 96 percent for Lalmonirhat Sadar, Aditmari Upazila and at aggregate, level respectively. Economic inefficiencies appeared to be 2, 3 and 4 percent for Lalmonirhat Sadar, Aditmari and all regions, respectively which indicated that the cost of production could be reduced on an average by 4percent keeping the output constant at the aggregate level.

Bempomaa and Acuah (2014) applied the single-stage modelling stochastic frontier approach to investigate the performance of maize farmers in the Ejura-Sekyedumase District of Ghana. Technical efficiency and its determinants for 306 maize farmers was estimated and found that land, labour and fertilizer influenced output positively whilst agrochemicals and seeds affected output negatively. On an average, farmers were 67 percent technically efficient, implying that 33 percent of maize yield was not realized. The return to scale which measures the productivity level of farmers was 1.22.

Ferdausi *et al.* (2014) undertook the study to estimate the profitability and resource use efficiency under different farm size groups of maize production.65 farmers were randomly selected from five villages of Bogra district for the study among them 30 were small, 30 were medium and 5 were large farmers. On an average per hectare total cost of maize production was estimated at Tk 46278 for all farmers and Tk 41263, 53554 and 48715 for small, medium and large farmers, respectively. Again, gross margins from maize production were estimated at Tk 67592, 64694 and 74089 for small, medium and large farmers, respectively.Net returns for the farm size groups of small, medium and large were calculated at Tk 57823, 53895 and 64138 per hectare, respectively. BCR was the highest (2.40) for the small farmers followed by medium (2.01) and large (2.32) farmers, respectively. Efficiency analysis indicated that most of the farmers inefficiently used their inputs.

Haque (2013) measured the technical efficiency of onion farmers and estimated the profitability of onion production in selected areas of two villages of Pabna district and two villages of Faridpur district. Primary data were collected from 150 farmers which constituted 75 farmers from each upazilas respectively. The Cobb-Douglas stochastic frontier production function was used for this study. The coefficients of parameters were highly significant and indicated positive effect on onion production. The significant value of γ and $\sigma 2$ indicates that there are significant technical inefficiency effects in the production of onion. Total cost of production, Gross returns and net returns were Tk. 40643.03 per hectare, Tk. 380423.04 and Tk. 174759.75 respectively. Per hectare yields of onion bulb and human labor used were found 13704.00 kg and 362 man-days respectively. Benefit Cost Ratio (BCR) was found to be 1.85 which implies that one taka investment in onion production generated Tk. 1.85.

Haque *et al.* (2012) measured the Profitability of hybrid maize (*zea mays* l.) Seed Production under contract farming in Bangladesh. The study was conducted with three categories of seed producers, namely BADC farms, LAL TEER Seed Company and BRAC farm. Data were selected randomly from 60 hybrid maize seed contract growers and 120 maize (Non-seed) growers for the study. The cost of production was found higher for NGO, the public agency and private company (Tk. 66472/ha), (64836/ha) and (Tk. 59352/ha) respectively. The yield of hybrid seed was higher under NGO (3780 kg/ha) than that of public agency and private company. Net return of hybrid seed production for contract growers was higher under public agency (Tk. 78204/ha) compared to private company (Tk. 39088/ha) and NGO (Tk. 33246/ha). Benefit cost ratio (BCR) was higher for the contract growers of public agency (2.21). Net return of hybrid maize seed production was 50percent higher than that of non-seed production.

Hasan *et al.* (2016) estimated the technical efficiency of Boro rice farms and determines the important factors affecting the level of technical inefficiency of the farms. Primary data were collected from 112 rice producing farms of Jhenaidah district using multistage random sampling technique and the Cobb-Douglas stochastic production frontier approach was employed. The technical efficiency of Boro rice production is on average 0.92 which indicated that the level of technical efficiency in the study area is high. Cost of labor, irrigation, seed and ploughing are the important factors for Boro rice production. Farm size, age, education, training and credit facility are the significant factors which are negatively related to technical inefficiency of Boro rice production.

Hasan (2014) carried out the study on economic efficiency and constraints of maize production in the northern Region of Bangladesh. The aim of the study was to estimate the costs, returns and economic efficiency of maize production compared to Boro rice.100farmers were selected randomly and all of them used hybrid seeds for maize cultivation with an average yield of 6.27 ton/ha, which is higher in Dinajpur (6.35 ton/ha) compared to Panchagarh district (6.18 ton/ha). The returns of scale of the selected inputs were 0.72 and 0.68 for Dinajpur and Panchagarh respectively. The technical efficiency was found on an average 0.84 at Dinajpur and 0.80 at Panchagarh. Comparatively high growth rate was found in area, production as well as in yield of maize since 1987-88 to 2005-06 as the composite and hybrid varieties were introduced in this period.

Hossain (2016) measured the technical efficiency of chili production in Bogra district (the largest produced area) of Bangladesh. A total of 50 chili growers were selected from the three villages Shibganj Upazila of Bogra districts. Cobb-Douglas type stochastic frontier production function was used in the study. The elasticity for land used for chili production was the largest (31.1434) and for the cost on insecticide is the lowest (0.0401). The average technical efficiency for the sample is about 88 percent. The estimated firm efficiency was near to one. Yet there was a scope for increasing chilli production by 12 percent by adopting the technology and the techniques.

Hossain *et al.* (2015) performed the study on Intercropping System of Maize with Different Winter Vegetables. The experiment was conducted at farmers' fields of Hqripur in Dauadkandi upazilla and experiment comprised of four treatments viz., Maize + Spinach, Maize + Red amaranth, Maize + Coriander and Sole maize with four replications .The experiment was laid out in Randomized Complete Block (RCB) Design with four replications. The data were analyzed following MSTATC program

(Gomez and Gomez, 1984).Each of maize- vegetables intercropping combinations showed superior in terms of gross return, net return, BCR and Maize equivalent yield (MEY) over sole cropping of maize. The highest grain yield of maize (9.61 t ha-1) was obtained from Maize + coriander and lowest (7.8 t ha-1) yield was received from the treatment of maize + red amaranth intercropping system. The highest Maize equivalent yield (12.85 t ha-1), gross return (Tk. 128500 ha-1), net return (Tk. 80080 ha-1) and BCR (2.65) were found in the intercropping system Maize + Spinach.

Hossain *et al.* (2008) assessed the Technical Efficiency of Potato Producers in three potato growing areas viz. Munshiganj, Bogra and Jessore covering 75 potato growers. Farmers obtained average tuber yield of 24.90 t/ha which was higher than the average yield of Bangladesh (14.90 t/ha) but close to potential yield (25-30 t/ha) of diamant and cardinal varieties. Gross margin and BCR for potato cultivation were Tk. 174319/ha and 2.40, respectively. The average level of technical efficiency among the sample farmers was 75 percent which implied that given the existing technology and level of inputs the output could be increased by 25 percent.

Hossain *et al.* (2002) undertook the study on impact of maize research and extension in Bangladesh. Economic Surplus Model with ex-post analysis was used to estimate the returns to investment on composite varieties and hybrids of maize that have replaced the local varieties for this study. The internal rate of return (IRR) to investment was calculated at 23 percent. The yield of composite varieties of maize ranged from 40 to 65 percent and hybrids ranged from 73 to 79 percent higher over the local varieties. The study indicated that the funding of maize research and extension was a good investment. Three periods were considered for the growth rate calculation of maize e.g. from 1980/81 to 1986/87, from 1987/88 to 2000/01 and from 1980/81 to 2000/01.The annual rates of growth in area, production and yield of maize were 11.29, 17.79 and 6.50 percent respectively for the above three periods.

Huq and Arshad (2010) assessed the technical Efficiency of Chili Production. A total of 100 chili growers were selected from six villages of Jamalpur districts. The Cobb-Douglas stochastic production frontier model was used to analyze the data. The net return against cultivating of chili was Tk 73,164 per hector while the Benefit Cost Ratio (BCR) was 1.93.The study revealed that cultivation of chili is highly profitable and for chili all of the farmers were found to have produced outputs which were not very close to the maximum frontier outputs (efficiency levels varying from 11-96 percent and their mean efficiency was 77 percent).On an average, 23 percent technical inefficiency appears which implies that the output per farm can be increased on an average by 23 percent through chili production using the prevailing technology.

Islam *et al.* (2011) attempted to determine the productivity, profitability and resource use efficiency of four promising spices crops such as garlic, chilli, ginger and turmeric. Cobb-Douglas Stochastic Frontier Production Function was used to measure the technical efficiency of 480 farm households in the crop year 2010-2011.Production of selected spices were profitable as farmers earned higher level of net returns from spices they produced The average estimated technical efficiencies for garlic, chilli, ginger and turmeric were respectively 88, 80, 69 and 79 percent which indicated that garlic production could be increased by 12 percent, chilli by 20 percent, ginger by 31 percent and turmeric by 21 percent with the same level of inputs without incurring any additional cost.

Kabir *et al.* (2015) Conducted the study is to estimate the impact of bioslurry to Boro rice production in Bangladesh. Translog production function through Stochastic Frontier Apoproach (SFA) was applied for estimating the efficiency of Boro production of four district of Bangladesh: Mymensingh, Pabna, Thakurgaon and Dinajpur. The impact of slurry variables had impact on farm technical efficiency. Slurry showed a positive significant relationship with biogas user by which households can have increase the total output.

Kamruzzaman and Islam (2008) estimated the technical efficiency and factors affecting inefficiency of wheat production in Dinajpur District of Bangladesh. The data were collected from 01 July to 30 September 2004. A total of 60 farmers were selected for the study using random sampling technique. Among the randomly selected 60 farmers, 30 were small, 15 were medium, and 15 were large. The range of technical efficiency varied from 40 percent to 99 percent and the average was 70.33 percent. Farmers with optimum sowing and optimum harvest were technically more efficient than the farmers with late sowing. In all farms technical efficiency was much higher for the farmers who use sandy loam soil for wheat production than the farmers who did not use sandy loam soil. There was a positive relationship between the educational level and technical efficiency of wheat practicing farmers. The farmers who contacted frequently with extension workers were technically more efficient than who contacted less with extension workers.

Karim *et al.* (2010) assessed the Economics of hybrid maize production in some selected areas of Bangladesh. A total of 120 farmers were selected randomly from four districts, namely Rangpur, Dinajpur, Bogra, and Kushtia. Cobb-Douglas production model was used for the study. The average seed rate was found to be 20.94 kg per hectare. The cost per kilogram of maize cultivation was Tk. 4.12. And return from one kilogram of maize production was calculated as Tk. 7.80.The average price of grain was Tk. 7.60 per kilogram. The average gross margin was observed to be Tk. 28456.benefit cost ratio was found to be Tk. 1.89. It indicated that for every one taka investment, the farmer will get Tk. 1.89.It is found that the coefficient of human labour, land preparation, irrigation, urea and borax have significantly impact on gross return.

Khandoker *et al.* (2018) conducted a study on Profitability of winter maize cultivation in drought prone areas of Bangladesh. A total of 200 farmers were taken among which 50 from each district were selected randomly for the study. Per hectare total cost of maize cultivation in drought prone areas and normal environment were found Tk. 92,582 and Tk. 79,594 respectively. Per hectare average yield were 7576 kg and 8729kg in drought prone and normal areas respectively. Per hectare net return of maize were Tk. 28,062 and Tk. 59,871; benefit cost ratio (BCR) were 1.31 and 1.75 in drought prone and normal areas respectively. Maize production was decreased by 22.4 percent in drought prone areas than normal environment according to semi-logarithmic regression model used.

Mango *et al*. (2015) analyzed the technical efficiency of maize production in Zimbabwe's smallholder farming communities following the fast-track land reform of the year 2000 with a view to highlighting key entry points for policy. Random sample of selected 522 smallholder maize producers were taken for his study, a stochastic frontier production model was applied, using a linearised Cobb–Douglas production function to determine the production elasticity coefficients of inputs, technical efficiency and the determinants of efficiency. According to his study, maize output responded positively to increases in inorganic fertilisers, seed quantity, the use of labour and the area planted. About 90 percent of farmers in the sample were between 60 and 75 percent efficiency, with an average efficiency in the sample of 65 percent. The significant determinants of technical efficiency were the gender of the household head, household size, frequency of extension visits, farm size and the farming region. The results implied that the average efficiency of maize production could be improved by 35 percent through better use of existing resources and technology.

Memon *et al.* (2016) analyzed the technical efficiency of hybrid maize production in Mirpurkhas district of Sindh province during the year 2014-15. A four stage sample design was used for collection of information from the field. 100 farmers were selected from the twelve villages, 5 farmers from each village Cobb-Douglas production function was used to find out the responsiveness of dependent variable (yield) to independent variables (fertilizer, animal labor, human labor, water application, pesticide application, number of plowing, weeding, farmyard manure, seed rate application and other inputs for maize crop. Technical efficiency for maize farms in sample area was 0.48 and most of the farms were technical inefficient below 0.50. The values of overall technical efficiency maize farmers ranged from 0.177 to 0.980. This implies that there is significant scope to increase efficiency levels. The frequencies of technical efficiencies indicated that sample farmers were categorized in three efficiency groups with low (<90 percent), medium (90-95 percent) and high (>95 percent) efficiency and assessed that 90 percent of the maize farms had low efficiency (<90 percent) and remaining 10 percent were highly efficient (above 95 percent) in district Mirpurkhas.

Mohiuddin *et al.* (2007) calculated the efficiency and sustainability of maize cultivation in an area of Bangladesh. About 60 maize growing farmers, of which 34 is small, 20 medium and 6 large categories of farmers from four villages at the sadar upazila of Kishoreganj district were surveyed. Exponential growth rate model, (using semi log) ordinary least square (OLS) and frontier production function were used to get result. Per hectare yield of maize was 4.70 tons and the average gross margin on TVC basis and on cash cost basis it were Tk. 18047/ha and Tk. 26887/ha respectively. It was found that the average returns to labour and benefit cost ratio (BCR) were Tk. 109.52/man-day and 1.37 on full cost basis. The findings also revealed that the farmers in the study area have failed to show their efficiency in using the resources but the farmers was obtained technical efficiency (98 percent).

Moniruzzaman *et al.* (2009) carried out the study on Agro-economic analysis of maize production in Bangladesh. Four major maize growing areas namely Chuadanga, Dinajpur, Bogra and Lalmonirhat were taken to know profitability level of maize production. The selected four districts covered 61 percent of total maize areas of the country. From 200 randomly selected maize growers the average yield and costs were found to be 8.00 Tk/ha and Tk 44197 per hectare. The gross margin, net return and benefit cost ratios were calculated as 36578/ha, Tk 25575 per hectare and 1.58 respectively. Maize cultivation was found to be more profitable from the study.

Mulinga (2013) estimate the level of technical efficiency in maize production in Musanze and Bugesera districts of Rwanda. Primary data were collected from random sample of 276 farmers through face-to-face interviews using multi-stage and pre-tested questionnaires. The Stochastic Production Frontier (SPF) analysis was used to estimate the technical efficiency of producing maize, and to determine the factors behind inefficiency such as age, educational level, marital status, family size, main occupation, type of seeds, and extension services. Also, descriptive statistics were used to analyze the socio-economic characteristics of farmers. The mean technical efficiency for maize production in both districts was 27 percent which means that farmers can increase their output by 34 percent, through better use of available resources and existing technology if they are to be technically efficient. Only two district were taken for the study to draw inferences on whole population. Apart from technical efficiency, other economic analysis could be done to get better result from the data set.

Musaba *et al. (*2014) examined technical efficiency of smallholder maize farmers in Zambia. Data were collected using a structured questionnaire from 100 randomly selected smallholder maize farmers in Masaiti district in Zambia. Descriptive statistics and a stochastic frontier production function approach were used to analyze the collected data. The estimated stochastic frontier Cobb-Douglas production function showed that maize land size and fertilizer were the significant factors that affected maize production. Farm level technical efficiency ranged between 52.2 percent and 93.2 percent with a mean of 79.6 percent. From their study, there was potential to increase maize production among smallholder farmers in the study area by 20.4 percent through efficient use of present technology. The results of the inefficiency model indicated that age of farmer, cooperative membership which implies access to fertilizer, and farm size, have significant positive effects of efficiency. The seed types used, rotation practices, and education level of the farmer had negative effects on technical efficiency. He only analyzed technical efficiency of smallholder maize farmers. Same model could be used for medium to large size farmers and profitability could also be calculated for better understanding.

Rahman *et al.* (2016) assessed the Competitiveness, Profitability, Input Demand and Output Supply of Maize Production in Bangladesh. A total of 165 farmers were selected from two major maize growing areas (i.e., Dinajpur and Lalmonirhat districts) of northwestern Bangladesh. Policy Analysis Matrix (PAM) and translog profit function were used for the study. Maize production is profitable at the farm level (Benefit Cost Ratio = 1.21) and also competitive globally. Maize farmers are also responsive to changes in market prices of inputs and outputs which implies that a 1percent increase in maize price will increase output supply by 0.4 percent. Land was the most dominant driver of maize supply and other input demands that is a 1 percent increase in available land will increase maize supply by a substantial 3.9 percent.

Rahman *et al.* (2013) Estimated Technical Efficiency of Maize Production in A Selected Area of Bangladesh. Natore district was purposively selected for the study. From three villages a total of 60 maize growing farmers were selected randomly for data collection taking 20 farmers each village. The Cobb-Douglas stochastic frontier production function was used to analyze productivity and resource use efficiency of Maize production. From the study, maize production was found profitable as benefit cost ratio (BCR) and net return from maize production on an average were 1.54 and Tk. 28340. The technical efficiency of maize farmers was very high (96.90 percent) that is the farmers were more efficient in maize production and the output per farm can be increased, on an average, only 3 percent without incurring additional production cost.

