TECHNICAL EFFICIENCY OF BORO RICE CULTIVATION IN JAMALPUR DISTRICT

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CERTIFICATE

This is to certify that thesis entitled, "TECHNICAL EFFICIENCY OF BORO RICE CULTIVATION IN JAMALPUR DISTRICT" 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 research work carried out by **Md. Rabiul Islam**, Registration No.: **13-05536** 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 been duly been acknowledged.

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(Prof. Dr. Md. Mizanur Rahman Sarker)
Supervisor

Dated: June, 2020
Place: Dhaka, Bangladesh

Dedicated

To

My Beloved Parents

TECHNICAL EFFICIENCY OF BORO RICE CULTIVATION IN JAMALPUR DISTRICT

ABSTRACT

Bangladesh is the country with distinct agricultural setting. It is the most populous country in the world with 163.7 million populations and population density of 1103 person per square kilometer. Boro rice production plays an important role in achieving food security of Bangladesh. Due to high population growth rate, food security has become a burning issue in Bangladesh economy where 21.8 percent people lived under poverty level. Efficiency of Boro rice producer is an important factor because of rice is the staple food in Bangladesh. Annual consumption of rice is 134.02 kg. per capita in Bangladesh. This study attempted to examine the profitability and technical efficiency level of Boro rice farmers and inefficiency factors which affects production. One hundred and twenty (120) Boro rice farmers has been selected through simple random sampling procedure from three villages under Jamalpur Sadar upazila of Jamalpur district which comprising of 40 farmers from each village. The study has employed Cobb-Douglas stochastic frontier production function to estimate technical efficiency for Boro rice cultivation. Result reveals that per hectare total cost of production was Tk. 114931.68 per hectare. Gross returns was Tk. 120600.43 and net returns was Tk. 5668.75. Per hectare yields of Boro rice was found 6940 kg. Benefit Cost Ratio (BCR) was found 1.05 which implied that one taka investment in Boro rice production generated Tk. 1.05. The mean technical efficiency of the Boro rice was 87 percent. Human labour, seeds, fertilizers, insecticides, irrigation and power tiller (for land preparation) were important factors for production of Boro rice. Education, experience, farm size and training has expected negative sign which can reduce the farmer's inefficiency in the study area. The study also identified some problems faced by the Boro rice growers and suggested some recommendations to improve the present Boro rice production.

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June, 2020 ***The Author***

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ABBREVIATIONS AND ACRONYMS

BBS : Bangladesh Bureau of Statistics

BCR : Benefit Cost Ratio

BER : Bangladesh Economic Review

BRRI : Bangladesh Rice Research Institute

et al. : and others (at elli)