Roy *et al.* (2017) assessed the growing popularity of maize cultivation in rangpur district of Bangladesh: an evidence from gangachara upazila. The study attempted to explore the reasons for the growing popularity of maize cultivation in the Gangachara upazila (Sub-district) of Rangpurdistrict. Three-stage cluster sampling method was used to collect data from110 farmers who have been involving themselves in maize cultivation for at least ten years. Two types of crop pattern were found and they are Potato-Maize-Aman and Maize-Aus6-Aman between these Potato-Maize-Aman crop was more popular. B-C ratio for maize, boro rice, and tobacco cultivation were 1.40, 0.68 and0.75 respectively. If the production cost of maize is Tk 1then it brings Tk. 1.40 from the market i.e. it creates a profit of Tk. 0.40 for the investment of Tk. 1.

Thabethe *et al.* (2014) measured the productive efficiency (technical, allocative and economic) levels of 231 small-scale sugarcane farmers in the Mpumalanga Province of South Africa using the stochastic frontier production function. A random sampling procedure was employed in selecting the respondents for this study. A total of 231 farmers were interviewed. From their study, the results indicated the sugarcane farmers lack technical, allocative and cost efficiencies. The mean technical, allocative and cost efficiency estimates are 68.5, 61.5 and 41.8 percent respectively. The study concluded that farmer education, land size, farming experience, and age contributed significantly and positively to productive efficiencies. Though his sample size was large enough to draw results and inferences. It is impossible to get a clear picture about the profit and loss of sugarcane production in that area from this study.

Uddin *et al.* (2017) estimated the efficiency of maize production in Bangladesh: a stochastic Frontier approach. Primary data have been collected from 120 maize farmers from Thakurgaon district of Bangladesh as this area encompasses the highest concentration of maize cultivation. The Translog Stochastic Frontier production function is applied to estimate the technical efficiency of both Rabi and Kharif seasons' maize. According to this study maize production in Thakuegaon was not technically efficient and 12.5 percent and 8percent production may be increased in Rabi and Kharif seasons, respectively, with the present level of technology. The mean technical efficiency is found as 87.5 percent in the case of Rabi season maize, whilst it is 92 percent for Kharif season maize where Rabi season was positively influenced by fertilizer and irrigation while it was negatively influenced by farm size. Again, farm size shows positive effect and irrigation shows negative effect on Kharif season maize production.

Uddin *et al.* (2010) conducted the study to estimate the relative profitability of Maize production under different farm size groups. A total of 74 maize growing farmers were selected randomly of which 25 were small, 32 were medium and 17 were large considering the scope and potentials of maize production from three villages under Pakundia thana of Kishoregonj district. Per hectare average total costs were Tk. 30,147.54, Tk. 31,892.00 and Tk. 34,059.00 for small, medium and large farmers, respectively. Per hectare gross return from maize production were Tk. 61,730.00, Tk. 79,716.00 and Tk. 75,707.00 for small, medium and large farmers, respectively. Per hectare gross margins from maize production was estimated at Tk. 36,836.00, Tk. 53,096.00 and Tk. 46,871.00 for small, medium and large farmers, respectively. Per hectare average net returns of maize were estimated at Tk. 31,583.00, Tk. 47,823.00 and Tk. 41,648.00 for small, medium and large farmers, respectively.

Wongnaa (2016) examined the economic efficiency and productivity of maize farmers to shed light on the causes of low productivity of maize in Ghana. Multi-stage sampling technique was employed to collect cross-sectional data from 576 maize farmers in eight districts in four agro ecological zones of Ghana. Multinomial logit model and the stochastic frontier production function were used to analyse the data and reveal results. The study revealed that an increase in educational level, credit, extension contact, experience, price of maize, group membership and ready market would increase use of maize productivity enhancing technologies. Fertilizer, pesticides, manure, herbicide, seed and land inputs were found to be positively related to maize output. Technical efficiency scores were 61.2 percent, 70.2 percent, 49.9 percent and 66 percent for maize farmers in the northern savannah, transitional, forest and coastal savannah zones respectively, it is most economical to produce maize in the transitional belt of Ghana. Overall mean scale efficiencies were 85.7 percent, 90.9 percent, 88.6 percent and 85.5 percent for maize farmers in the northern savannah, transitional, forest and coastal savannah zones respectively.

Zheng (2013) examined technical efficiency using frontier efficiency estimation techniques from parametric and non-parametric approaches. Five different frontier efficiency estimation techniques are considered which were SFA, DFA, DEA-CCR, DEA-BCC and DEA-RAM. These techniques were then used on an artificially generated panel dataset using a two-input two-output production function framework based on characteristics of German life-insurers. The study used simulated panel dataset to estimate frontier efficiency techniques and secondly compared multiple frontier efficiency techniques across parametric and nonparametric approaches in the context of simulated panel data. Parametric and non-parametric approaches can both generate comparable technical efficiency scores with simulated data. Techniques from parametric approaches, i.e. SFA and DFA were consistent with each other whereas the same applies to nonparametric approaches, i.e. DEA models.

CHAPTER 3
METHODOLOGY

3.1 Introduction

The methodology of the study is adopted by various steps to select the best method fit to attain the set objectives of research. Methodology is an indispensable and integral part of any study. The reliability of a specific study finding depends to a great extent on the appropriate methodology used in the study. The methodology is the general research strategy that outlines the way in which research is to be undertaken and, among other things, identifies the methods to be used in it. Methods, described in the methodology, define the means or modes of data collection or, sometimes, how a specific result is to be calculated. The author has great responsibility in describing clearly what sorts of method and procedure is to be followed in selecting the study areas, the sources of data and the analyses as well as interpretations to arrive at a meaningful conclusion. This study was carried out by using a primary data collection from selected maize producers in selected areas of Bangladesh for estimation of technical efficiency and profitability of maize production. A chronological description of the methodology used for this study is presented below.

3.2 Sampling Frame

The sampling frame for the present study were selected purposively to select the area where the maize cultivation was intensive. On the basis of higher concentration of maize crop production, six villages namely Jhitka kolahata, Jhitka moddho para, Nouhata, Jhitka thakur para, Jhitka bepari apra, Dakkhain gorail under Harirampur upazila in Manikgonj district and four villages namely Bausha hedati para, Khurdo bausha , Tethulia, and Pirgacha under Bagha upazila in Rajshahi district were selected for the study. The main considerations in selecting the study areas were as follows-

i. A large number of maize growers are available and maize grows well and farmers use a good portion of their land for producing maize in these study areas.

ii. These villages had some identical characteristics like topography, soil and climatic conditions for producing maize.

iii. Easy accessibility and good communication facilities in these villages.

iv. The researcher was familiar with the local language and other socio- economic characteristics of the farmers in the selected villages and the anticipated cooperation from respondents was high which indicated the likelihood of obtaining a reasonably accurate set of data.

v. To conduct a socioeconomic study in these study areas.

3.2.1 Sample Size

Sampling is a crucial part of any research work. Survey area and sample size was selected considering time and money constrain. The larger the sample size, the lower the error and the higher the accuracy of the result in case of drawing inferences of the population as a whole based on sample. A sample size of 60 is generally regarded as the minimum requirement for larger population that will yield a sufficient level of certainty for decision-making (Poate and Daplyn, 1993). A sample size of 131 (65 from Manikganj and 66 from Rajshahi districts) maize farmers in the study area was determined by using statistical formula (Arkin & Colton 1963). The total number of household in Harirmpur and Bagha upazila were 33513 (BBS, 2013a) and 46711 (BBS, 2013b) respectively according to population census 2011.

3.2.2 Sample Selection Procedure

For this study farm level data are collected from every respondent directly through interview method. Simple random sampling is the best way to avoid biasness in the sample selection process as each unit of the population has an equal chance for selection (Scheaffer, 1979). Simple random sampling technique was used in sampling maize farmers. This study used farm-level, cross-sectional data for the year 2018, for maize crop selected from two districts. Villages from two upazilas were selected purposively from each district considering maize productivity of last 10 years. Then villages were selected from each of the upazila by simple random sampling method and the ultimate sampling units (Households) were selected by random sampling method.

3.3 Data Collection Procedure

Primary data has been collected through field survey and direct interview method from maize producers. The collected data were regarding socio economic factors of farmers, maize production practices, input use, labor utilization, output, cropping pattern of the study are, natural and socio-economic constraints, prices and market activities. Field survey, review of previous studies, and interviews with knowledgeable maize producers, and also direct observation were conducted by the researchers.

3.3.1 Design of Questionnaire

Semi structured questionnaire were developed for collecting appropriate information from respondents. As the survey mainly depends upon the preparation of the survey schedule, therefore, firstly a draft questionnaire was prepared for pre-testing to verify the relevancy of the questions and nature of response of the farmers. Final survey schedule and questionnaire were developed after pre-testing with necessary correction, modification and adjustment. In this study the questionnaires were designed with the following heads-

3.3.2 Questionnaire Pattern for Maize Producers

A) General information of the sample farmers;

B) Family composition of the sample farmers, no of members engaged in farming.

C) Age of farmer and years of experience in farming.

D) Occupational and educational status of sample farmers;

E) Information about total land, cultivable land, orchard, pond, leased land;

F) Production cost of maize;

G) Amount of yield obtained from maize and selling price of output.

H) Training and loan facility for maize production;

I) Cropping pattern of the study area;

J) Problem faced by the farmers in producing maize.

3.3.3 Data Collection Techniques

Required Data were collected by the researcher with semi-structured questionnaire from primary source and secondary sources. Interviews and survey methods were carried out to fulfil the objectives of the study. After fixing the survey schedule, field level primary data were collected from the farmers through direct interview. Brief description of the purpose of the study was disclosed to the farmers before starting. Respondents were ensured that their provided information would be remained secret. Due to the unavailability of producers' records regarding farm activities, researchers have to rely on memory recall for basic information such as labor use, wages, input costs. Data were recorded in interview period and information was checked carefully. Secondary data had been collected from various research documents and papers like-

- ✓ Statistical Yearbook of Bangladesh,
- ✓ Bangladesh Economic Reviews,

- ✓ Related published papers, books,
- ✓ Website of Bangladesh Bank (BB)
- ✓ MS thesis of Sher-e-Bangla Agricultural University
- ✓ The national and international journals, articles and publications and
- ✓ Internet

3.4 Period of Data Collection

Farming is seasonal enterprise. Maize can be planted in two cropping seasons e.g. Rabi and Kharif I. Farmers generally plant maize in November and February to March, harvest after five to six months in Rabi season and three or four months in Kharif I based on the weather condition and type of soil and land. Data for the present study were collected during the period of September to December 2018 by the researcher herself with the help of agricultural extension officer of respective area.

3.5 Processing, Editing and Tabulation of Data

The research title was interesting and challenging. Data collection procedure was too challenging too. The collected data were checked and verified for the sake of consistency and completeness. Editing and coding were done before putting the data in computer. After completion of data collection, raw data were edited, coded and inserted in computer using the concerned software Microsoft Excel. Two different statistical software were used to analyze the collected data e.g. SPSS and STATA. Descriptive analysis was completed with the help of SPSS and data were presented in the tabular and graphical form, because these were of simple calculation, widely used and easy to understand. Besides, functional analysis was also adopted to arrive at expected findings. Technical efficiency analysis of data was done using the concerned software Microsoft Excel and statistical package STATA.

3.6 Analytical Techniques

Data were analyzed with a view to achieving the objectives of the study. Several analytical methods were employed in the present study. Tabular method was used for a substantial part of data analysis. This technique was used for its inherent quality of purporting the actual picture of the farm economy in the easiest form. Relatively simple statistical techniques such as percentage and arithmetic mean or average were employed to analyze data and to describe socioeconomic characteristics of maize growers, input use, costs and returns of maize production and to calculate undiscounted benefit cost ratio (BCR). In order to estimate the level of technical efficiency in a manner consistent with the theory of production function, Cobb-Douglas type stochastic frontier production function will be used in the present study.

3.6.1 Economic Profitability Analysis

The net economic returns of maize were estimated using the set of financial prices. The financial prices were market prices actually received by farmers for outputs and paid for purchased inputs during the period under consideration in this study. The cost items identified for the study were as follows-

- Land preparation
- Human labour
- Seed
- Fertilizer
- Insecticide
- Irrigation
- Interest on operating capital
- Land use

The returns from the crops were estimated based on the value of main products. In this study variable cost, fixed cost and total cost had been described. Total variable cost (TVC) included land preparation, human labour, seed, fertilizers (e.g. urea, TSP, MoP), insecticides, irrigation and interest on operating capital. Fixed cost (FC) included only rental value of land. Total cost (TC) included total variable cost and fixed cost.

3.6.1.1 Cost of Land Preparation

Land preparation considered one of the most important components in the production process. Land preparation for maize production included ploughing, laddering and other activities needed to make the soil suitable for planting seedling. It was revealed that the number of ploughing varied from farm to farm and location to location.

3.6.1.2 Cost of Human Labour

Human labour cost was considered one of the major cost components in the production process. It is generally required for different operations such as land preparation, sowing and transplanting, weeding, fertilizer and insecticides application, irrigation, harvesting and carrying, threshing, cleaning, drying, storing etc. In order to calculate human labour cost, the recorded man-days per hectare were multiplied by the wage per man-day for a particular operation.

3.6.1.3 Cost of Seed

Cost of seed varied widely depending on its quality and availability. Market prices of seeds of respected maize were used to compute cost of seed. The total quantity of seed needed per hectare was multiplied by the market price of seed to calculate the cost of seeds for the study areas.

3.6.1.4 Cost of Urea

Urea was one of the important fertilizers in maize production. The cost of urea was computed on the basis of market price. In order to calculate cost of urea the recorded unit of urea per hectare were multiplied by the market price of urea.

3.6.1.5 Cost of TSP

The cost of TSP was also computed on the basis of market price. In order to calculate cost of TSP the recorded unit of TSP per hectare were multiplied by the market price of TSP.

3.6.1.6 Cost of MoP

Among the three main fertilizers used in maize production, MoP was one of them. To calculate the cost of MoP per hectare, the market price of MoP was multiplied by per unit of that input per hectare for a particular operation.

3.6.1.7 Cost of Insecticides

Farmers used different kinds of insecticides for 2-3 times to keep their crop free from pests and diseases. Cost of insecticides was calculated based on the market price of the insecticides which was used in the study areas per hectare.

3.6.1.8 Cost of Irrigation

Water management helps to increase maize production. Cost of irrigation varies from area to area. It was calculated based on how many times irrigation needed per hectare and how was its cost.

3.6.1.9 Interest on Operating Capital

Interest on operating capital was determined on the basis of opportunity cost principle. The operating capital actually represented the average operating cost over the period because all costs were not incurred at the beginning or at any single point of time. The cost was incurred throughout the whole production period; hence, at the rate of 10 percent per annum interest on operating capital for four months was computed for maize. Interest on operating capital was calculated by using the following formula:

$IOC = AIit$

Where,

IOC= Interest on operating capital

i= Rate of interest

AI= Total investment / 3

t = Total time period of a cycle

3.6.1.10 Land Use Costs

Land use cost was calculated on the basis of opportunity cost of the use of land per hectare for the cropping period of four months. So, cash rental value of land has been used for cost of land use.

3.6.1.11 Calculation of Returns

3.6.1.11.1 Gross Return

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

Gross Return= (Quantity of the product * Average price of the product) + Value of by product.

3.6.1.11.2 Gross Margin

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

Gross margin = Gross return – Variable cost

3.6.1.11.3 Net Return

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

Net return = Total return – Total production cost

The following profit equation was used to assess the profitability of maize production at the farm level:

$$\pi = P_r Q_r + P_b Q_b - \sum_{i=1}^{n} (P_{xi} X_i) - \mathrm{TFC}$$

Where,

π = Profit per hectare for producing maize

P_r = Per unit price of maize (Tk. /Kg)

Q_r = Quantity of maize (Kg/ha)

P_b= Per unit price of by-products (Tk. /kg)

Q_b= Quantity of by-products (Kg/ha)

P_{xi}= Per unit price of the ith (Variable) inputs (Tk. /kg)

X_i = Quantity of the ith inputs (Kg/ha)

i = 1, 2, 3………..n and

TFC = Total fixed cost

3.6.1.11.4 Undiscounted Benefit Cost Ratio (BCR)

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

$$\text{BCR} = \frac{\text{Total Return (Gross Return)}}{\text{Total Cost}}$$

3.6.2 Technical Efficiency Analysis

Technical efficiency is one of the component of productive efficiency The ability to minimize wastages by producing as much output by given level of inputs or by using as little input to produce given level of output is known as the technical efficiency component. Among many researchers, Debreu (1951) and Farrel (1957) introduced a measure of technical efficiency. Based on Farrel (1957), measure of technical efficiency can be obtained by using input and output quantity without introducing prices of these inputs and outputs. As technical efficiency is one component of overall economic efficiency, a firm must first be technically efficient in order to be economically efficient.

3.6.2.1 Specification of Production Model

The stochastic frontier production method was adopted to estimate the technical efficiency of maize production in the study area. This model is appropriate because agricultural production in general exhibits shocks, and hence there is a need to separate the influence of stochastic variables (random shocks and measurement errors) from resulting estimates of technical inefficiency (Battese, 1992).The Stochastic Frontiers production method was proposed for the first time by Aigner (1977) and Meeusen, and Broeck (1977). The stochastic frontier model can be generally represented as:

$Y_i = f(X_i;B) \exp (V_i – U_i)$ (3.1)   where i = 1, 2,…,n

Where:

Y_i = output of the ith farm

X_i = Vector of input quantities used by the ith farm

B = Vector parameters to be estimated

V_i- U_i = Composite error term.

V_i denotes the random error not under the control of the famers, assumed to be independently and identically distributed as N (0, σ_u^2), independent of U, which is the non-negative random variable associated with technical inefficiency and is identically and independently distributed as a truncated normal, with truncations at zero of the normal distribution (Battese and Coelli, 1995).

Battese and Coelli (1995), proposed a model in which the technical inefficiency effects in a stochastic production frontier are a function of other explanatory variables. The technical inefficiency model, U_i is defined as:

$u_i = \delta_0 + \sum_{i=1}^{n} \delta_i Z_i$ (3.2)

Where Zi represents the vector of farm-specific variables and δ_0 is a vector of unknown coefficients of the farm specific inefficiency variables both the unknown parameters to be estimated.

The technical efficiency (TE) of an individual farm is defined in terms of the ratio of the observed output (Y_i) to the corresponding frontier output (Y*), conditioned on the level of inputs used by the farm and mathematically expressed as:

$TE = Y_i / Y_i^*$ (3.3)

TE= f(X_i;B) exp (V_i – U_i) / f(X_i;B) exp (V_i) (3.4)

TE = exp (-U_i)

Any farmer who is fully technically efficient will have a value of one and farmers with values lying between zero and below one are said to be technically inefficient. The frontier production function is estimated by the Maximum Likelihood technique which yields estimators for β, λ and σ where β was defined earlier,

$\lambda = \sigma_u^2 / \sigma^2$ and $\sigma^2 = \sigma_u^2 + \sigma_v^2$.

The parameter γ represents total variation of output from the frontier that is attributed to technical inefficiency and it lies between zero and one, that is $0 \leq \gamma \leq 1$.

3.6.2.2 Empirical Model

For the investigation of the technical efficiency and factors affecting efficiency of maize producers in Harirampur and Bagha upazilas under Manikgonj and Rajshahi district, a Cobb-Douglas production function was adopted. For this study the following Cobb-Douglas stochastic frontier production function was specified in order to estimate the level of technical efficiency. The functional form of stochastic frontier is as follows:

$$Y = \beta_0 \, X_1\beta_1 \, X_2\beta_2 \, \ldots\ldots\ldots X_5\beta_5 \, e^{Vi-Ui} \qquad (3.5)$$

The above function is linearized double-log form:

$$\ln Y = \ln\beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + Vi-Ui \qquad (3.6)$$

Where,
Y = Output (kg/ha)
X_1 = Human labour (man days/ha)
X_2 = Land preparation cost (Tk./ha)
X_3= Seed (Kg/ha),
X_4 = Fertilizer (kg/ha)
X_5 = Irrigation cost (Tk./ha).

The technical inefficiency model based on Battese and Coelli (1995) was specified as:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + W_i \qquad (3.7)$$

Where,
Z_1…….. Z_5 are explanatory variables.
The equation can be written as:

$$U_i = \delta_0 + \delta_1 \text{Education} + \delta_2 \text{Maize farming experience} + \delta 3 \text{ Extension service} + \delta 4 \text{ Training} + \delta 5 \text{ Farm size} + W_i \qquad (3.8)$$

Where, W_i is two-sided uniform random variable having a positive half normal distribution. The model was estimated simultaneously using statistical package STATA version 14. This software has the advantage of allowing simultaneous estimation of the production function coefficients and those of the technical inefficiency model.

The β and δ coefficients of unknown parameters to be estimated together with the variance parameters which are expressed in terms of

$\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \sigma_u^2/\sigma^2$

The value of γ lies between zero and one, that is $0 \leq \gamma \leq 1$.

CHAPTER 4
DESCRIPTION OF THE STUDY AREA

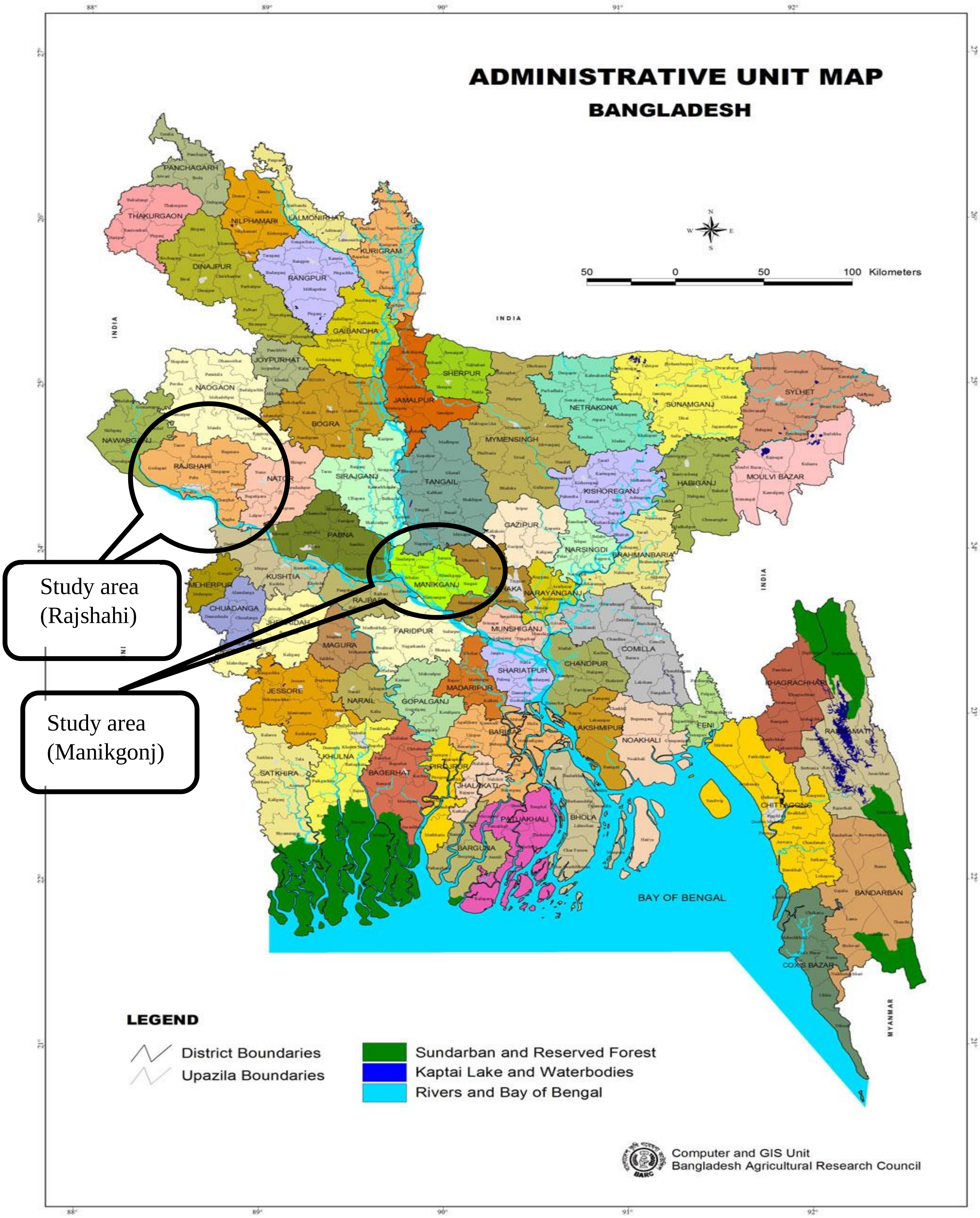
4.1 Introduction

For any research, to know the physical feature of the study area is crucial because it provide overall scenario of agriculture. A short overview of features of the study area has been presented in this chapter. The knowledge of the study area is essential to understand and interpret the findings of the study and also to know the agricultural activities, possible development opportunities and potentials of the study area. Location, area, population, monthly average temperature and rainfall, agriculture, occupation, cropping patterns, communication and marketing facilities of the study area are discussed in this chapter. However, for the production of any crop, to know the climate and topography of the study areas is very essential.

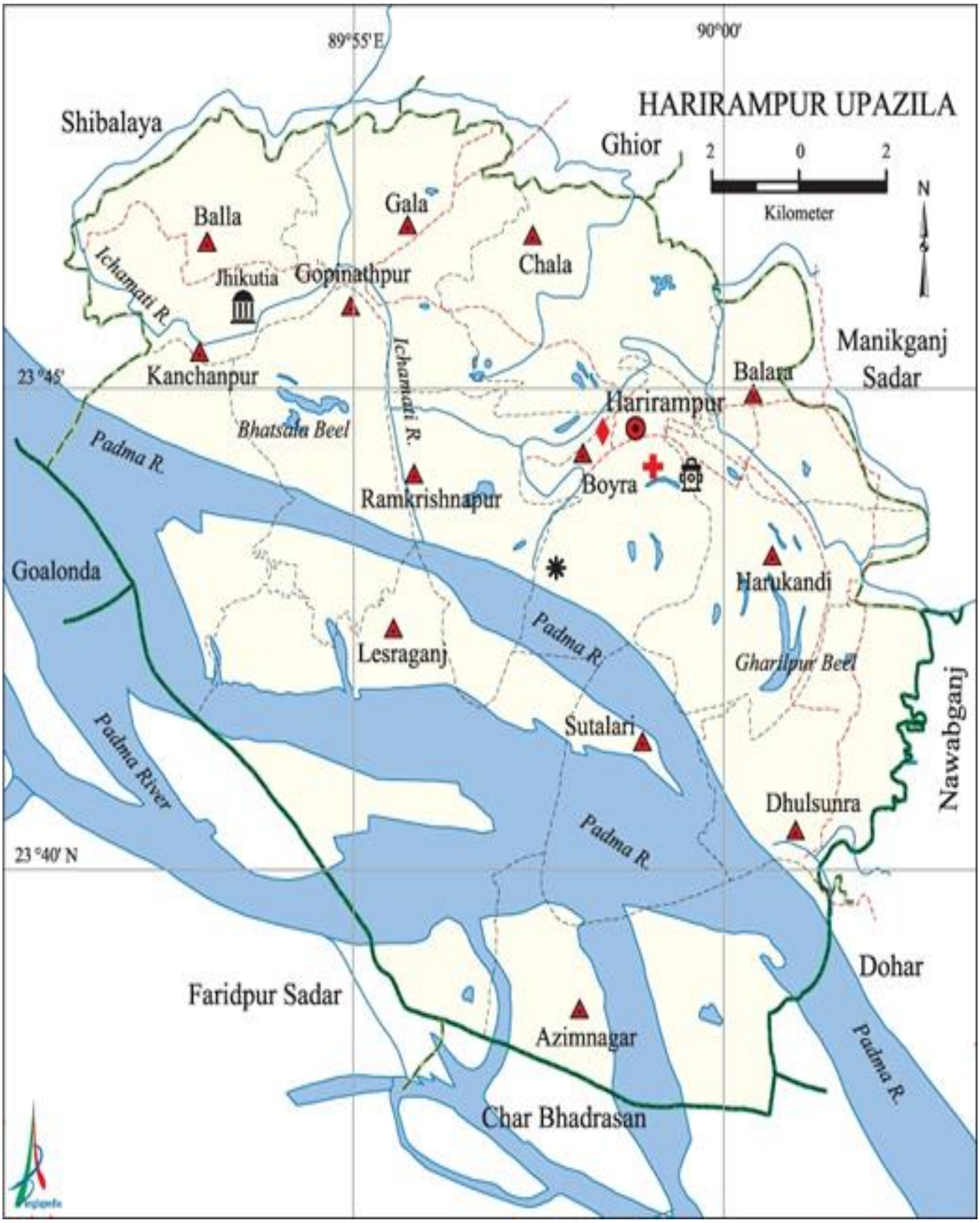
4.2 Location

Harirampur upazila (manikganj district) area 245.42 sq km, located in between 23°38' and 23°48' north latitudes and in between 89°50' and 90°03' east longitudes. It is bounded by shivalaya, ghior and manikganj sadar upazilas on the north, char bhadrasan faridpur sadar upazilas on the south, manikganj sadar, nawabganj (Dhaka) and dohar upazilas on the east, shibalaya, goalanda and faridpur sadar upazilas on the west (BBS, 2013). Bagha Upazila (rajshahi_district) area 184.25 sq km, located in between 24°07' and 24°19' north latitudes and in between 88°44' and 88°55' east longitudes. It is bounded by charghat and bagatipara upazilas on the north, daulatpur (kushtia) upazila on the south, lalpur and Bagatipara upazilas on the east, west bengal (India) and Padma river on the west (BBS, 2013).

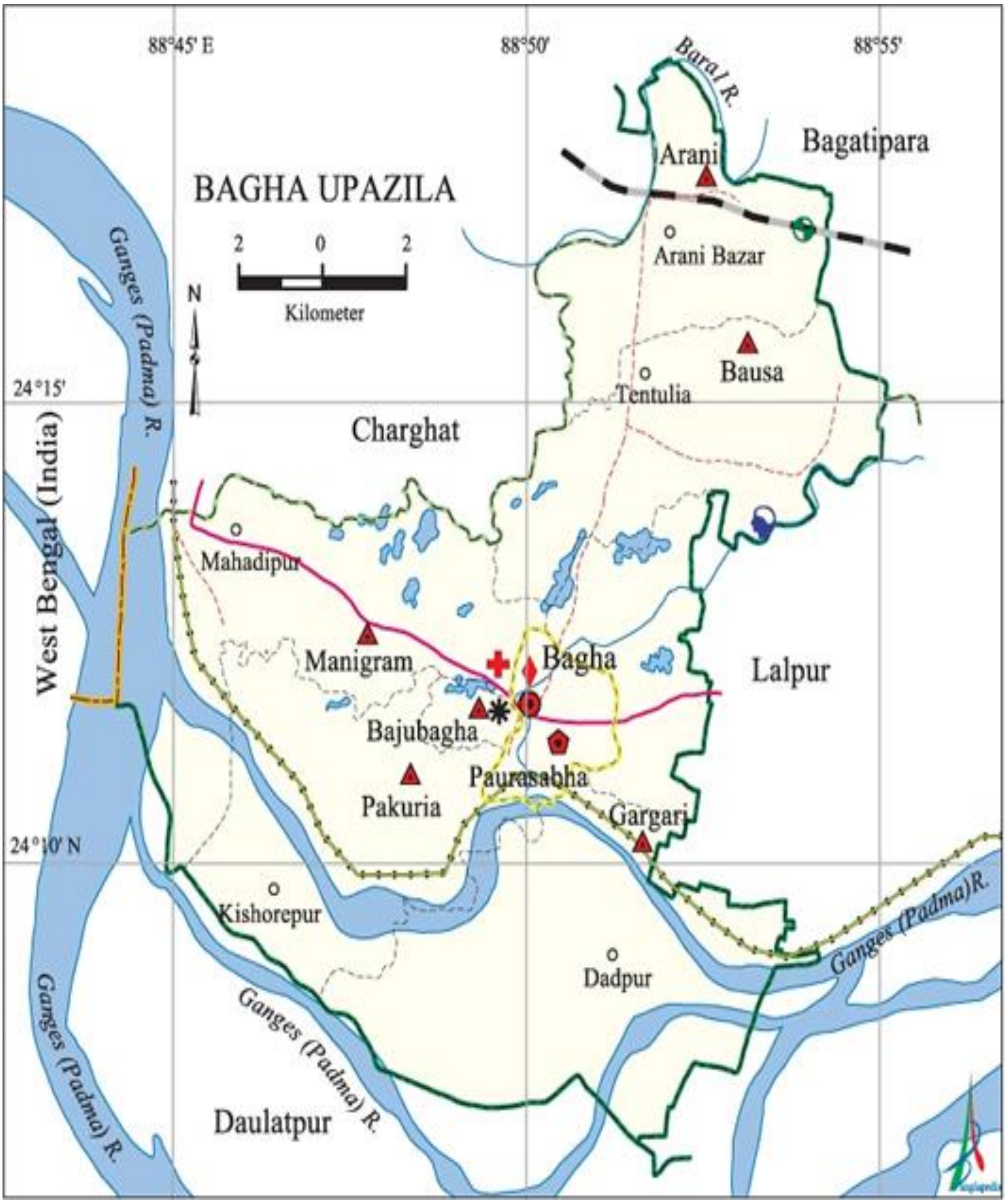
The selected sample farmers were located in ten villages under four union of two district among these six villages namely Jhitka kolahata, Jhitka moddho para, Jhitka thakur para, Jhitka bepari para, Dakkhain gorail and Nouhata under Harirampur upazila and remaining four villages namely Bausha hedati para, Khurdo bausha , Tethulia and Pirgacha under Bagha upazila respectively. Harirampur upazila is under the Manikganj district and Bagha upazila is under the Rajshahi district.



Map 4.1: Map of Bangladesh



Map 4.2: Map of Harirampur Upazila



Map 4.3: Map of Bagha Upazila

4.3 Physical Features, Topography and Soil Condition

Manikganj district lies between 23º38' and 24º 03' north latitudes and between 89º41' and 90º08' east longitudes. It is situated in the eastern half of the Ganges River Floodplain which is low-lying. The region has a typical meander floodplain landscape of broad ridges and basins. Soils of the region are silt loams and silt clay loams on the ridges and silt clay loams to heavy clays on lower sites. General soil types predominantly include Calcareous Dark Grey and Calcareous Brown Floodplain soils. Organic matter content is low in ridges and moderate in the basins. Soils are calcareous in nature having neutral to slightly alkaline reaction. General fertility level is medium (BBS, 2013a).