ha : Hectare

IOC : Interest on Operating Capital

MoA : Ministry of Agriculture

MoP : Muriate of Potash

MT : Metric Ton

MV : Modern Varieties

TSP : Triple Super Phosphate

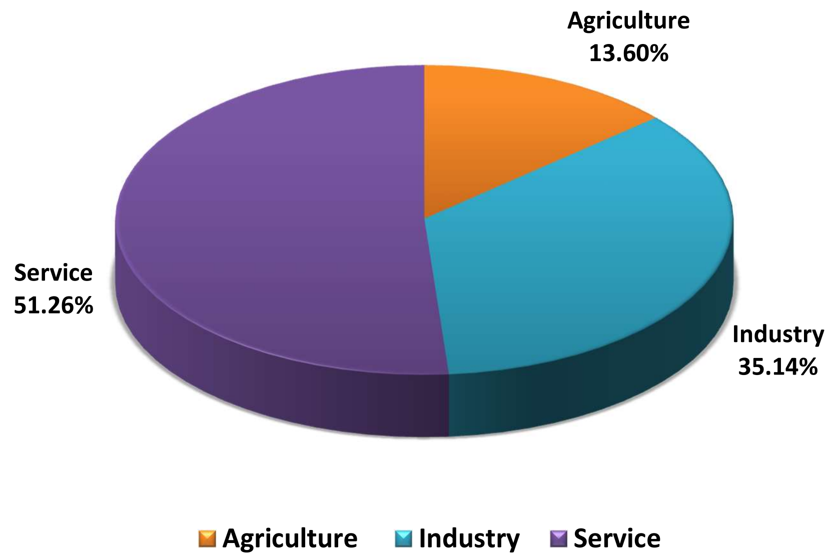
CHAPTER 1
INTRODUCTION

1.1 Background of the Study

Bangladesh is the country with distinct agricultural setting. The substantial part of its typographically and climatically diverse economy is set in the Sundarbans Delta, the largest delta of the world. It is the most populous country in the world with 163.7 million populations with high population density of 1103 person per sq. km. Sixty six percent population lives in rural areas. Agriculture is main occupation of the working population with 40.6 percent being engaged in these activities (BER, 2019). Contribution of agriculture in GDP is more than 13.60 percent (BER, 2019). In Bangladesh, rice is the major staple food and it covers about 74.85 percent of the total cropped area (15.03 million hectares). The consumption pattern of rice is 134.02 kg/capita/annum in Bangladesh (BBS, 2018). Rice production plays an important role in achieving food security of Bangladesh. Rice is cultivated in almost all agro-ecological regions of Bangladesh. The total area and production of rice in Bangladesh during 2017-18 were 11.63 million hectares and 36.28 million metric tones (MT) respectively. Per hectare yield of rice is about 3.17 MT in 2017-18 and it was about 2.82 MT in 2010-11 fiscal year (BBS, 2018). However, the increased yields of 0.35 MT per hectare during 2017-18 fiscal year due to use of quality seeds of modern varieties and appropriate technologies (BBS, 2018). In Boro season is the main rice production period in Bangladesh and it covered about 4.76 million hectares of total rice cropped area and production was 18.91 million metric tones (MT), which is 8.67 percent higher than 2016-17 fiscal year (BBS, 2018). National average rice productivity is still poor because of low yielding traditional varieties. The composition of area allocated to traditional rice still covers 1.63 million hectares which is 14.10 percent of total rice production area (MOA, 2018). Although, the cropping intensity is 194 percent of the country is the higher of the world, the decreasing land-man ratio is more frequently reminds about the intensive use of land.

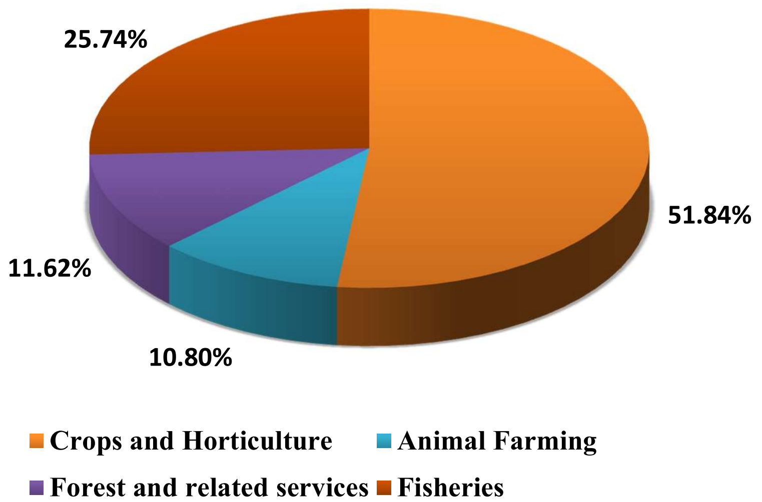
1.2 Status of Bangladesh Agriculture

The main drivers of economic growth for Bangladesh remain the agricultural sector and the readymade garments industry. The agricultural sector accounted for about 13.60 percent of Gross Domestic Product (GDP) in 2019 and it provides employment to 40.6 percent of the country's population (Figure 1.3) and meets the national food requirements. Agriculture is also the major source of income generation for the majority of rural households in Bangladesh. The agricultural sector is regarded as the major sector for investments to raise income, improve food security and reduce overall poverty. Agriculture plays a key position in the overall economic range of the country in terms of its contribution to Gross Domestic Product (GDP). Figure 1.1 denotes the sectors share of GDP at constant market prices (Base Year: 2005-06). Agriculture sector which comprises crops and horticulture, animal farming, forest and related services and fisheries contributes 13.60 percent to the Gross Domestic Product (GDP) as a whole in the FY 2018-19 (BER, 2019). The shares of fisheries, animal farming, and forestry, crops and horticulture sector are increasing and accounts for 7.05, 1.47, 1.58, 3.50 percent respectively in the share of agricultural GDP in FY 2018-19 that shown in Figure 1.2 (BER,2019). In FY 2018-19, within the broad agricultural sector, the provisional growth rate of agriculture and forestry sector stood at 3.47 percent according to the base year 2005-06. Of this growth performance, the growth of crops and horticulture sub-sector scaled up from 0.59 percent in FY 2012-13 to 3.06 percent in FY 2017-18 (BBS, 2018). The estimated total production of cereal crops (e.g. rice, wheat and maize) was 415.74 lakh MT in FY 2018-19, which increased by 2.49 lakh MT compared to 413.25 lakh MT of the previous fiscal year 2017-18. According to provisional data, the production of aus, amon and boro stood at 27.02 lakh MT, 141.34 lakh MT and 196.24 lakh MT in FY 2018-19, respectively, which was 0.06 lakh MT lower, 1.4 lakh MT and 0.47 lakh MT higher than that of previous fiscal year 2017-18 (BER, 2019).