Rajshahi district lies between 24°07′ to 24°43′ north latitudes and between 88°17′ to 88°58′ east longitudes. The district is included in the western part of the Ganges River Floodplain which is predominantly highland and medium highland. Most areas have a complex relief of broad and narrow ridges and inter-ridge depressions, separated by areas with smooth broad ridges and basins. There is an overall pattern of olive-brown silt loams and silt clay loams on the upper parts of floodplain ridges and dark grey, mottled brown, mainly clay soils on ridge sites and in basins. Most ridge soils are calcareous throughout. General soil types predominantly include Calcareous Dark Grey Floodplain soils and Calcareous Brown Floodplain soils. Organic matter content in brown ridge soils is low and higher in dark grey soils. Soils are slightly alkaline in reaction. General fertility level is low (BBS, 2013b).

Maize can be grown in any type of soil. The ideal soil for growing maize is well-drained, preferably a sandy loam. It was evident from the study that low-lying land and highland to medium highland high land with silt loams and silty clay loams soil at Harirampur and Bagha upazila were mostly conducive for maize production through the year round.

Table 4.1: Occurrence of River Erosion during the Year 2008-2011 (Yes/No)

Upazila	2008	2009	2010	2011
Horirampur	Yes	Yes	Yes	Yes

Source: BBS, 2013a

Occurrence of river erosion and flooding is severe in case of Harirampur uoazila. On the other hand river erosion and flooding were not experienced in Bagha upazila as most of the land in this area is high land (table 4.1 and table 4.2).

Table 4.2: Occurrence of Flood during the Year 2008-2011 (Yes/No)

Upazila	2008	2009	2010	2011
Bagha	No	No	No	No

Source: BBS, 2013b

Total cultivable land in two upazilas are 157.31 acres and 158.68 acres respectively (table 4.3).

Table 4.3: Broad Classification of Area.

Upazila	Total area	Land area	Reserve forest	Riverine area
Horirampur	244.31	157.31	0	87.0
Bagha	185.16	158.68	14.48	12.00

Source: BBS, 2011

Note: land area in '000' acres

4.4 Area and Population

The total area, population and density of population of the selected upazilas are presented in Table 4.4 .The highest population density (995 per sq.km) is Bagha upazila and the lowest population density (570 sq. km) is in Harirampur Upazilla.

Table 4.4: Number of Household, Population and Density, 2011

Upazila	House-hold	Population			Sex ratio (M/F)	Average size of household	Density Per sq.km.
		Male	Female	Total			
Horirampur	33513	65815	73503	139318	90	4.15	570
Bagha	46711	92010	92173	184183	100	3.94	995

Source: BBS, 2011

4.5 Climate, Temperature and Rainfall

The climate, temperature and rainfall are very important factors for production of any crops. It is basically warm and humid in Bagha upazila. Maximum temperature of the study areas were 23.4 °C and 38.0 °C and minimum temperature were from 12.2 °C and 5.8 °C in Harirampur upazilla and Bagha upazila respectively (Table 4.5). The annual total rainfall of the study areas were 1777 mm to 4637.3 mm in Harirampur upazilla and Bagha upazila respectively. Percentage of Relative humidity were 68.2 percent and 88 percent in two upazilas respectively. Maximum, minimum temperature (°C) and annual total rainfall (mm) from 2008 to 2011 are shown in table 4.6 and Figure 4.1 below.

Table 4.5: Temperature, Rainfall, Humidity during the Years 2011

District	Temperature (centigrade)		Rainfall (milimeter)	Humidity (%)
	Maximum	Minimum		
Manikgonj	23.4	12.2	1777	68.2
Rajshahi	38.0	5.8	4637.3	88

Source: BBS, 2011

Table 4.6: Average Maximum and Minimum Temperature (°C) in Selected Upazilas

Upazila	2008		2009		2010		2011	
	Max	Min	Max	Min	Max	Min	Max	Min
Harirampur	34.2	12.5	35.6	14.8	35.0	12.8	23.4	12.2
Bagha	40.0	6.7	41.5	6.1	42.5	6.5	38.0	5.8

Source: BBS, 2011

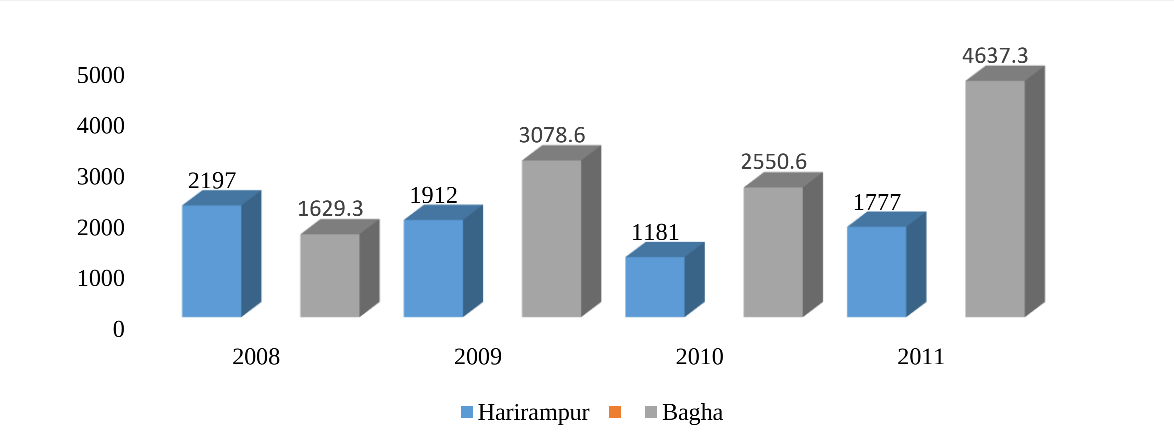


Figure 4.1: Annual Total Rainfalls in Millimeter in Selected Upazilas

Source: BBS, 2011

The monthly rainfall of the study areas in 2010 presented in Table 4.2

Table 4.7: Monthly Total Rainfall in Bangladesh, 2018

Name of Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rajshahi	0	12	9	144	107	139	239	85	116	87	0	17
Dhaka	0	20	17	328	442	308	357	140	74	45	13	13

Source: BBS, 2018

4.6 Land and Agriculture

Total cultivable land in two districts is 215000 acres and 464000 acres respectively. Maize is one of the main crop grown in the study areas. Besides mustard, chili, paddy, jute, onion, sesame, coriander, garlic, potato, groundnut, brinjal are grows well in Harirampur upazila. On the other hand wheat, sugarcane, garlic, pulse, onion, paddy, turmeric, mustard are grows well in Bagha upazila. It is evident from the study that, cropping pattern in the study areas are almost same and it were onion-maize-aman, maize-irri rice- fellow, mustard-jute-aman in Harirampur upazila and the scenario was Maize-turmeric-irri rice, sugarcane- sugarcane- sugarcane, maize-pulses-irri rice, pulses-maize-irri rce, wheat-maize-irri rice for Bagha upazila. Land under cropped in the study areas are given in Figure 4.2.

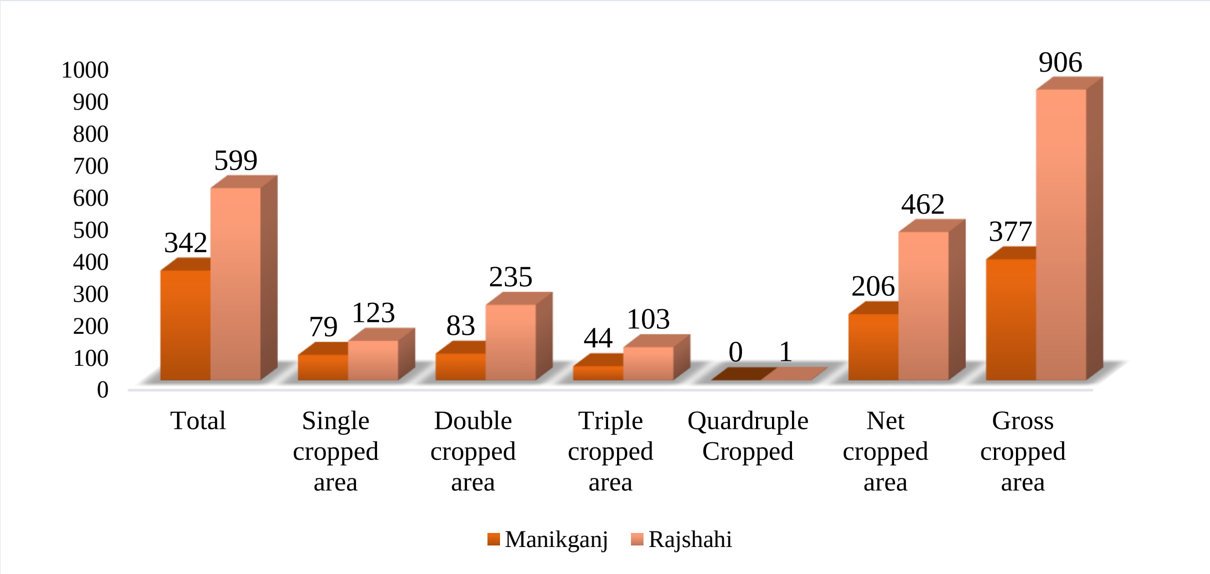


Figure 4.2: Information of Land under the Study Areas

Source: BBS, 2018

Note: Area in '000' acres

CHAPTER 5
SOCIO-DEMOGRAPHIC PROFILE OF MAIZE FARMERS

5.1 Introduction

Main purpose of this section is to identify socio economic characteristics of the maize farmers and provide basic information about the areas of observation. Social scientists use socio economic characteristics as an important term to cover a wide variety of interested social and economic factors .Socio factors refers to any number of demographic and social conditions such as the age structure, racial compositions ratio, marital status etc. Economic refers to the economic condition such as income, employment rate etc. Decision making behavior of an individual is determined to a large extent by his socioeconomic characteristics. It was not possible to collect all the information regarding the socio-economic characteristics of the sample farmers due to limitation of time and resources. In the present study 65 (49.62 percent) and 66 (50.38 percent) farmers were taken from the upazila, Harirampur and Bagha respectively because there are numerous interrelated attributes that characterizes an individual and influences the development of behavior and personality of that person. The socioeconomic characteristics considered in the present study were age, education, experience, major and minor occupation, family size, no of family members engaged in agriculture, land ownership, availability of credit, extension, training facilities etc.

5.2 Age

In the present study, all categories of farmers of the study area were classified into three different age groups e.g. 0-14 years, 15-64 years and above 65 years. It is evident from the table that most of the maize farmers were middle aged in the study area. In two upazilas, 100 percent of the sample farmers were male and not a single farmers were found below 15 years old. In Harirampur upazila about 76.9 percent of the populations were under 15-64 years age group and only 23.1 percent were of 65 years or above (Figure 5.1). On the other hand, in Bagha upazila, 87.9 percent of the populations were under 15-64 years age group and only 12.1 percent was of 65 years or above (Figure 5.1). This findings imply that majority of the sample farmers were in the most active age group of 15-64 years.

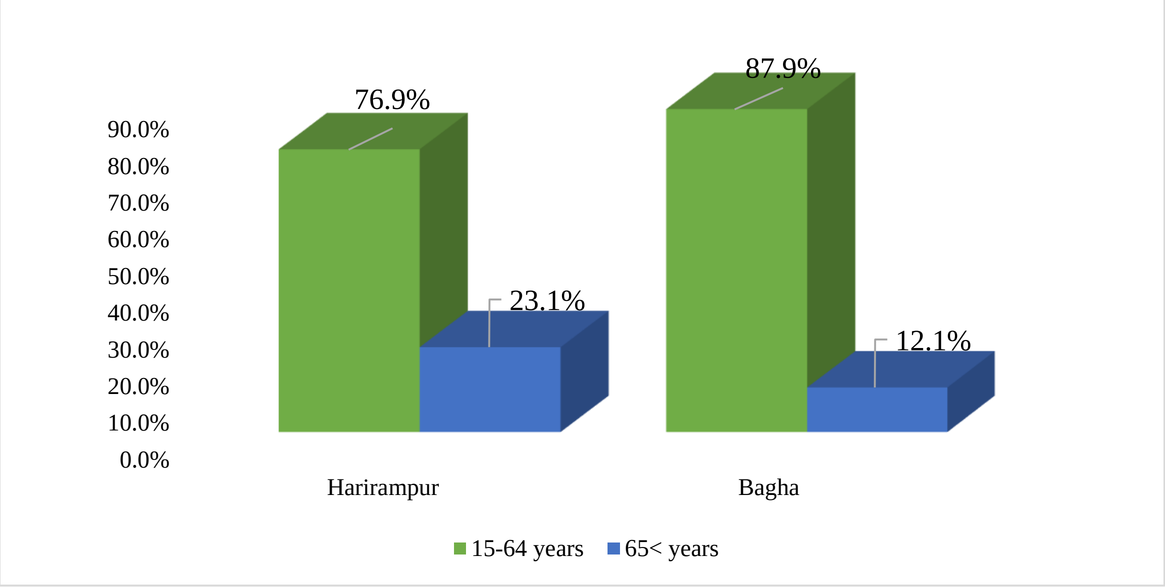


Figure 5.1: Age of the Maize Farmers in Study Area
Source: Field survey, 2018.

5.3 Sex Ratio, Dependency Ratio

The average family size of Harirampur and Bagha upazila were about 4.15 and 3.94 (BBS, 2011). The average family sizes of the maize producing farmers were found to be 5.04 according to collected data which were higher than the average family size of two upazila. The sex ration in Harirampur and Bagha upazilas were found 117 and 120 male per 100 women (Figure 5.2), respectively, which were remarkably higher than the national figure 90 for Harirampur and 100 for Bagha upazila (BBS, 2011c), possibly because of the sample framework used for the survey. Both ratios were significantly higher than national overall sex ratio which is of 100.2 males per 100 females (BBS, SVRS-2019). The dependency ratios of the study population were estimated at 30 and 13.79 (Figure 5.2) which were significantly lower than the national dependency ratio. The overall national (Total) dependency ratio is 51 percent according to SVRS report, meaning that 51 inactive persons are dependent on 100 economically active persons (BBS, 2019).

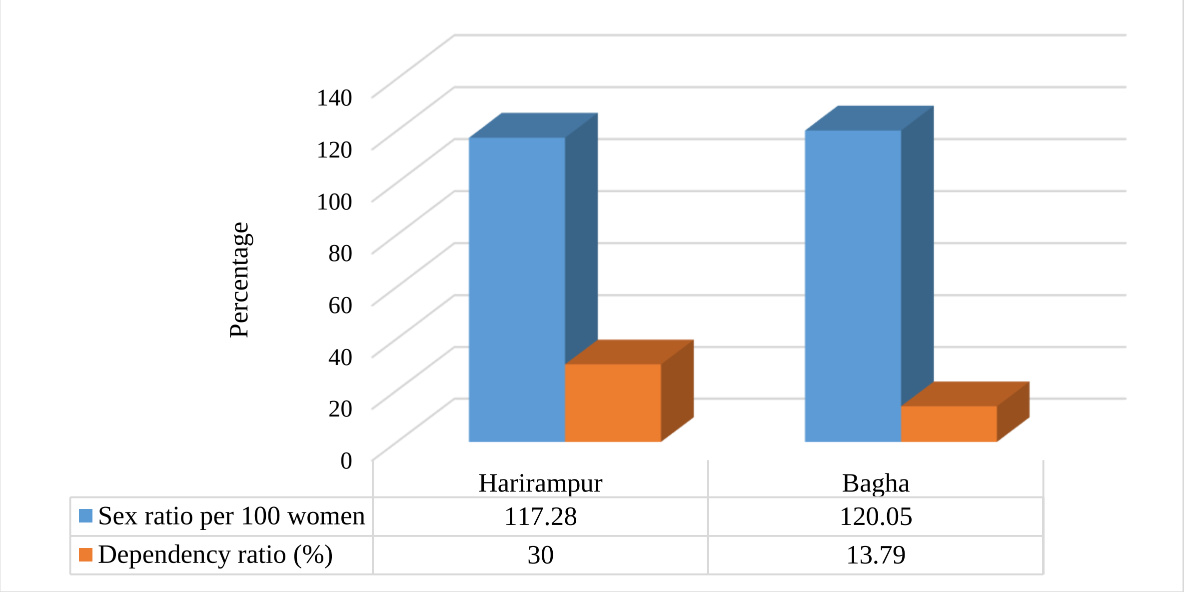


Figure 5.2: Sex Ratio of Family Members and Dependency Ratio of Maize Farmers
Source: Field survey, 2018.

5.4 Education

Education is the sign of social advancement of a community. Education plays an important role in alleviating poverty and inequality, improving health and enabling the use of knowledge. Educated people can have a better access to the pertinent information related to food and livelihood system. Education is also correlated with higher levels of income which is again interdependent to better level of earnings. Educated farmers plays a significant role in accelerating agricultural development and also influences the vast adoption of new technology and scientific knowledge regarding farming.

Figure 5.3 showed that, in Harirampur upazila, about 13.80 percent of the study population were found to have no education, about 24.60 percent were literate or can read/write only, about 20.00 percent were found to complete primary level education, about 33.80 percent were found to have secondary and about only 1.50 percent had higher secondary level education and only 6.20 percent people were found to have attained/completed graduation level of education.

In Bagha upazila, out of 66 sample farmers, about 25.80 percent of the study population were found to have no education, about 45.50 percent farmers were literate only, about 19.70 percent farmers had primary education, 4.50 percent farmers had completed their secondary level education, 3.00 percent farmers had completed their higher secondary education and last of all only 1.50 percent farmers had completed their higher study.

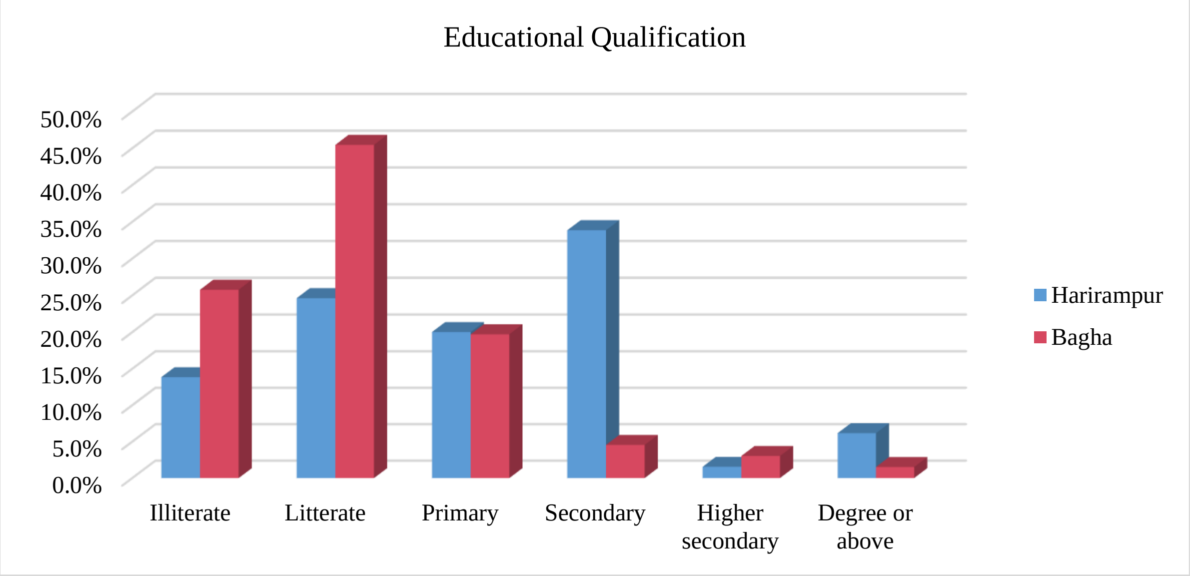


Figure 5.3: Education of the Maize Farmers in Study Area
Source: Field survey, 2018.

5.5 Farmer's Professional Distribution Percentage

The work in which people engaged more or less throughout the year for their livelihood is considered as the occupation of the people. The distribution of principle occupation varies greatly depending on how much they are involved and what level of income is earned from the present occupation.

5.5.1 Major Occupation

The occupation of the study population aged 15 years or more showed that, in Harirampur upazila, about 80.00 percent (out of 65) were engaged in agriculture, 12.30 percent were engaged in business and only 7.70 percent were engaged in service as their main occupation. On the other hand, in Bagha upazila, about 57.60 percent, 36.40 percent and 6.10 percent (out of 66) were engaged in agriculture, business and service as their main occupation (Figure 5.4).

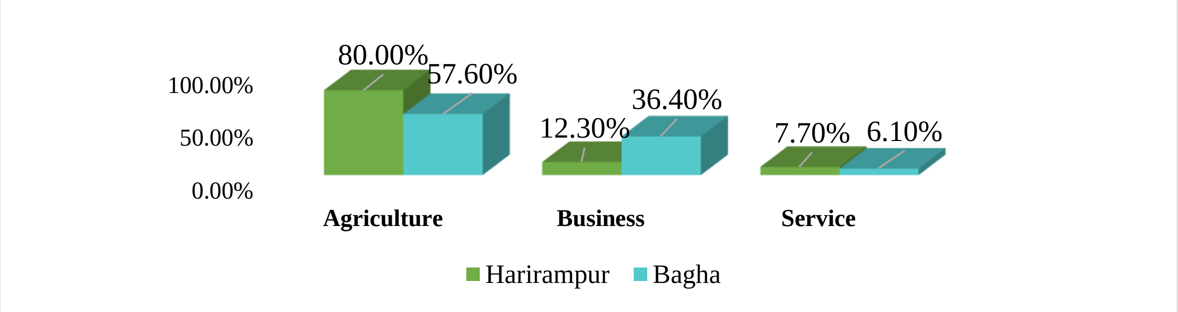


Figure 5.4: Major Occupation of the Maize Farmers in Study Area
Source: Field survey, 2018.

5.5.2 Minor Occupation

Minor occupational status of the sample farmers are shown in the following figure (Figure 5.5**)**. It is evident from the figure that in Harirampur upazila, about 44.4 percent and 55.6 percent farmers were involved in agriculture and business as their subsidiary occupation. On the other hand, in Bagha upazila, about 41.3 percent and 58.7 percent farmers (out of 66) were engaged in agriculture and business as their subsidiary occupation.

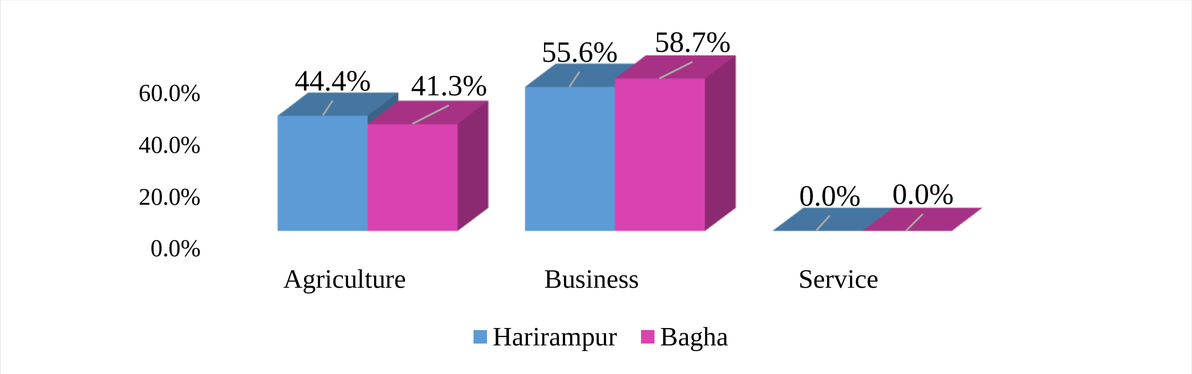


Figure 5.5: Minor Occupation of the Maize Farmers in Study Area
Source: Field survey, 2018.

5.6 Maize Cultivated Land

The spread of maize cultivation in Bangladesh is in an increasing trend with the increase of poultry industry as well as increase of wheat price. Increasing trend in area, production level and yield need to be identified for better understanding the potential productivity of maize in Bangladesh. Between two upazilas, relatively more land were engaged in maize production in Bagha upazila compared to Harirampur upazila. In Harirampur upazila, on an average 0.14 ha land was engaged in maize cultivation. The minimum and maximum land for maize cultivation were observed to be 0.67 ha and 0.02 ha respectively. On the other hand, in Bagha upazila, average size of land utilization for maize cultivation was 0.17 ha. The minimum and maximum land for maize cultivation were observed to be 0.81 ha and 0.04 ha respectively (Table 5.1).

Table 5.1: Size of Land for Maize Cultivation.

Criteria	Harirampur			Bagha		
	Mean	Max	Min	Mean	Max	Min
Maize land(ha)	0.14	0.67	0.02	0.17	0.81	0.04

Source: Field Survey, 2018.

5.7 Land Ownership

Between two upazilas, relatively more land were owned by a household at Bagha upazila compared to Harirampur upazila. In Harirampur upazila, on an average 0.60 ha land was owned by a household on the basis of collected data (out of 65 household). The minimum and maximum land size owned by a household were observed to be 4.11 ha and 0.02 ha respectively. On the other hand, in Bagha upazila, average size of land of a household was 1.47 ha on the basis of observed data (out of 66). The minimum and maximum size of land owned by a household in that area were observed to be 6.53 ha and 0.06 ha respectively (Table 5.2).

Table 5.2: Size of Land Ownership by the Household.

Criteria	Harirampur			Bagha		
	Mean	Max	Min	Mean	Max	Min
Total land(ha)	0.60	4.11	0.02	1.47	6.53	0.06

Source: Field Survey, 2018.

5.8 Experience in Agriculture

From the collected data it can be estimated that the highest proportion of respondents, about 53.80 percent and 56.10 percent of maize farmers had 25-44 years of experience in agriculture in Harirampur upazila and Bagha upazila respectively. The lowest percentage belonged to more than 65 years of experience and the number of respondents was about 3.10 percent in case of Harirampur. In Harirampur upazila, about 29.20 percent and 13.8 percent maize farmers had 5-24 years and 45-64 years of experience in agriculture respectively. On the other hand, in Bagha upazila, about 19.70 percent and 24.20 percent maize farmers had 5-24 years and 45-64 years of experience in agriculture respectively (Figure 5.6).

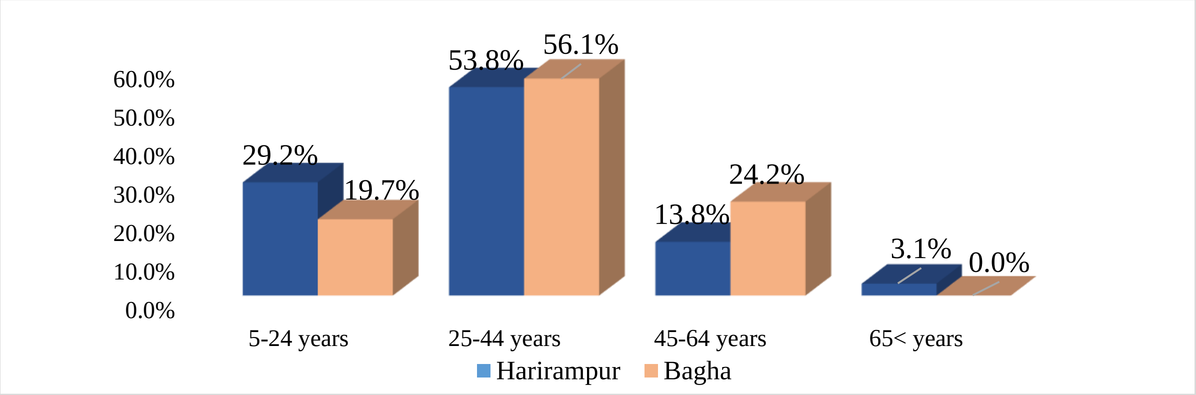


Figure 5.6: Farmer’s Experience in Agriculture in Study Area
Source: Field Survey, 2018.

5.9 Family Size

In the study area, family size has been considered as one which has a total number of People living together with the same head of the family. In the study area, the average size of family in both upazilas was 5, which is larger than average family size of the country 4.06 (HIES, 2016). In Harirampur upazila, the families were consisted of maximum 14 members and minimum 3 members in a household respectively. On the other hand, in Bagha upazila, household were consisted of maximum 8 members and minimum 2 members respectively (Table 5.3).

Table 5.3: Size of Household of Maize Farmers in the Study Area

Criteria	Harirampur			Bagha		
	Mean	Max	Min	Mean	Max	Min
Family size	5	14	3	5	8	2

Source: Field Survey, 2018.

The total numbers of persons of all families were divided into three categories according to their family size. The different family size of maize farmers is presented in Table 5.5. Table indicates that about 66.20 percent and 75.80 percent families of maize farmers consisted of 2-5 members in Harirampur upazila and Bagha upazila respectively. In Harirampur upazila, about 29.20 percent and 4.60 percent families consisted of 6-10 members and more than 10 members respectively. About 24.20 percent families consisted of 6-10 members in Bagha upazila (Figure 5.7).

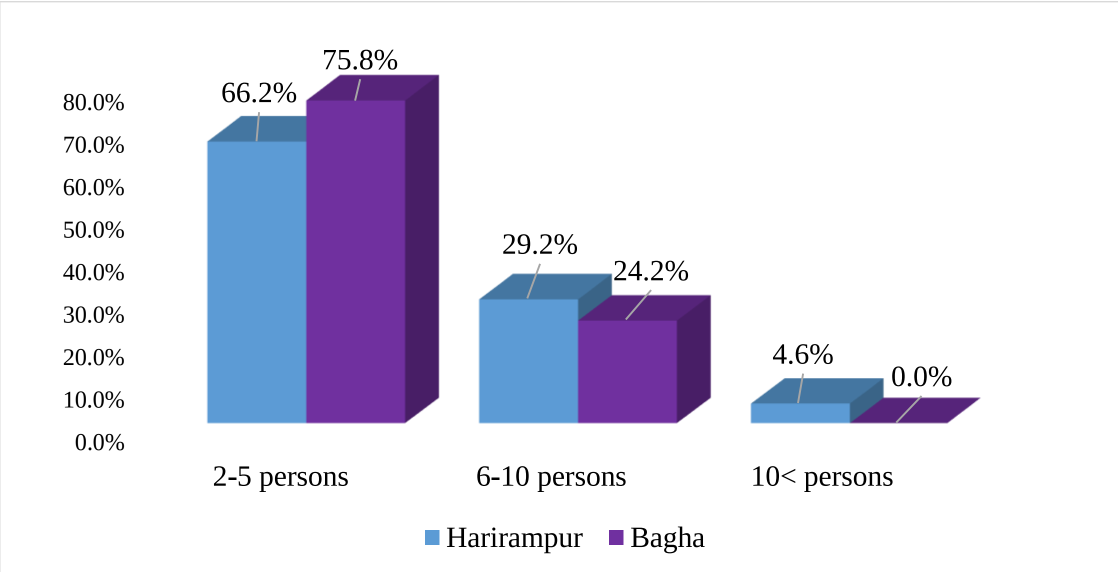


Figure 5.7: Family Size of Maize Farmers in the Study Area
Source: Field Survey, 2018.

5.10 No of Family Member Engaged in Agriculture

In case of both upazilas, on an average 1 person was engaged in agriculture from a household on the basis of observed data (out of 131). Maximum 5 persons of a houselhold in Harirampur upazila and 3 persons from a family in Bagha upazila were engaged in agriculture directly for their livelihood (Table 5.4).

Table 5.4: Involvement of Members of a Household in Maize Farming

Criteria	Harirampur			Bagha		
	Mean	Max	Min	Mean	Max	Min
Engagement in Agriculture	1	5	1	1	3	1

Source: Field Survey, 2018.

In the present study, involvements of family members in maize cultivation were categorized into five categories: 1 member involvement, 2 persons involvement, 3 persons involvement, 4 persons involvement and 5 persons involvement. It is evident from the figure 5.8 that in case of about 69.80 percent and 86.20 percent household only 1person involved in agriculture in Harirampur upazila and Bagha upazila respectively. About 25.40 percent household had 2 persons involvement in agriculture and about 1.60 percent family had 3, 4 and 5 persons involvement in agriculture in Harirampur upazila. In Bagha upazila, about 12.30 percent and 1.50 percent household had 2 and 3 persons involvement in agriculture respectively.

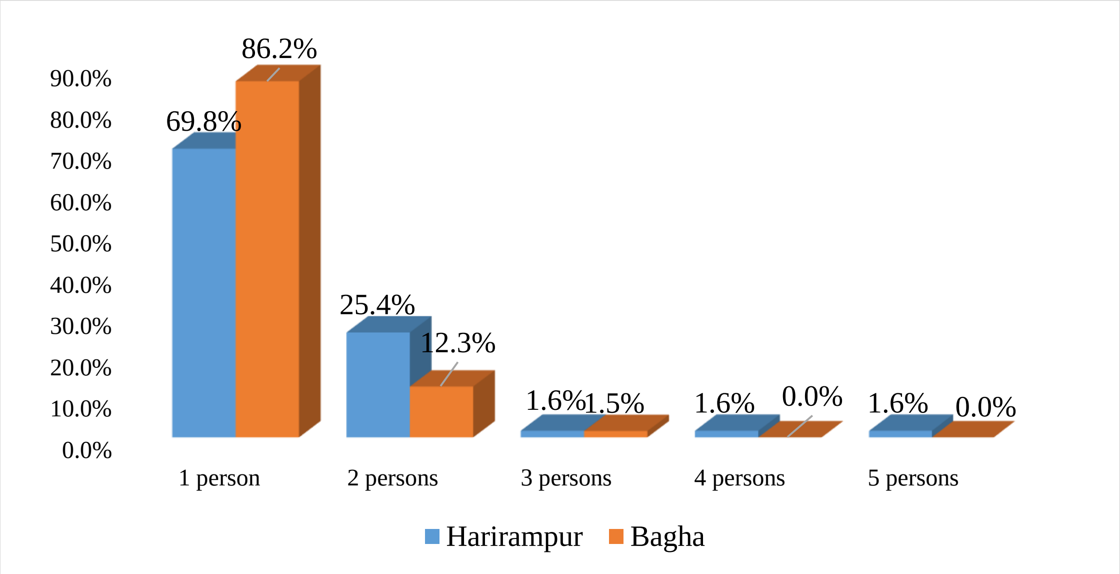


Figure 5.8: Involvement of Family Members in Agriculture
Source: Field Survey, 2018.

5.11 Extension Service

Among the respondent farmers, 56.90 percent and 68.20 percent farmers had direct or indirect communication with agricultural extension officers in Harirampur upazila and Bagha upazila respectively. They acquired valuable knowledge about different agricultural technologies regarding Maize farming from officers whereas 43.10 percent and31.80 percent farmers relied on their traditional farming knowledge in case of maize farming as they didn't have contact with extension officers (Figure 5.9).