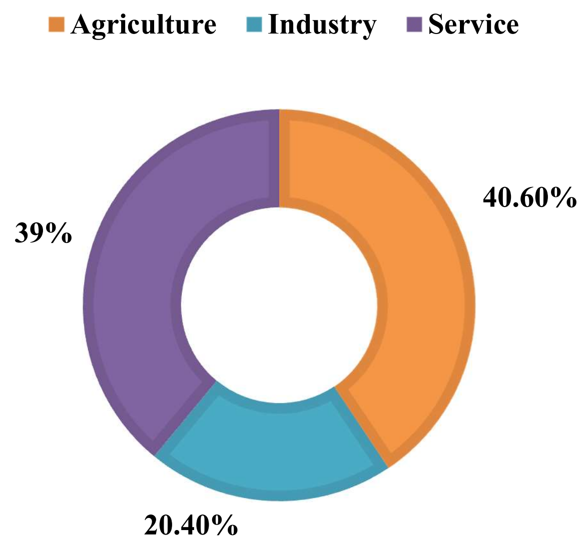
Source: BER, 2019

Figure 1.1: Sectoral Share of GDP at Constant Prices



Source: BER, 2019

Figure 1.2: Sub-Sectoral Share of Agricultural GDP at Constant Prices



Source: BER, 2019

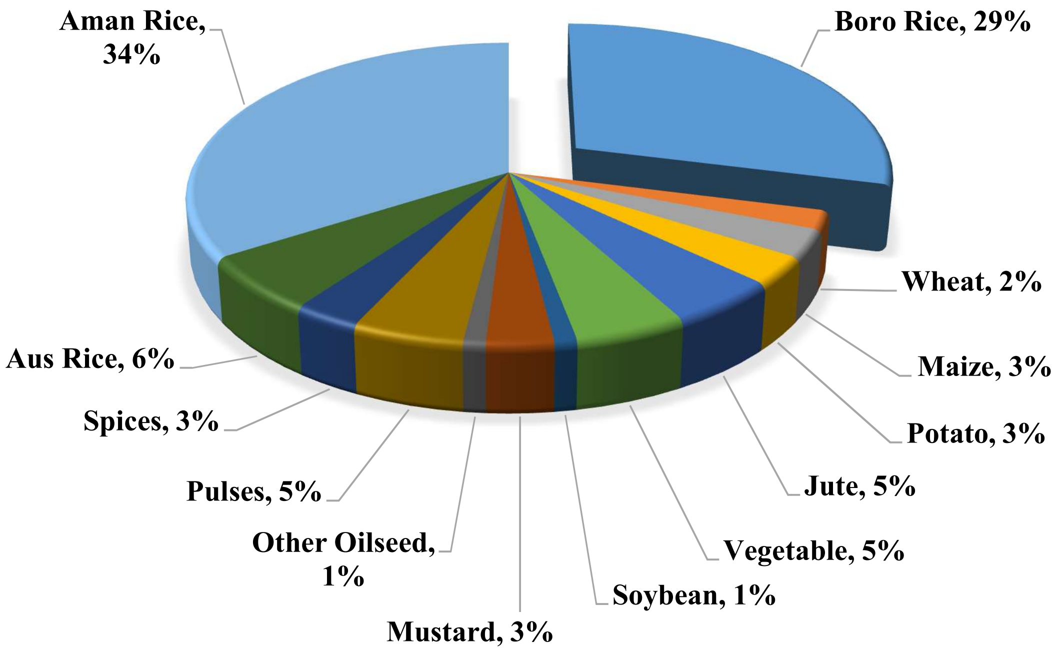
Figure 1.3: Employment Generation by different major Sector

1.3 Importance of Rice

Rice is the astonishing food grain that shapes the diets, culture, economy and the way of life in Bangladesh as well as in South Asia. It is the staple food for entire 163.7 million people of Bangladesh (BER, 2019). On the other hand, the annual growth rate for rice consumption in the Asia-Pacific Region over a period of 45 years (1950 to 1995) has kept pace with the demand, more through yield increase rather than area expansion (Papademetriou, 2000). Within 2030 our world population will be increased by 8.27 billion and we can ensure enough rice for the increasing population (Kubo and Purevdorj, 2004).

Keeping this in cognizance, since the independence all the successive governments have given high priority for attaining self-sufficiency in food production particularly in rice production. Accordingly, the demand for paddy is constantly rising and 1.37 percent new population are being added each year to its total population. The development of high yielding modern rice varieties of rice which are highly responsive to inorganic fertilizer and insecticides, effective soil management and water control helped the country to meet the increasing food grain (Hayami and Ruttan, 1985).

Among the high yielding varieties boro rice varieties have maximum share to the total rice production which is almost stable over the last decades. Rice continuously provides 73 percent of total calorie intake for the people particularly for hard working people or day labor. The rice area is about 11.30 million hectares (BBS, 2018). The rice production is by far the most important provider of rural employment (HIES, 2016). The area, production and yield rate of aus, aman and boro rice in different years were shown in Table 1.1 and Figure 1.4 showed percentage of cultivated land of different major crops that are produced in Bangladesh.



Source: MoA, 2018

Figure 1.4: Cultivation Area of Major Agricultural Crops in Bangladesh

Rice is the staple food of Bangladesh. It covers about 69 percent of total cropped area. A total 6, 34 and 29 percent area of Bangladesh brought under aus, aman and boro rice cultivation.

Though the share of boro rice cultivated area is lower than aman rice but boro plays significant role in rice production. Besides rice other cereal crops, vegetables spices and oil seeds are cultivated in rest of the areas. Both rice and non-rice crops plays a vital roles in achieving food security in Bangladesh.