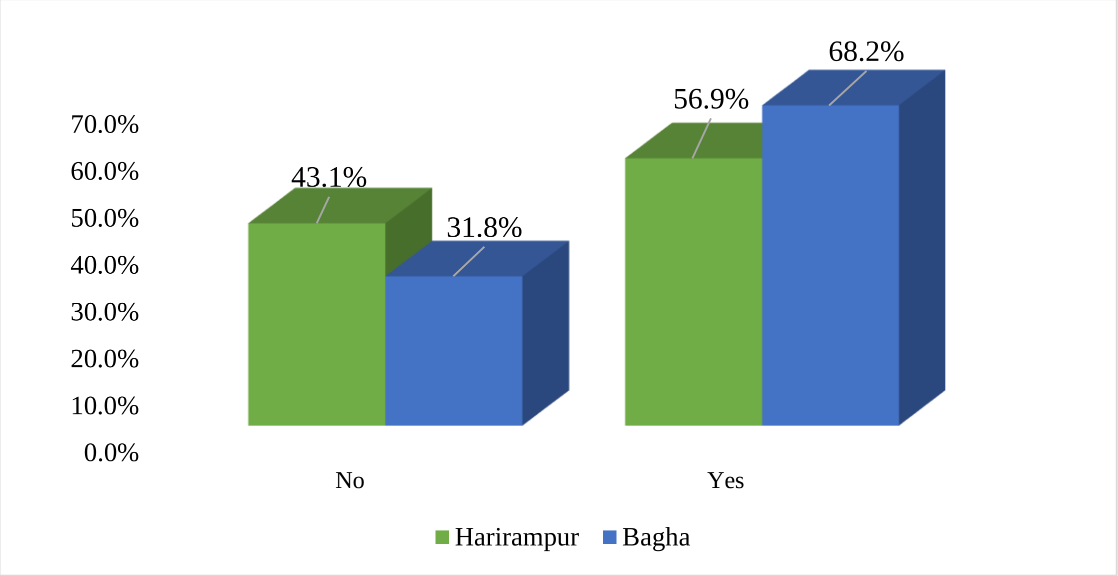


Figure 5.9: Availability of Extension Services for Maize Farmers
Source: Field Survey, 2018.

5.12 Credit Facility

Sufficient amount of funding is a crucial factor for any kind of farming enterprise. Most of the farmers didn't have credit facilities for maize cultivation in the study area. About 30.80 and 47.00 percent farmers were taken loan from Banks and different NGO's for maize cultivation in Harirampur upazila and Bagha upazila respectively. About 69.20 percent and 53.00 percent farmers were used their own funding for maize cultivation in the study areas respectively (Figure 5.10).

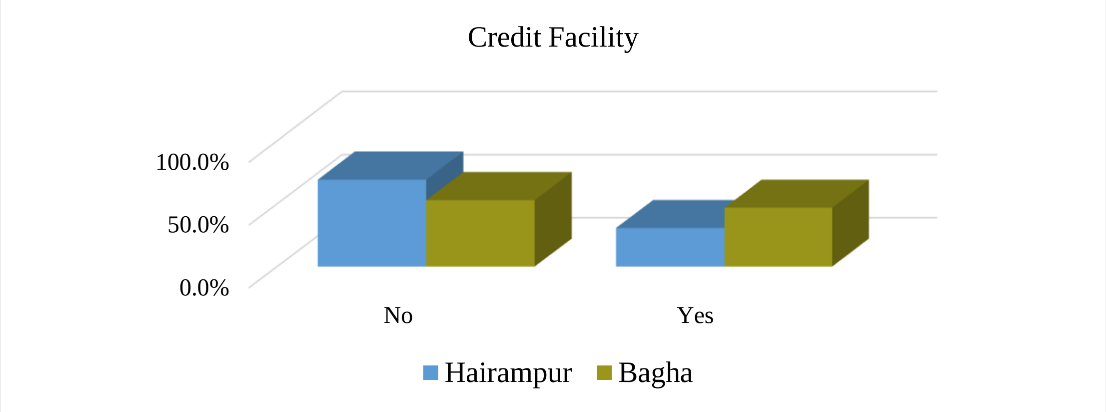


Figure 5.10: Availability of Credit Facilities for Maize Farmers
Source: Field Survey, 2018.

5.13 Training Facility

Among the respondent farmers in Harirampur upazila, 40.00 percent farmers got training on different advanced agricultural technologies whereas, 60.00 percent farmers did not get training for this purpose. On the other hand, 37.90 percent of respondent farmer got training on production of different agricultural crops whereas, 62.10 percent farmers did not get training on crop cultivation in Bagha upazila (Figure 5.11). According to collected data (out of 131) most of the farmers didn't have any training on crop cultivation.

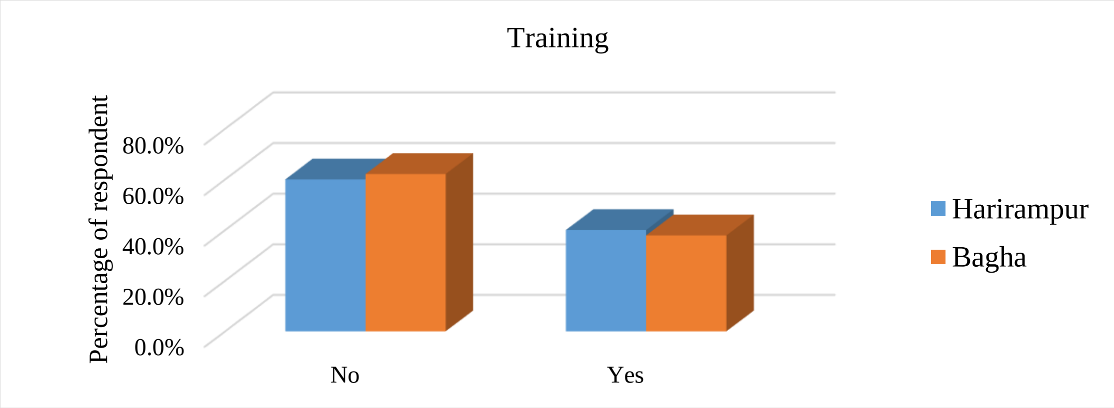


Figure 5.11: Training on Crop Cultivation
Source: Field Survey, 2018.

5.14 Concluding Remarks

This chapter analyzed the socioeconomic attributes of the sample farmers of two different upazilas. From the above discussions it is evident that there are some variations in socio-economic attributes between the maize farmers in two upazilas, Harirampur and Bagha. But the magnitude of the variations was not significant.

CHAPTER 6
TECHNICAL EFFICIENCY OF THE MAIZE FARMERS

6.1 Introduction

Technical efficiency estimation with the help of production function has been a popular practice of econometrics. Technical efficiency reveals the ability of a farmer to achieve the maximum possible output from a given level of inputs and production technology. It is a relative concept, since each farmers production performance is compared to a best-practice input-output relationship or production frontier. If farmers fails to produce maximum output from a given level of inputs, they are supposed to be technically inefficient in the sense that. Technical inefficiency is measured as the deviation of a farmer from the best-practice frontier. The main objective of this chapter is to estimate the technical inefficiency as well as frequency distribution of maize farmers on an average and by region through technical efficiency analysis. The technical efficiency in production was estimated by using the stochastic frontier production.

6.2 Interpretation of ML Estimates of the Stochastic Frontier Production

The Maximum Likelihood Estimates of the stochastic production frontier parameters and those of the inefficiency model are presented in Table 6.1. The variance parameters for sigma square and gamma were .00923 and 0.9531 respectively. They were significant at 1percent level. The sigma square indicated the goodness of fit and correctness of the distributional form assumed for the composite error term. The gamma estimate indicated the systematic variance that is unexplained by the production function and is the dominant source of random errors (Umoh, 2006). The estimate of γ= 0.9531or 95.31percent means that the inefficiency effects make significant contribution to the technical inefficiency of maize farmers in the study area.

6.2.1 Human Labour (X_1)

The regression coefficients of Human labour (X_1) was positive and the value of regression coefficients of human labour (X_1) was .0888878 which was not significant. Therefore, human labour had no statistically significant effect on maize cultivation (Table 6.1).

6.2.2 Land Preparation Cost (X_2)

The regression coefficients of land preparation cost (X_2) was positive and significant at 5 percent level of significance. The regression coefficients of land preparation cost (X_2) was .0454045, which implied that, holding other factors constant, 1 percent increase in the expenditure on land preparation would increase the yield of maize by .0454045 percent (Table 6.1).

6.2.3 Seed (X_3)

The regression coefficients of seed (X_3) was positive and significant at 1 percent level of significance. The regression coefficients of seed (X_3) was .2930331, which implied that, holding other factors constant, 1 percent increase in the amount of seed would increase the yield of maize by .2930331 percent (Table 6.1).

6.2.4 Fertilizer (X_4)

The regression coefficients of fertilizer (X_4) was positive and the value of regression coefficients of fertilizer (X_4) was .0468128 which was not significant. Therefore, fertilizer had no statistically significant effect on maize cultivation (Table 6.1).

6.2.5 Cost of Irrigation (X_5)

The regression coefficient of irrigation cost (X5) of maize production was positive and significant at 1 percent level of significance. The value of coefficient was .0361106, which implied that if the expenditure on irrigation was increased by 1 percent then the yield of maize would be increased by .0361106 percent, other factors remaining constant (Table 6.1)

Table 6.1: ML Estimates for Parameters of Cobb-Douglas Stochastic Frontier Production Function and Technical Inefficiency Model for Maize Farmers

Variables	Parameter	Coefficients	T-Ratio
Stochastic Frontier:			
Constant (X_0)	β_0	6.836241***	16.92
Human Labour (X_1)	β_1	.0888878	1.08
Land Preparation (X_2)	β_2	.0454045**	2.02
Seed (X_3)	β_3	.2930331***	8.15
Fertilizer (X_4)	β_4	.0468128	0.82
Irrigation (X_5)	β_5	.0361106***	2.99
Inefficiency Model			
Constant	δ_0	-3.511386***	-6.63
Education (Z_1)	δ_1	.0260398	0.20
Experience (Z_2)	δ_2	-.0014693	-0.12
Extension service (Z_3)	δ_3	-2.018662***	-5.66
Training (Z_4)	δ_4	.2408838	0.73
Farm size (Z_5)	δ_5	-.0159831***	-2.90
Variance Parameters			
$\sigma^2_s = \sigma^2_v + \sigma^2_u$		.0092301***	6.26
$\gamma = \sigma^2_u / \sigma^2_s$		0.953109***	
Log-likelihood Function		192.11	

Note: ***, ** and * indicates significant at 1, 5 and 10 percent level respectively.

Source: Field Survey, 2018.

6.3 Interpretation of Technical Inefficiency Model

In the technical inefficiency effect model, experience, extension service, farm size have expected (negative) coefficients. The negative coefficient of experience implies that more experienced farmers are technically more efficient than less experienced farmers though the coefficient of experience was -.0014693 which was not statistically significant.

The negative and significant (1 percent) coefficient of extension service postulates that farmers having contacts with extension officers are technically more efficient than others.

The negative and significant (1 percent) coefficient of farm size implies that large farm households are technically more efficient than small farm households.

The coefficients of education and training are positive meaning that these factors have no impact on the technical inefficiency of maize production though the coefficient of education and training were not statistically significant. That is, these factors do not reduce or increase technical inefficiency of producing maize.

The γ-parameter associated with the variance in the stochastic production frontier model is estimated to be close to one (0.953109) and highly significant. Although the γ-parameter cannot be interpreted as the proportion of the total variance explained by the technical inefficiency effects, the result indicates that technical inefficiency effects do make a significant contribution to the level and variation of maize production in the study area.

6.4 Technical Efficiency and Its Distribution

Table 6.2 shows frequency distribution of farm-specific technical efficiency for maize farmers. It reveals that average estimated technical efficiencies for maize are 93.78 percent which indicate that maize production could be increased by 6.22 percent with the same level of inputs without incurring any further cost. Increase of only managerial skills result a substantial increase of output for maize. It was observed that 49.62 percent of sample farmers were found to have received outputs which were very close to the maximum frontier outputs maintaining the efficiency level more than 95 percent.

On the other hand, second highest proportion of respondents about 30.52 percent of sample farmers obtained 91 to 95.99 percent technical efficiency level. The minimum and maximum technical efficiencies were observed to be 71.19 and 99.38 percent respectively.

Table 6.2: Frequency Distribution of Technical Efficiency of Maize Farms

Efficiency (%)	No. of farmers	Percentage of farms
71-75	3	2.29
76-80	3	2.29
81-85	6	5.34
86-90	17	9.92
91-95	40	30.53
96-100	62	49.62
Total	131	100.0
Minimum	71.19	
Maximum	99.38	
Mean	93.78	

Source: Field Survey, 2018.

6.5 Technical Efficiency of the Maize Producing Farms by Region

Estimation of the technical efficiency level helps to decide whether to improve the existing efficiency level or to develop new technologies to raise the productivity level. A farm is technically inefficient in the sense that if it fails to produce maximum output from a given input. Technical efficiency of maize cultivation at farm level estimation in the study area is shown in Table 6.3.

Table 6.3: Frequency Distribution of Technical Efficiency by Region

Efficiency (percent)	Harirampur		Bagha	
	No. of Farmers	Percentage of Farms	No. of Farmers	Percentage of Farms
71-75	2	3.08	0	00
76-80	2	3.08	2	3.03
81-85	3	4.62	3	4.55
86-90	11	16.92	6	9.09
91-95	19	29.23	21	31.82
96-100	28	43.07	34	51.51
Total	65	100	66	100
Minimum	71.18		75.51	
Maximum	99.37		99.11	
Average Efficiency (%)	92.97		94.57	

Source: Field Survey, 2018.

From Table 6.3 it was observed that the farm specific technical efficiency coefficient varied among farmer to farmers and ranged from 0.71 to 0.99 with a mean of 0.92 at Harirampur followed by efficiency range 0.75 to 0.99 with mean of 0.94 at Bagha upazila. For better presentation of the efficiency result, farms were categorized into 6 different groups with intervals of five points. It was found that 43.07 and 51.51 percent of the total farmers at Harirampur and Bagha upazila respectively belonged to the most efficient category (96 to 100 percent); about 3.08 percent farms at Harirampur upazila was in the least efficient group (61 to 70.99 percent). However, about 31.82 percent farmers at Bagha upazila belonged second higher efficiency group (91 to 95.99 percent) compared to farmers of Harirampur upazila, where the percentage was 29.23 percent (96 to 100 percent).

CHAPTER 7
PROFITABILITY OF MAIZE PRODUCTION

7.1 Introduction

Cost plays a pivotal role in decision making for the producers in each production process. The costs were classified into two type e.g. variable costs and fixed costs. The main purpose of this chapter is to assess the costs, returns and profitability of maize production. Profitability is a major criterion to make decision for producing any crop at farm level. This chapter measures production profitability in terms of net return, gross margin and undiscounted benefit-cost. The costs of all items were calculated to identify the total cost of production. The returns from the crops have been estimated based on the value of main products and by-products.

7.2 Profitability of Maize Production

7.2.1 Variable Costs

7.2.1.1 Cost of Land Preparation

Land preparation is the most important components in the production process. Land preparation included ploughing, laddering and other activities needed to make the soil suitable for maize cultivation. For land preparation in maize production, no. of tiller was required 3 with Tk. 2688.83 per tiller. Thus, the average land preparation cost of maize production was found to be Tk. 8066.49 per hectare, which was 7.54 percent of total cost (Table 7.1).

7.2.1.2 Cost of Human Labour

Human labour cost is one of the major cost components in the production process. It is one of the most important and largely used inputs for producing maize. It is generally required for different operations such as land preparation, sowing, weeding, fertilizer and insecticides application, irrigation, harvesting and carrying, threshing, cleaning, drying, storing etc. The quantity of human labour used in maize production was found to be about 110 man-days per hectare and average price of human labour was Tk.

363.57 per man-day. Therefore, the total cost of human labour was found to be Tk. 39993.00 representing 37.37 percent of total cost (Table 7.1).

7.2.1.3 Cost of Seed

Cost of seed varied widely depending on its quality and availability. The quantity of seed used in maize production was found to be about 19.04 kg per hectare and average price of seed was Tk. 412.98 per kg. Per hectare total cost of seed for maize production were estimated to be Tk. 7863.19, which constituted 7.35 percent of the total cost (Table 7.1).

7.2.1.4 Cost of Urea

In the study area, farmers used different types of fertilizers. Among the different kinds of fertilizers used, on an average, farmers used urea 271.92 kg per hectare. Per hectare cost of urea was Tk. 4394.20, which represents 4.12 percent of the total cost (Table 7.1).

7.2.1.5 Cost of TSP

Among the different kinds of fertilizers used, the rate of application of TSP was 123.97 kg per hectare which was lower than other fertilizers. The average cost of TSP was Tk. 2777.99 which representing 2.59 percent of the total cost (Table 7.1).

7.2.1.6 Cost of MoP

The application of MoP per hectare was 261.81 kg per hectare. Per hectare cost of MoP was Tk. 3821.51 for maize production, which represents 3.57 percent of the total cost (Table 7.1).

7.2.1.7 Cost of Insecticides

Farmers used different kinds of insecticides to keep their crop free from pests and diseases. The amount and cost of insecticides used for maize production were too negligible to mention. The average cost of insecticides for maize production was found to be Tk. 730.45 per hectare which was 0.68 percent of the total cost (Table 7.1).

7.2.1.8 Cost of Irrigation

Cost of irrigation is one of the most important costs for maize production. Production of maize largely depends on irrigation. Right doses application of irrigation water help to increase yield per hectare. The average cost of irrigation was found to be Tk. 12017.47 per hectare, which represents 11.23 percent of the total cost (Table 7.1).