Table 1.1: Area, Production and Yield of Boro rice in Bangladesh

Year	**Area (M ha)**	**Production (MMT)**	**Yield (t/ha)**
2000-01	3.76	11.92	3.17
2001-02	3.77	11.77	3.12
2002-03	3.85	12.22	3.17
2003-04	3.95	12.84	3.25
2004-05	4.06	13.84	3.41
2005-06	4.07	13.98	3.43
2006-07	4.25	14.97	3.52
2007-08	4.61	17.76	3.85
2008-09	4.72	17.81	3.77
2009-10	4.78	18.34	3.84
2010-11	4.77	18.62	3.90
2011-12	4.81	18.76	3.90
2012-13	5.17	18.78	3.63
2013-14	4.79	19.01	3.97
2014-15	4.84	19.19	3.96
2015-16	4.77	18.94	3.97
2016-17	4.48	18.01	4.02
2017-18	4.86	19.58	4.03
Growth Rate (%)	**1.43**	**2.76**	**1.33**

Source: BER, 2019

Boro rice cultivation area of Bangladesh are increasing day by day. In 2000-01, total Boro rice area was 3.76 million hactre (M ha) and in 2017-18 total Boro rice cultivated area increased to be 4.86 million hactre (M ha). The production of Boro rice in 2000-01 was 11.92 million metric tons (MMT) and it was increased to be 19.58 million metric ton (MMT) in 2017-18 fiscal year. The yield per hactre was increased dramatically due to increasing the use of modern Boro rice varieties. The yield of Boro rice in 2000-01 was 3.17 ton per hactre and in 2017-18 increased to be 4.03 ton per hactre (Table 1.1). The growth rate of Boro rice cultivated area, production and yield was 1.43, 2.76 and 1.33 percent respectively.

1.4 Nutritional value of Rice

Rice is the staple food of over half the world's population. It is the predominant dietary energy source for 17 countries in Asia and the Pacific, 9 countries in North and South America and 8 countries in Africa. Rice provides 20% of the world's dietary energy supply, while wheat supplies 19% and maize 5%. A detailed analysis of nutrient content of rice suggests that the nutrition value of paddy varies based on a number of factors. It depends on the strain of rice, that is between white, brown, red, black and purple varieties of rice, each widespread in different parts of the world. It also depends on texture and nutrient quality of the soil where rice is grown in, whether and how the rice is refined or treated, the mode it is enriched, and how it is processed before consumption. Starch is the most common form of carbohydrates in foods, made up of long chains of glucose known as amylose and amylopectin. Amylose and amylopectin have different properties that may contribute to both the texture and digestibility of rice. Rice that is high in amylose, such as basmati rice, does not stick together after cooking. Amylose also slows down the digestion of starch and is often associated with so-called resistant starch, a type of healthy fiber. On the other hand, rice that is low in amylose and high in amylopectin is sticky after cooking. High digestibility is one of the downsides of the protein in sticky rice. For a high-protein food, good digestibility is not always favorable because it may cause an unhealthy spike in blood sugar, especially among diabetics. Rice is mainly composed of carbohydrates. Some types may cause unhealthy spikes in blood sugar, making them unsuitable for diabetics.

About 40 percent of the world's population derives most of their calories from rice. Almost 90 percent of the population of Bangladesh, Myanmar, Sri Lanka and Vietnam are rice eaters. However, rice is intermingled with Bengali culture from the time immemorial. It is the symbol of wealth in the South Asian regions. The Food Department of the Government of Bangladesh recommends 410 gm of rice/capita/day. But the people of Bangladesh are intake 446.73 gm of rice/capita/day.

Table 1.2: Nutrition from Per 100 gm Rice

Composition	Content Per 100 gm Rice
Calories (kilocalorie)	325
Moisture content (percent)	13.30
Carbohydrate (percent)	79.00
Protein (gm)	6.40
Fat (gm)	0.40
Beta carotine (µg)	0.00
Vitamin B(mg)	0.00
Thiamin	0.21
Riboflovine	0.09
Vitamin C(mg)	0.00
Calcium (Ca) (mg)	9.00
Iron (Fe) (mg)	1.00

Source: Bose and Som, 1986; Wahed and Anjan, 2008

1.5 Justification of the Study

The researcher was motivated to identify whether boro rice farmers utilize their full capacity in production processes or not, and to find ways of improving their productivity, in case they were less efficient. This study is designed to help find solutions which would promote increases in boro rice productivity as well as overall output. Therefore, this study will have important benefits to the researcher, boro rice producers, policy makers in government and to contribution to the body of knowledge in production economics and finally to come up with policy proposals to address the constraints. Identifying inefficiency in boro rice production helps rice producers to use their inputs efficiently thereby helping in minimizing the already scarce resources in the country. It is important that farmers use resources efficiently to achieve the maximum yield. That is, if boro rice farmers can increase productivity with the same input quantities under efficient allocation and management of resources at the farm level; this will have great implication for overall national development and food security.

Additionally, results of this study will help policy makers to design policies to target interventions according to the identified needs and constraints of boro rice producers. Moreover, the results from this study will contribute to the already existing body of knowledge in production economics and efficiency studies in particular. The efforts here could provoke efficiency studies on other crops in the Bangladesh.

As it was also investigated that boro rice productivity in farmer fields are often below what will be possible with improved management. A good understanding can enable us to identify progress in boro rice farmer fields and also help us identify the extent to which increased cost can be justified to raise yields or reduce yield losses. Identifying the productivity gaps also enables the major yield limiting factors (e.g. drought, flooding, fertilizer deficiencies, extreme temperature etc.) and yield reducing factors (e.g. pests, diseases etc.) to be identified.

Productivity gaps occur in low-input systems with irrigation control and relatively poor input management, but often also in high-input systems with good irrigation control that allows for more suitable management practices. Rice plants growth and development can be severely hampered by drought or floods.

Absence or late availability of critical inputs may also undermine farmer's ability to make management decision and undertake farm operations on time.

However, adoption of increasing agricultural new technology can be an important option for the farmers to get rid of hunger and food insecurity by improving crop productivity, reducing food price and making more food accessible for the poor households. Further, promoting the adoption of improved crop varieties in a sustainable manner helps to improve welfare of the households (Asfaw *et al*, 2012a).

By considering all of aspects the present study will help to find the fundamental problems and develop our consideration on the boro rice cultivation and decision making in production of boro rice. Further, the study will help in affording a picture of the benefits and costs of these initiatives, which will help individual researchers who will conduct further studies of the similar nature and encourage in conducting more comprehensive and detailed investigation in this particular field of the study. Finally, the study will be helpful for the individual farmers for effective operation and management of their farms through pointing the drawbacks and for the planners for proper planning and policy making. The study may be helpful to the extension workers to learn about various problems related to boro rice cultivation and to suggest the farmers for copying with those problems.

1.6 Problem statement

Rice is the most important staple food crop in The Bangladesh with a total annual consumption in 2017 estimated at 134.02 kg/capita/annum (BBS, 2018). As the main staple food of the Bangladesh, rice is consumed at least twice a day in most households in the country. In recent years the production of rice has increased in South Asian Countries but in other countries of the region yields have stagnated (Mutert and Fairhurst, 2002). Bangladesh has huge population as compared to many others country and it occupies 8th position over the world because of over population. With the increase of population our cultivated land in decreasing day by day. About 75% country's population is engaged in agricultural sector (BSGDMA, 2007). Rice is one of the dominant crops of the agrarian economy of Bangladesh and it reflected in the high per capita rice consumption in this country.

Despite pressure from overpopulation, the country has reached self-sufficiency in rice production (Shelley *et al.*, 2016). In Bangladesh rice production most rain fed rice is faced problem because of drought and Diurnal temperature range (Rahman *et al.*, 2017).

The rice is grown in all agro ecological zone of the country and serves as the source of livelihood for over 70% of the farming households in the country. Due to its critical role in employment generation and contribution to household food and income security in the Bangladesh, the government has prioritized the rice production particularly in boro season and supported farmers over the years with improved varieties and subsidized fertilizers to ensure increased production and productivity.

Despite efforts at increasing boro rice productivity through the cultivation of modern or improved rice varieties in all the regions of the country, yields of rice in the Bangladesh have remained lower than expected level. Low productivity rice sector, which has warranted the unsustainable levels of rice imports, could be attributed to constraints farmers face, including environmental factors, technological constraints and poor management practices. Environmental factors responsible for low yields in rice productivity include heavy rainfall or the steady decline in rainfall which led to critical drought condition; and this leading to low productivity. Depletion of soil fertility, along with poor management of weeds, pest and diseases, is a major biophysical cause for the low per capita rice production in the Bangladesh. Over decades, large quantities of nutrients from the soil have been removed without using sufficient quantities of manure and fertilizer to replenish the soil. Also inappropriate fertilizers are used in many areas because there is lack of soil testing. The identified constraints are likely to affect farmer's production levels and their overall efficiency in rice cultivation.

However, the opportunity cost of food imports may be high in terms of lower investment and consequently reduced rate of economic growth (Ghatak and Ingersent, 1984). The overall performance of the economy is, therefore, yet intricately linked to the performance of the agricultural sector (Matin, 2004). Hence, it is evident that Bangladesh should develop its agriculture sector to attain sustainable economic development.

The total cropped area of Bangladesh is about 15.03 million hectares of which 54.42 percent is cultivable, 3.74 percent is current fallow land and rest 41.85 percent is covered by homesteads, rivers, tidal creeks, lakes, ponds, roads, etc. (BER, 2019). So there is a little scope left to increase agricultural output by bringing new land under cultivation. Increase in agricultural output could be attained, however, by using modern boro rice varieties and adopting improved cultural and management practices.

1.7 Objectives of the Study

The specific objectives of the study are as follows:

i. To identify the socio-economic profile of Boro rice growers;
ii. To find out the profitability level of Boro rice cultivation;
iii. To estimate the level of Technical Efficiency of Boro rice cultivation; and
iv. To identify the problems of Boro rice cultivation and suggest some policy guidelines.

1.8 Organization of the Study

The study consists of nine (9) chapters. Chapter 1 describes introduction of the study. Relevant review of literature is presented in Chapter 2. Methodology and analytical Techniques are presented in Chapter 3. Following Chapter 4 description of the study area are shown. Socioeconomic characteristics of the sample farmers are described in Chapter 5. Profitability analysis of boro rice cultivation is presented in Chapter 6. Technical efficiency of boro rice production is presented in Chapter 7. Following problems of boro rice growers are shown in Chapter 8. Lastly, the summary, conclusion and recommendations are presented in Chapter 9.

CHAPTER 2
REVIEW OF LITERATURE

The main purpose of this chapter is to review some related studies in connection with the present study. Only a few studies have so far conducted related to technical efficiency and profitability of Boro rice cultivation in Bangladesh. Bangladesh has made remarkable progress in food production and achieving its food security. Since independence in 1971, production and consumption of food grains grew substantially over time.

Even though, there were ups and downs, production of food grains generally experienced an upward trend. At present, agriculture as a whole accounts for 14.10 of Gross Domestic Product (GDP) (BBS, 2018) and 40.6% of labor employment (BER, 2019). Although the contribution of agriculture sector to GDP has gradually been declining in recent years but still it is playing a major role in the economy of 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.