Table 7.1: Per Hectare Cost of Maize Production

Items of Cost	Quantity (kg/ha)	Rate (Tk./Kg)	Cost (Tk./ha)	Percentage of Total Cost
Land preparation	3	2688.83	8066.49	7.54
Human labour	110	363.57	39993.00	37.37
Seed	19.04	412.98	7863.19	7.35
Urea	271.92	16.16	4394.21	4.11
TSP	123.97	22.39	2777.99	2.59
MoP	261.81	14.61	3821.51	3.57
Cost of Insecticides			730.45	0.68
Cost of Irrigation			12017.48	11.23
A. Total Operating Cost (TOC)			79664.33	74.44
Interest on operating capital @ of 10percent for months			2655.48	2.48
B. Total Variable Cost (TVC)			82319.81	76.92
Rental value of land			24692.38	23.07
C. Total Fixed Cost (TFC)			24692.38	23.07
D. Total cost (B+C)			107012.19	100

Source: Field Survey, 2018.

Note: Quantity and rate for land preparation are expressed in no. of tiller per hectare and Tk. per tiller units, respectively. Quantity and rate of human labour are expressed in man-days per hectare and Tk. per man-days units, respectively.

7.2.1.9 Interest on Operating Capital

It may be noted that the interest on operating capital was calculated by taking in to account all the operating costs incurred during the production period of maize. Interest on operating capital for maize production was estimated at Tk. 2655.48 per hectare, which represents 2.48 percent of the total cost (Table 7.1).

7.2.1.10 Total Variable Cost

Therefore, from the above different cost items it was clear that the total variable cost of maize production was Tk. 82319.81 per hectare, which was 76.92 percent of the total cost (Table 7.1).

7.2.2 Fixed Cost

7.2.2.1 Rental Value of Land

Rental value of land was calculated on the basis of opportunity cost of the use of land per hectare for the cropping period of three months. Cash rental value of land has been used as cost of land use. On the basis of the data collected from the maize farmers the land use cost was found to be Tk. 24692.38 per hectare, and it was 23.07 percent of the total cost (Table 7.1).

7.2.3 Total Cost (TC) of Maize Production

Total cost was calculated by adding all the cost of variable and fixed inputs. In the present study per hectare total cost of producing maize was found to be Tk. 107012.19 (Table 7.1).

7.2.4 Return of Maize Production

7.2.4.1 Gross Return

Return per hectare of maize cultivation is shown in table 7.2. Per hectare gross return was calculated by multiplying the total amount of product with respective per unit price. It is evident from table that the average yield of maize per hectare was 8563.421 kg and the average price of maize was Tk. 16.47. The average price of by Product of maize was Tk. 10221.67 per hectare. Therefore, the gross return was found to be Tk. 151323.72 per hectare (Table 7.2).

7.2.4.2 Gross Margin

Gross margin is the gross return over variable cost. Gross margin was calculated by deducting the total variable cost from the gross return. On the basis of the data, gross margin was found to be Tk. 69003.91 per hectare (Table 7.2).

7.2.4.3 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 return was estimated as Tk. 44311.53 per hectare (Table 7.2).

Table 7.2: Per Hectare Cost and Return of Maize production

Measuring Criteria	Yield (kg/ha)	Unit price	Cost (Tk./ha)
Main Product Value	8563.421	16.47	141102.04
By Product Value			10221.67
Gross Return (GR)			151323.72
Total Variable Cost (TVC)			82319.81
Total Cost (TC)			107012.19
Gross Margin (GR-TVC)			69003.91
Net Return (GR-TC)			44311.53
BCR (undiscounted)(GR/TC)			1.41

Source: Field Survey, 2018.

7.2.5 Benefit Cost Ratio (Undiscounted)

Benefit Cost Ratio (BCR) is a relative measure, which is used to compare benefit per unit of cost. Benefit Cost Ratio (BCR) was found to be 1.41 which implies that one taka investment in maize production generated Tk. 1.41 (Table 7.2). From the above calculation it was found that maize cultivation is profitable in Bangladesh.

7.3 Profitability of Maize Production by Region

Table 7.3: Cost and Economic Returns of Maize Cultivation in Two Upazilas.

	Harirampur		Bagha	
Items of Cost	**Cost (Tk./ha)**	**percent of Total Cost**	**Cost (Tk./ha)**	**% of Total Cost**
Land preparation	7243.03	6.18	8877.48	9.15
Human labour	49814.47	42.51	30320.35	31.26
Seed	7773.69	6.63	7951.32	8.19
Urea	4130.1	3.52	4654.31	4.79
TSP	2751.76	2.35	2803	2.89
MoP	3693.76	3.15	3947.93	4.07
Cost of Insecticides	1111.72	0.94	354.96	0.36
Cost of Irrigation	11023.48	9.41	12996.42	13.40
A. Total Operating Cost (TOC)	87542.01	74.71	71905.77	74.13
Interest on operating capital @ of 10percent for months	2918.07	2.49	2396.86	2.47
B. Total Variable Cost (TVC)	90460.08	77.20	74302.63	76.59
Rental value of land	26715.15	22.79	22700.26	23.40
C. Total Fixed Cost (TFC)	26715.15	22.79	22700.26	23.40
D. Total cost (B+C)	117175.23	100	97002.89	100
Average yield (kg/ha)	8352.37		8771.27	
Gross Return (GR) (Tk)	148201.16		154398.96	
Gross Margin (GR-TVC) (Tk)	57741.08		80096.33	
Net Return (GR-TC) (Tk)	31025.93		57396.07	
BCR (undiscounted)(GR/TC)	1.26		1.59	

Source: Field Survey, 2018.

7.3.1 Yield by Region

Average yield was 8563.421 kg/ha. But the highest yield was obtained by farmers at Bagha upazila (8771.27 kg/ha) followed by farmers at Harirampur upazila (8352.37 kg/ha).

7.3.2 Costs by Region

7.3.2.1 Variable Cost:

Average variable cost of maize cultivation was Tk. 82319.81 per hectare, which was the higher at Harirampur (Tk. 90460.08 per ha) than the variable cost of Bagha (Tk. 74302.63 per ha). Major portion of variable cost was occupied by human labor (42.51 percent) followed by cost of irrigation (9.41 percent), cost of fertilizers (9.02 percent), seed cost (6.63 percent) and land preparation cost (6.18 percent) in Harirampur, while in Bagha upazila those variable costs were 31.26 percent, 13.40 percent, 11.75 percent, 9.15 percent and 8.19 percent for human labor, cost of irrigation, cost of fertilizers, land preparation cost and seed cost respectively (Table 10).

7.3.2.2 Fixed Cost:

Fixed cost included land use cost which is the rental value of land in this case. On an average, total fixed cost was Tk. 24692.38 per hectare. The fixed cost varied only for variation in land use cost at two different upazila which was Tk. 26715.15 per hectare in Harirampur and Tk. 22700.26 per hectare for Bagha upazila (Table 10).

7.3.2.3 Total Cost:

Total production cost of maize was Tk. 107012.19 per hectare, which was higher at Harirampur upazila (Tk. 117175.23 per ha) and lower at Bagha upazila (Tk. 97002.89 per ha).

7.3.4 Returns by Region

Average gross return was Tk. 151323.72 per hectare, gross margin was Tk. 69003.91 per hectare and net return was Tk. 44311.53 per hectare. Between the two regions, gross return, gross margin and net returns were the higher at Bagha upazila compared to Harirampur upazila. Gross return, gross margin and net returns were Tk. 154398.96 per ha, Tk. 80096.33 per ha and Tk. 57396.07 per ha at Bagha upazila and Tk. 148201.16 per ha, Tk. 57741.08 per ha and Tk. 31025.93 per ha at Harirampur upazila respectively. Benefit Cost Ratio (BCR) were found to be 1.26 and 1.59 for Harirampur and Bagha upazila respectively.

7.4 Concluding Remarks

From the above discussion it is easy to understand about the different cost items and their application doses, yields and returns per hectare of maize cultivation. Very negligible amount of insecticides were required for maize cultivation and the amount of fertilizer and irrigation were also lower compared to other crops. Timely and efficient use of these inputs were the most important to increase production of maize and profitability. On the basis of above discussions it could cautiously be concluded here that cultivation of maize was more profitable in Bagha upazila than Harirampur upazila. Cost of cultivation of maize was higher in Harirampur upazila compared to Bagha upazila. Cultivation of maize would help farmers to increase their income earnings.

CHAPTER 8
PROBLEMS OF MAIZE PRODUCTION

8.1 Introduction

The focus of this chapter is to identify the extent of problems encountered by the Maize farmers. Farmers faced a lot of problems in producing Maize. The problems were social and cultural, financial and technical. This chapter aims at represent some socioeconomic problems and constraints to producing Maize. The problems and constraints faced by the farmers were identified according to opinions given by them. The major problems and constraints related to Maize cultivation are discussed below:

8.2 High Price of Seeds

High price of seeds was one of the most important limitations of producing Maize in the study area. From Table 8.1 it is evident that about 73.8 percent Maize growers in Harirampur Upazila reported this as high problem whereas about 72.7 percent Maize farmers in Bagha Upazila reported this as high problem. High price of seeds was a moderate problems to about 16.9 percent and 12.1 percent of respondents in Harirampur and Bagha Upazila respectively (Table 8.1). On an average about 73.3 percent of farmers reported this problem as severe (Table 8.2).

8.3 High Price of Fertilizers

Fertilizers is vital input for increasing maize production of farm. Day by day price of fertilizers is increasing. Most common problem faced by small maize farmers was responded as high fertilizer cost. About 44.2 percent Maize growers in Harirampur Upazila reported this as moderate problem whereas about 43.9 percent Maize farmers in Bagha Upazila reported this as high problem. High price of seeds was a severe problems to about 36.9 percent and moderate to about 22.7 percent of respondents in Harirampur and Bagha Upazila respectively (Table 8.1). On an average about 40.5 percent of farmers reported this problem as severe (Table 8.2).

8.4 Lack of Irrigation Water

Irrigation is a prime input for maize production. Yield of Maize varies with the application of irrigation water in a great extent. Few farmers had shallow tube well but most of the farmers had no deep tube well of their own in the study areas and for this they had to pay a higher charge for irrigation water. Source of was not available too in

Bagha upazila. Table 8.1 shows that about 47.7 percent Maize growers in Harirampur Upazila reported this as moderate problem whereas the percentage was about 48.5 percent in case of Bagha Upazila. Lack of Irrigation Water was a severe problems to about 38.5 percent and 47 percent of respondents in Harirampur and Bagha Upazila respectively (Table 8.1). On an average about 42.7 percent of farmers reported this problem as severe (Table 8.2).

8.5 Low Price of Grains

The main problem of maize cultivation was its very low price of grains. About 56.9 percent Maize growers in Harirampur Upazila and about 62.1 percent Maize farmers in Bagha Upazila reported this as severe problem. Low price of grains was a moderate problems to about 23.2 percent and about 22.7 percent of respondents in Harirampur and Bagha Upazila respectively (Table 8.1). On an average about 49.5 percent of farmers reported this problem as severe (Table 8.2).

8.6 Lack of Suitable Land

About 47.7 percent Maize growers in Harirampur Upazila and about 51.5 percent Maize farmers in Bagha Upazila reported lack of suitable land as moderate problem. This problem was a low problems to about 36.9 percent and about 34.8 percent of respondents in Harirampur and Bagha Upazila respectively. This problem was severe for few farmers in both upazilas (Table 8.1). On an average about 14.5 percent of farmers reported this problem as severe (Table 8.2).

8.7 Inadequate Extension Service

During the investigation some farmers reported that they did not get required extension services regarding improved method of Maize cultivation from the relevant officials of the Department of Agricultural Extension (DAE). In Harirampur Upazila about 47.7 percent Maize growers and about 34.8 percent of Maize farmers in Bagha Upazila reported this as a moderate problem for maize cultivation (Table 8.1). This problem was a low problems to about 30.8 percent and about 43.9 percent of respondents in Harirampur and Bagha Upazila respectively (Table 8.1). This problem was severe for few farmers in both upazilas. On an average about 21.4 percent of farmers reported this problem as severe (Table 8.2).

8.8 Natural Calamities

In Harirampur Upazila about 76.9 percent Maize growers and about 66.7 percent of Maize farmers in Bagha Upazila reported this as a hogh problem for maize cultivation (Table 8.1). This problem was a moderate problems to about 15.4 percent and about 28.8 percent of respondents in Harirampur and Bagha Upazila respectively. This problem was low for few farmers in both upazilas (Table 8.1). On an average about 71.8 percent of farmers reported this problem as severe (Table 8.2).

8.9 Lack of Quality Seeds

Lack of quality seeds was one of the most important limitations of producing maize in the study area. From Table 8.1 it is evident that about 41.5 percent maize growers in Harirampur Upazila reported this as moderate problem whereas about 39.4 percent maize farmers in Bagha Upazila reported this as severe problem (Table 8.1). Lack of quality seeds was a severe problems to about 30.8 percent and moderate to about 30.3 percent of respondents in Harirampur and Bagha Upazila respectively. On an average about 35.1 percent of farmers reported this problem as severe (Table 8.2).

8.10 Lack of Scientific Knowledge of Farming

Although modern agricultural technologies have been using in the study area, few of the farmers have no adequate knowledge of right doses and methods of using modern inputs and technologies of producing maize. In Harirampur upazila 66.1 percent Maize growers and about 54.5 percent of Maize farmers in Bagha Upazila were encountered this problem as low (Table 8.1). The problem was moderate for about 29.2 percent of farmers and 30.3 percent of farmers in Harirampur upazila and Bagha Upazila respectively. On an average about 11.5 percent of farmers reported this problem as severe (Table 8.2).

8.11 Lack of Credit Facility

The farmers of the study area had credit constraints. For cultivation of Maize, a huge amount of cash money was needed to purchase various inputs like, human labour, seed, fertilizers, irrigation etc. In Harirampur Upazila about 53.8 percent Maize farmers reported that they did not get sufficient amount of credit for purchasing the required quantity of inputs for the relevant enterprises and marked this as high problem whereas near 45.5 percent of Maize growers in Bagha Upazila reported this as moderate problem (Table 8.1). The problem was moderate for about 35.4 percent of farmers and severe for about 42.4 percent of farmers in Harirampur upazila and Bagha Upazila respectively. On an average about 6.87 percent of farmers reported this problem as severe. (Table 8.2).

Table 8.1 Problems of Maize Production by Study Areas

Type of Problems	Harirampur							Bagha						
	Rank	Low		Medium		High		Rank	Low		Medium		High	
		No	%	No	%	No	%		No	%	No	%	No	%
High price of seeds	2nd	6	9.2	11	16.9	48	73.8	1st	10	15.2	8	12.1	48	72.7
High price of fertilizers	6th	12	18.5	29	44.6	24	36.9	5th	22	33.3	15	22.7	29	43.9
Lack of irrigation facilities	5th	9	13.8	31	47.7	25	38.5	4th	3	4.5	32	48.5	31	47
Low price of grains	3rd	13	20	15	23.1	37	56.9	3rd	10	15.2	15	22.7	41	62.1
Lack of suitable land	9th	24	36.9	31	47.7	10	15.4	10th	23	34.8	34	51.5	9	13.6
Inadequate extension service	8th	20	30.8	31	47.7	14	21.5	8th	29	43.9	23	34.8	14	21.2
Natural Calamities	1st	5	7.7	10	15.4	50	76.9	2nd	3	4.5	19	28.8	44	66.7
Lack of Quality Seed	7th	18	27.7	27	41.5	20	30.8	7th	20	30.3	20	30.3	26	39.4
Lack of Scientific Knowledge	10th	41	66.1	19	29.2	5	7.7	9th	36	54.5	20	30.3	10	15.2
Lack of credit facility	4th	7	10.8	23	35.4	35	53.8	6th	8	12.1	30	45.5	28	42.4

Source: Field Survey, 2018

Table 8.2 Rank of Problems of Maize Production

Type of Problems	No. of farmers	Percentage of farmers	Rank
High price of seeds	96	73.3	1^{st}
Natural Calamities	94	71.8	2^{nd}
Low price of grains	78	59.5	3^{rd}
Lack of credit facility	63	48.1	4^{th}
Lack of irrigation facilities	56	42.7	5^{th}
High price of fertilizers	53	40.5	6^{th}
Lack of Quality Seed	46	35.1	7^{th}
Inadequate extension service	28	21.4	8^{th}
Lack of suitable land	19	14.5	9^{th}
Lack of Scientific Knowledge	15	11.5	10^{th}

Source: Field Survey, 2018

CHAPTER-9

SUMMARY, CONCLUSION AND RECOMMENDATIONS

9.1 Introduction

This chapter focuses on the summary in the light of the discussions made in the earlier chapters. Conclusion has been made on the basis of empirical result. Policy recommendations are drawn for improvement of the existing inefficiency of maize, production in Bangladesh.

9.2 Summary

Agriculture is the key driver of the growth of Bangladesh economy. The economic development is inevitably linked with the performance of this sector. Crop sector is the most prominent contributors in agriculture and total GDP of the country, indirectly the overall growth and development of the economy. The performance of this sub sector has a significant impact on major macroeconomic goal like generation of employment, alleviation of poverty, human development, food and nutritional security. GDP growth rate reached 7.86 percent in 2017-18, significantly higher than the growth of 7.28 percent in the preceding fiscal year. Among the broad sectors of GDP, the contribution of agriculture to GDP slid down by 0.51 percentage point to 14.23 percent (BER, 2018). Agriculture provides employment to nearly about 40.06 percent of its total labor forces (BER, 2018). Despite increase in the shares of fisheries, livestock, and forestry, crop sub-sector alone accounts for 7.51 percent share of agricultural GDP (BER, 2018).