Husain *et al.* (2001) conducted a study on Bangladesh agriculture and found that agriculture in Bangladesh dominated by rice production, is already operating at its land frontier and has very little or no scope to increase the supply of land to meet the growing demand for food required for its ever-increasing population. The expansion in crop area, which was a major source of production growth till the 1980s, has been exhausted and the area under rice started to decline thereafter.

Ali (2000) attempted to measure and compare resource use and land productivity within tenure groups. Total gross cost for producing aman, boro and aus were the highest in owner farms and the lowest in tenant farms. It observed that owner operators used higher level of inputs than owner-cum-tenant and tenant operators. Rice owner-cum-tenant operators obtained higher yield in Aman and Aus production then owner and tenant operators.

In Boro paddy production tenant operators obtained maximum net return than owner operators and owner-cum- tenant operators in owner land. Finally, it was concluded that tenancy affects positively on resource use and production in a predictable fashion even in small scale peasant agriculture.

Hasan (2000) studied on the economic potential of alok hybrid rice and found that per hectare total cost for hybrid alok was Tk. 36,276.33 per hectare variable cost was calculated as Tk. 2,927.05 and per hectare yield was 6,557.07 kg. The price of alok paddy was Tk. 7.81/kg. Taking the by product into account the gross return of hybrid alok per hectare was Tk. 5,465.02. The net return per hectare was Tk. 18,375.50 and the gross margin was Tk. 26,409.97.

Baffes and Gautam (2001) observed the growth in rice production, at an annual rate of 2.34% for the period 1973–1999, has been largely attributed to conversion of traditional rice to modern varieties rather than to increases in yields of modern rice varieties. The study also found that about 61% of total rice area is allocated to modern varieties and the upper bound of conversion, set at 85%. But, it seemed to be optimistic as it assumed a minor increase in gross rice cultivated area while the past experience revealed a stagnancy and/or minor decline in land under rice cultivation.

Bera and Kelly (1990) studied on the conversion potential from local to modern varieties seems to be limited as the adoption level of modern high yielding rice varieties in Bangladesh appears to be reached. Furthermore, even though modern rice varieties currently account for only about 49 per cent of total rice area, it shows that the ceiling adoption level in Bangladesh has nearly been reached.

Mustafi and Azad (2000) conducted a study on adoption of modern rice varieties in Bangladesh. They examined the comparative profitability of BR-28 and BR-29 and found that the average yields 5,980 kg and 6,670 kg per hectare respectively. The gross margin was higher for BR-29 which was Tk. 27,717.02 per hectare. The farm level data also showed that the unit cost of BR-29 and BR-28 were Tk. 4.70 and Tk. 5.12 per kg. They also compared to BR-28 return from BR-29 is higher by Tk. 3,759 per hectare.

Husain *et al.* (2001) carried out an experiment on the principal solution to increasing food production lies in raising the productivity of land by closing the existing yield gaps and developing varieties with higher yield potential. On the other end of the spectrum, the study that farmers will have to generate large marketable surplus to feed the growing urban population estimated at 46% of total population of 173 million by 2020. The study implied that Bangladeshi farmers not only need to be more efficient in their production activities, but also to be responsive to market indicators, so that the scarce resources are utilized efficiently to increase productivity as well as profitability, and ensure supply to the urban market.

Akter (2001) conducted a study on relative profitability of alternate cropping patterns under irrigation condition in some selected area of Barguna district. The relative profitability of 5 dominant cropping patterns in two villages of Barguna district Bangladesh was assessed. The cropping patterns considered were (1) T. Aus Rice-T. Aman rice-HYV Boro rice; (2) T. Aus rice-T. Aman rice-wheat; (3) T. Aman rice-Jute-HYV Boro rice; (4) T. Aman rice -chilli-fallow; and (5) T. Aman Rice-Jute-potato. Data were obtained through interviews with 60 farmers 10 farmers from each cropping pattern during June-August 2000. Cropping pattern 1 had the highest per hectare gross margin (Tk. 43312) and net return (Tk. 27643). While cropping pattern 4 had the lowest gross margin (Tk. 29575) and net return (Tk. 19000). The inclusion of HYV boro rice as a third crop in the cropping pattern increased both income and employment.

Bhuiyan (1992) conducted a study and highlighted that for intensive, high-yielding rice production, access to irrigation water and drainage facilities is crucial. Provision of irrigation facilities expanded rapidly in the 1970's and early 1980's in the major rice-producing countries of Asia, but the management of water has remained inefficient. Investments in new irrigation have declined as the rice supply improved and the development of new water resources became increasingly costly. This trend is not likely to be reversed in the foreseeable future. Consequently, improved efficiency in the use of water is needed to maintain rice production growth.

Quazi and Paul (2002) conducted a study on comparative advantages of crop production in Bangladesh.

In their study, the economic profitability analysis demonstrates that Bangladesh has a comparative advantage in domestic production of rice for import substitution. However, at the export parity price, economic profitability of rice is generally less than economic profitability of many non-rice crops, implying that Bangladesh has more profitable options other than production for rice export. Several non-cereal crops, including vegetables, potatoes and onions have financial and economic returns that are as high as or higher than those of High Yielding Variety (HYV) rice.