Maize (*Zea mays*) belongs to the family Grammies a versatile photo insensitive crop. Maize is one of the oldest crops and the third most important crop after rice and wheat among the cereals in Bangladesh for its versatile nature with highest grain yield and multiple uses. It is most commonly used in poultry and fish feed industries, for baking and other foods such as popcorn, fried corn for human consumption (Rahman *et.al*, 2016). Bangladesh has the opportunity to increase the maize cultivation area and yield for its soil conditions, topography, and climate (Hossain *et. al*, 2015). Among total cropped area, only 2.20 percent land was utilized for maize production (BBS, 2018).

The area under maize cultivation has increased to 963000 acres in 2016-17 from 804000 acres in 2014-15. Increasing trend was also noticeable in yield rate which was 2826 kg per acre in 2014-15, increased to 3141 kg per acre in 2016-17. Total volume of production of maize have was 3026000 M. Tons in 2016-17 Total area under production of Kharif maize and Rabi maize were 13886 acres and 35456 acres in Manikgonj district whereas total area under production of Kharif maize and Rabi maize were 27704 acres and 84713 acres in Rajshahi district in 2016-17.

The sampling frame for the present study were selected purposively as to select the area where the maize cultivation was intensive. On the basis of higher concentration of maize crop production, six villages namely Jhitka kolahata, Jhitka moddho para, Nouhata, Jhitka thakur para, Jhitka bepari apra, Dakkhain gorail under Harirampur upazila in Manikgonj district and four villages namely Bausha hedati para, Khurdo bausha , Tethulia, and Pirgacha under Bagha upazila in Rajshahi district were selected for the study. A total of 131 (65 from Manikganj and 66 from Rajshahi districts) maize farmers selected as samples for the study. Maize grows well in our country through the year round due to favorable climatic condition. Considering this situation, few specific objectives of the study were taken to assess the profitability and technical efficiency of maize production in few selected areas of Bangladesh. These were

1. To identify the socio-demographic profile of maize farmers
2. To calculate the technical efficiency of maize cultivation.
3. To estimate the profitability from maize cultivation.
4. To address the problems facing by maize farmers and to suggest policy options to overcome these problems.

Data for the present study collected during the period of September to December 2018.Primary data has been collected through field survey and direct interview method from maize producers. Selected respondents were interviewed personally with the help of pre-tested semi-structured questionnaires. Editing and coding were done before putting the data in computer. All the collected data were summarized and scrutinized carefully to eliminate all possible errors. After completion of data collection, raw data were edited, coded and inserted in computer using the concerned software Microsoft Excel. Two different statistical software were used to analyze the collected data e.g. SPSS and STATA. Descriptive analysis was completed with the help of SPSS and data were presented in the tabular and graphical form, because these were of simple calculation, widely used and easy to understand. Technical efficiency analysis of data was done using the concerned software Microsoft Excel and statistical package STATA version 14.

A short overview of features of the study area has been presented. The knowledge of the study area is essential to understand and interpret the findings of the study and also to know the agricultural activities, possible development opportunities and potentials of the study area. Location, area, population, monthly average temperature and rainfall, agriculture facilities of the selected area were discussed for the purpose of study.

The socioeconomic characteristics considered in the present study were age, education, experience, major and minor occupation, family size, no of family members engaged in agriculture, land ownership, availability of credit, extension, training facilities etc. The sample of 65 household in Harirampur upazila and 66 household in Bagha upazila comprised a total population of 33513 and 46711 in Harirampur upazila, Manikgonj and Bagha upazila, Rajshahi, respectively (BBS, 2013). In two upazilas, 100 percent of the sample farmers were male and not a single farmers were found below 15 years old. In Harirampur upazila about 76.9 percent of the populations were under 15-64 years age group and only 23.1 percent were of 65 years or above. On the other hand, in Bagha upazila, 87.9 percent of the populations were under 15-64 years age group and only 12.1 percent was of 65 years or above. The sex ration in Harirampur and Bagha upazilas were found 117 and 120 male per 100 women), respectively, which were remarkably higher than the national figure 90 for Harirampur and 100 for Bagha upazila (BBS, 2013). Sex ratios of both upazilas were significantly higher than the sex ratio of the country 100.2 (BBS, SVRS-2019).The dependency ratios of the study population were estimated at 30 and 13, which were significantly lower than that reported in SVRS-2019 survey (51) (BBS, 2019), possibly because of the sample framework used for the survey. In Harirampur upazila, about 13.80 percent of the study population were found to have no education and only 1.50 percent farmers had completed their higher study. The occupation of the study population aged 15 years or more showed that, in Harirampur and Bagha upazila, about 80.00 percent (out of 65) and about 57.60 (out of 66) percent were engaged in agriculture. In Harirampur upazila, on an average 0.14 ha land was engaged in maize cultivation and in Bagha upazila, average size of land utilization for maize cultivation was 0.17 ha. On an average 0.60 ha and1.47 ha land were owned by a household in Harirampur and Bagha upazila respectively on the basis of collected data. The highest proportion of respondents, about 53.80 percent and 56.10

percent of maize farmers had 25-44 years of experience in agriculture in Harirampur upazila and Bagha upazila respectively. In the study area, the average size of family in both upazilas was 5. In case of both upazilas, on an average 1 person was engaged in agriculture from a household on the basis of observed data (out of 131). Maximum 5 persons of a houselhold in Harirampur upazila and 3 persons from a family in Bagha upazila were engaged in agriculture directly. About 25.40 percent and 12.30 percent household had 2 persons involvement in agriculture in Harirampur and Bagha upazila respectively. Among the respondent farmers, 56.90 percent and 68.20 percent farmers had direct or indirect communication with agricultural extension officers in Harirampur and Bagha upazila respectively. About 69.20 percent and 53.00 percent farmers were used their own funding for maize cultivation in Harirampur and Bagha upazila respectively. According to collected data (out of 131) most of the farmers didn’t have any training on crop cultivation.

Economic profitability is a major criterion to make decision for producing any crop at farm level. It can be measured based on net return, gross margin, gross return and ratio of return to total cost. The average land preparation cost of maize production was found to be Tk. 8066.49 per hectare, which was 7.54 percent of total cost. The quantity of human labour used in maize production was found to be about 110 man-days per hectare and average price of human labour was Tk. 363.57 per man-day. Therefore, the total cost of human labour was found to be Tk. 39993.00 representing 37.37 percent of total cost. Per hectare total cost of seed for maize production were estimated to be Tk. 7863.18, which constituted 7.35 percent of the total cost.

On an average, farmers used Urea, TSP, MoP 271.92 kg, 123.97 kg and 261.81 kg respectively, per hectare. The average cost of insecticides for maize production was found to be Tk. 730.45 whereas the average cost of irrigation was found to be Tk. 12017.47 per hectare which were Tk. 11023.48 per hectare and Tk. 12996.42 per hectare for Harirampur and Bagha upazila. The total variable cost of maize production was Tk. 82319.81 per hectare, which was 76.92 percent of the total cost. For Harirampur and Bagha upazila the total variable cost of were Tk. 90460.08 per hectare and Tk. 74302.63 per hectare respectively. The average yield of maize per hectare was 8563.421 kg and the amount were 8352.37 kg and 8771.27 kg per hectare in Harirampur and Bagha upazila. The average price of maize was Tk. 16.47. Gross returns, gross margin were Tk. 151323.72 per hectare, Tk. 69003.91 per hectare and net returns was

Tk. 44311.53 per hectare. Gross returns, gross margin were Tk. 148201.16 per hectare, Tk. 57741.08 per hectare and net returns was Tk. 31025.93 per hectare in Harirampur upazila. In case of Bagha upazila Tk. 97002.89 per hectare, Tk. 154398.96 per hectare Tk. 80096.33 per hectare Tk. 57396.07 per hectare were total cost of production, gross returns, gross margin and net returns respectively. Benefit Cost Ratio (BCR) was found to be 1.41 which implies that one taka investment in maize production generated Tk. 1.41 in the study area. BCR were found to be 1.26 and 1.59 for Harirampur and Bagha upazila respectively.

Technical efficiency reflects the ability of a farmer to obtain the maximum possible output from a given level of inputs and production technology. Technical inefficiency is then measured as the deviation of a farmer from the best-practice frontier. The regression coefficients of Seed (X_3) and Irrigation (X_5) were positive and were highly significant and the coefficient of Land Preparation cost (X_2) was significant at 5 percent level. The coefficient of Human labour (X_1) and Fertilizer (X_4) were found positive but were insignificant. It indicates that if the amount of Seed (X_3), Irrigation cost (X_5) and Land Preparation cost (X_2) were increased by one per cent, the production maize would increase by .2930331, .0361106, and .0454045 per cent of sample farmers respectively.

In the technical inefficiency effect model, experience, extension service, farm size have expected (negative) coefficients. The negative coefficient of experience implies that experienced farmers are technically more efficient than non-experienced farmers. The coefficient of education was .0260398 though the coefficient was not statistically significant. The negative and significant (1 percent) coefficient of extension service postulates that communication of farmers with extension officers reduces inefficiency of maize production. The negative and significant (1 percent) coefficient of farm size implies that large farm households are technically more efficient than small farm households. The coefficients of education and training are positive but insignificant meaning that these factors have no impact on the technical inefficiency of maize production. That is, these factors do not reduce or increase technical inefficiency of producing maize. Average estimated technical efficiencies for maize are 93.78 per cent which indicate that maize production could be increased by 6.22 per cent with the same level of inputs without incurring any further cost. The farm specific technical efficiency coefficient varied among farmer to farmers and ranged from 0.71 to 0.99 with a mean of 0.92 at Manikgonj followed by efficiency range 0.75 to 0.99 with mean of 0.94 at

Rajshahi. The variance parameters for sigma square and gamma are 0.00923 and 0.9531, respectively. They are significant at 1percent level. The sigma square indicates the goodness of fit and correctness of the distributional form assumed for the composite error term. The value γ-parameter associated with the variance in the model was 0.9531, indicates that inefficiency effects have a significant contribution in determining the level and variability of output of maize farms.

Farmers faced a lot of problems in producing maize. High price of seeds, high price of fertilizers, lack of irrigation water, low price of grains, lack of suitable land, inadequate extension service, natural calamities, lack of quality seeds, lack of scientific knowledge of farming, lack of credit facility were the major problems faced by maize farmers. Among these high price of seeds, natural calamities and low price of grains ranked 1st, 2nd and 3rd respectively on the basis of magnitude of problem faced by farmers. Govt. and different NGOs should take initiatives to reduce or eliminate these problems for the sake of better production of maize.

9.3 Conclusion

Maize is the third cereal crop after rice and wheat grown by farmers in Bangladesh. The study areas have tremendous potential for maize cultivation. The findings of the present study indicate that maize production is profitable and it would help improve the socioeconomic condition of farmers in the study areas. Due to the decreasing trend of land it is difficult to increase maize production by increasing the area of land under cultivation in Bangladesh. But, production can be increased by improving the existing technology. Farmers are relatively inefficient due to traditional farming system, illiteracy, small size of land holdings etc. The present study indicate that farmers are technically inefficient that means there is an opportunities to increase production to a great extent using the existing level of agricultural inputs, the agricultural extension services and the available technology. The present and future demand of maize should be determined through a comprehensive study in order to initiate a planned maize production programme at national level.

9.4 Recommendations

According to findings of the study, maize farming was considered a profitable enterprise for investment decision and it can provide huge income generating and employment opportunity to people of Bangladesh. There are few problems faced by the farmers in profit maximization. The policy makers should come forward with necessary measures. The following specific recommendation are made to increase the production of maize.

a) As most of the maize farmers are quite efficient at present farming system and released varieties of maize. New variety should be developed to increase further productivity of maize.
b) Price of seed should be reduced at reasonable level to farmers. Subsidies for purchase of seed and adoption of advanced technology should be provided to farmers for encouraging them to cultivate maize.
c) Drought tolerant, heat tolerant, saline tolerant maize varieties should be developed in order to get further production.
d) Govt. should ensure the fair price of cultivated maize through a structured market system for farmers.
e) Cost of irrigation should be reduced in both district. Establishment of more shallow and deep tube well in Bagha upazila will encourage farmers to invest in maize cultivation and production will be increased.
f) Adequate extension services should be provided to maize farmers on improved technology adoption, which will enhance the production and technical efficiency of maize.
g) Institutional credit at lower rate of interest will encourage small and marginal farmers to invest in maize cultivation. Easy loan disbursement policy and collateral free loan has also significant positive impact.
h) Storage facilities should be enhanced in both district.

9.5 Limitations of the Study

There are some limitations of the study. These are mentioned below:

a. Most of the data were collected through interviewing the farmers and sometimes they were not interested to respond.
b. The information gathered were mostly based on the memories of the farmers which were not always fully correct. There might have some margin of error.

c. Due to resource and time constraints, broad based and in-depth study got hampered to some extent.

9.6 Scope for Further Study

Although the present study is intended to provide some valuable information for the guidance of farmers, extension workers, policy makers as well as researchers, it is not free from criticisms. Due to limitation of time and resources this study could not cover some important areas. The weaknesses of the present study, of course, open avenues for further research which are given below:

a. The present study was conducted only in 10 villages of two upazilas. A similar study could be conducted covering various geographical regions of the country.
b. A further study can be undertaken by taking into account different farm sizes to assess the divergence of profitability of maize income and employment by farm size.
c. The study of comparative productivity and profitability of different crops may be conducted.
d. Acreage response, growth and instability of maize production can be studied in Bangladesh.

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APPENDICES

Table A-1: Summary Data on Sample Characteristics

Criteria	Harirampur	Bagha
Soil type	Loam-40percent Clay loam- 40percent	Loam-70.4percent Silt loam-39.6percent
Land type	High land-2.7, Medium high land-21.6, Medium low land-37.8, Low land=27, Extreme low land-10.8 percent	High land-31.9, Medium high land-36.2, Medium low land-31.9,
Planting	**Rabi:** Novemver (Kartik 4-Agrahayon 1) **Kharif:** February (Falgun)	**Rabi:** Novemver (Kartik 4 – Agrahayon 1) **Kharif:** March (Falgun 4- Chaitra 1)
Harvesting	**Rabi:**15thApril-15th May (Boishakh) **Kharif:** June (Ashar)	**Rabi:**15thApril-30th May (Boishakh) **Kharif:** June (Jaystha 4-Ashar 1)
No. of irrigation	2	4
No. of weeding	2	2
No. of cultivation	2	2
Rabi crops	Maize, Mustard, Onion, Potato, Chili, Radish, Carrot, Sesame, Coriander, Brinjal, Rice seedling, Garlic	Maize, Wheat, Onion, Garlic, Sugarcane, Lentil, Mustard, Grass pea
Kharif-1 crops	Maize, IRRI rice, Jute, Chili, Sesame	Mungbean, Jute, Turmeric, Arum
Kharif-2 crops	Aman rice or land remain fellow	IRRI rice
Women involvement in threshing	76.9percent (out of 65 respondents)	3percent(out of 66 respondents)
Main competitive crops to maize	Onion, Mustard, Jute	Onion, Garlic, Sugarcane

Source: Field Survey, 2018

Table A-2: Area and Production of Maize (Rabi & Kharif) by Division, 2014-15 to 2016-17

Division	2014-15		2015-16		2016-17	
	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)
Barishal	1656	2933	1714	2937	2211	3267
Chittagang	38704	76878	25211	50955	41351	82891
Dhaka	60246	152993	67590	172066	76776	202563
Khulna	168136	582507	165357	603503	190784	720460
Mymensing	14287	42091	19503	70720	20206	79770
Rajshahi	106445	243594	97294	232711	112417	319681
Rangpur	414717	1171732	451071	1313501	519203	1616670
Sylhet	30	75	39	101	52	90
BANGLADESH	803869	2271998	827387	2445578	963000	3025392

Source: BBS, 2017

Table A-3: Area and Production of Rabi Maize by Division, 2014-15 to 2016-17

Division	2014-15		2015-16		2016-17	
	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)
Barishal	1656	2933	1714	2937	2211	3267
Chittagang	20403	42621	20440	43448	37419	77418
Dhaka	58220	164071	70819	208518	60122	169337
Khulna	166450	579888	164356	602042	190005	719184
Mymensing	14287	42091	19503	70720	20206	79770
Rajshahi	73866	174610	68808	181174	84713	258853
Rangpur	341303	997329	372552	1123128	422258	1378913
Sylhet	30	75	39	101	52	90
Bangladesh	661928	1961527	698728	2161348	816986	2686832

Source: BBS, 2017

Table A-4: Area and Production of Kharif Maize by Division, 2014-15 to 2016-17

Division	2014-15		2015-16		2016-17	
	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)	Area (acres)	Production (M. Ton)
Barishal	0	0	0	0	0	0
Chittagang	18301	34257	4771	7507	3932	5473
Dhaka	14907	28705	14829	31364	16654	33226
Khulna	1686	2619	1001	1461	779	1276
Mymensing	0	0	0	0	0	0
Rajshahi	32579	68984	28486	51537	27704	60828
Rangpur	73414	174403	78519	190373	96945	237757

Sylhet	0	0	0	0	0	0
Bangladesh	141941	310471	128659	284230	146014	338560

Source: BBS, 2017

Table A-5: Acreage and Production of Maize in Bangladesh, 2000 to 2017-18

Year	Area in '000' acres	Production in '000' tons
2000	8	4
2000-2001	12	10
2001-2002	49	64
2002-2003	72	117
2003-2004	124	241
2004-2005	165	356
2005-2006	243	522
2006-2007	373	902
2007-2008	553	1343
2008-2009	317	730
2009-2010	376	887
2010-2011	409	1018
2011-2012	487	1298
2012-2013	580	1548
2013-2014	759	2124
2014-2015	804	2272
2015-2016	827	2445
2016-2017	963	3025
2017-2018	990	3288

Source: BBS, 2018