Lampe (1995) conducted a study rice and found that rice is the staple food for about 2.4 billion people and provides more than 20% of their daily calorie intake. This number will be increased to 4.6 billion people by 2050. Just to meet the projected demand for rice in the 21st Century, the world's annual rough rice production must be increased from 520 million tons to at least 880 million tons by 2025, an increase of almost 70%. That requirement may be raised to one billion tons by the year 2050. To produce such an increase, on decreasing arable land, with reduced water resources, with less rural labor input, and with fewer agrochemical inputs, will require major contributions from research to increase yields and reduce inputs, costs and losses. And, more important, it will require coordinated national and international scientific efforts and, above all, strong political will, determined governments and major investments in food research in the rice-consuming countries of the world.

Rahman *et al.* (2002) attempted to measure the technical efficiencies obtained by owner operated farming and share cropping for boro, aus and aman rice were 86 percent, 93 percent and 80 percent, respectively whereas mean technical efficiencies obtained by sharecroppers for boro, aus and aman rice were respectively 73 percent, 76 percent and 72 percent. The study revealed that owner operators were technically more efficient than sharecroppers in the production of all the rice crops. To reduce the difference of technical efficiencies between owner operator and sharecropper a perfect leasing system is inevitable.

Mondal (2005) attempted to measure and compare resource use, efficiency and relative productivity of farming under different tenurial conditions. It is found that total cash expenses as well as total gross cost producing HYV boro rice was highest in owner-cum-tenants owned land than in rented in land.

When individual inputs were concerned it was observed that expenses on human labour shared a major portion of expenses in the production of HYV boro rice under all tenure groups. The fertilizer cost in owner's own land was significantly different from that of tenant's rented land. It was found that owner farmers were more efficient than owner-cum-tenant and tenant farmers. Again, owner-cum-tenants were more efficient in production in the case of his owned land than in rented in land.

Milovanovic and Smutka (2017) conducted a study and found that rice is an important Asian commodity, a region with diverse production systems and consumption patterns. With an increasing population leading to an increase in demand, the main drivers which determine rice production need to be identified. The study attempted to identify and assessed the key drivers of rice production and the future prospects in major rice producing countries within the region using simple and stepwise multiple linear regression. In most of the countries, rice production was found to be determined by indicators such as yield, country consumption and country population, each accounting for about 90 percent of variation in rice production. Among the mentioned indicators, country population should be given the most weight to as majority of rice is consumed by humans, thus validating the need to address the necessity to enhance rice production that commensurate with an increasing population.

Zaman (2002) conducted a study to accomplish a comparative analysis of resource productivity and adoption of modern technology under owner and tenant farms. It was found that gross cost for producing HYV boro rice were the highest in owner farms and the lowest in tenant farms. Owner operators used more hired labour where tenant operators used more family labour. The maximum return over total cost per hectare was obtained by owner operators and minimum by tenant operators. It was also observed that owner operators were more efficient than tenant operators. It was also observed that owner operators were more efficient than tenant operators; it was also found that the degrees of adequacy level in the application of modern farm inputs were higher in owner farms than in tenant farms.

Ahmed (2004) conducted a study on rice production in Bangladesh and found that the increased yield because of the use of modern technology and the price of rice is increasing due to rising agriculture wage rates and decline availability of cultivable land. It brought a remarkable success in attaining near self-sufficiency in the production of rice. This paper traced the transformation of the rice economy of Bangladesh over the past two decades. It has examined the factors behind the growth in rice production and the role of market-oriented policy reforms, particularly in respect of the liberalization and privatization of agricultural input markets. The paper argued in favor of strengthening the role of the private sector in input markets while emphasizing larger allocations of public resources for agricultural research and water resource development.

Talukder and Chile (2014) carried out a study and found that agricultural trade liberalization facilitated rice farmers with access to cheaper inputs such as irrigation, fertilizers, pesticides and HYV seeds, and led to the technological transformation in rice cultivation. The technological transformation in agricultural production led to major structural changes in agriculture and the rural economy, resulting in a substantial increase in productivity of rice. Average yields per hectare and total rice production increased significantly, leading to a substantial increase in the supply of rice in the domestic market which resulted in significant reductions in rice prices. The average production cost of rice per acre in terms of input use varied across the three rice crops as well as across the various stages of rice cultivation. Average yields per hectare and total rice production increased significantly, leading to a substantial increase in the supply of rice in the domestic market.

Salam *et al.* (2012) conducted a study in boro season, varieties like traditional, MVs and hybrid are being cultivated. Farmer's perceptions on growing hybrid and MVs are slightly different due to management practices. The study estimated of technical inefficiency implied that education, farming experience, extension contact, land type, seedling age, and number of seedlings per hill were the major determinants of inefficiency for both inbred and hybrid rice growers. The mean technical efficiency was about 80% for inbred and 86% for hybrid rice producers, respectively, indicating hybrid rice growers were technically more efficient than inbred growers.

Although, inbred and hybrid rice producers faced some problems, but it was more severe for hybrid varieties.

Banik (1994) conducted a study on importance of new modern varieties development and way to improve the farm level efficiency of the existing technology. The measurement of technical efficiency of boro rice producers in Bangladesh was the first aim of this paper. Following that, the efficiency differentials across farms were explained, which assist in identifying ways to improve efficiencies. The study estimated technical efficiency of 99 modern Boro rice farmers in the central region of Bangladesh at 82 per cent and found that farm size and tenure status had no influence on efficiency.

Islam *et al.* (2007) carried out a study to examine the income and price elasticities of demand for different types of rice in Bangladesh. The total budget for cereal field allocated to aromatic, fine, course rice and wheat was 4.0%, 23.3%, 65.2% and 7.5% respectively. The estimated expenditure elasticities of demand for those types of cereal were 0.85, 0.79, 0.29 and 0.55 respectively. The study showed the nature of rice consumption pattern with respect to price of rice.

Wadud (2003) carried out a study that estimated the technical, allocative and economic efficiency of farms using farm-level survey data for rice farmers in Bangladesh. The study applied the stochastic efficiency decomposition technique and Data Envelopment Analysis (DEA). Inefficiency effects were modelled as a function of farm-specific human capital variables, irrigation infrastructure and environmental factors. The results from both the approaches showed that there was substantial technical, allocative and economic inefficiency in production and that analysis of technical, allocative and economic inefficiency in terms of land fragmentation, irrigation infrastructure and environmental factor are robust. Policies leading to reduction of land fragmentation and improvement of irrigation infrastructure and environmental factors could promote technical, allocative and economic efficiency, reduce yield variability and enhance farm income and household welfare.

Abedullah and Mushtaq (2007) carried out the study and employed a Stochastic Frontier Production approach to determine the future investment strategies that can enhance the production of rice. The results of stochastic production function indicated that coefficient of pesticide was not significant probably due to heavy pest infestation while fertilizer found to have negative impact on rice production mainly because of improper combination of N, P, and K nutrients. The improper combination of input use indicates poor dissemination of extension services. The results of inefficiency model suggested that investment on tractor (mechanization) could significantly contribute to improve farmer's technical efficiency, implying that the role of agricultural credit supply institutes (such as banks) needs to be redefined. Rice farmers were 9 percent technically inefficient, implying that little potential existed that could be explored through improvement in resource use efficiency.

Hossain *et al.* (2006) conducted a study that showed how the technological progress helped Bangladesh to achieve self-sufficiency in rice production in 2001 from a heavy import-dependence, despite doubling of population and a reduction in arable land since its independence in 1971. As the adoption of modern varieties (MV) of rice was reaching a plateau, particularly for the irrigated ecosystem, an important for the research system that helped to sustain the growth of production. The study addressed the following questions: (i) to what extent farmers had been replacing the old MV with the new MV, and (ii) what had been the impact of the variety replacement on productivity and profitability. How crucial was the continuous research and release of improved rice varieties toward improving farm production and income for farmers.

The above review indicates that a few studies have been conducted on technical efficiency of modern boro rice varieties cultivation in Bangladesh. The result of these studies varies widely in different reasons as well different regions. The present study aims to gather information on profitability of boro rice cultivation and the level of technical efficiency and inefficiencies of rice farmers. The result of the study would help researchers, related farmers, extension workers and policy makers in taking necessary steps for increasing rice production in our country.

CHAPTER 3
METHODOLOGY

3.1 Introduction

Methodology is an important and fundamental part of any research. The acceptance and reliability of a specific research finding depends on the appropriate methodology used in the study. Inappropriate methodology very often leads to misleading the research result. So, careful considerations are needed by an author to follow a scientific and logical methodology for carrying out the study.

This chapter discuss the study area, type and source of data, sampling procedure and sample size. It also presents the survey design, methods of data analysis, theoretical framework and empirical models. It concludes with definition, measurement and a-priori expectations of variables.

3.2. Selection of the study area

The study area covers one of the main rice production hubs of Bangladesh. Study area selection plays an important role in any research. However, selection of the study region is a vital phase for the farm management research. "The area in which a farm business survey is to be carried out depends on the particular purpose of the research and the probable cooperation from the farmers" (Yang, 1965). A primary survey in Jamalpur Sadar Upazila of Jamalpur district was conducted to achieve the objectives of the present study. On the basis of pimary information, Purba Par Dighuli, Sonotia and Megha villages from Jamalpur Sadar were selected purposively because a large number of farmers grow boro rice in these villages.

The other reasons for selecting the study region were as follows:

i. The area represented the similar agro-ecological characteristics
ii. These area were typical boro rice growing villages with desirable soil condition, topography and patterns
iii. Good communication system existed in the selected villages

iv. Co-operation from the respondents were expected to be high since the researcher was familiar with the area and
v. No socio-economic study of this type was conducted previously in this area.

3.3 Sampling Procedure

It is impossible to collect information from the whole population in an empirical investigation. So, researchers are drawn inferences based on information derived from a representative sample of the population. The size of the sample, extent of variation, usually affect the quality of information obtained from the survey. Using appropriate sampling methods, both factors can be controlled (Scheaffer, 1979). The aim is to devise a sampling scheme, which is economical and easy to operate, and provides unbiased estimates with small variance (Barnett, 1991). The major features of sampling theory applied in this study are discussed below:

3.3.1 Sampling Method

The selection of a sample from the population is commonly used in economics and other socio-economic research because of limitations of covering the whole population (Barnett, 1991; Kinnear and Taylor, 1987). The authors consider that cost is the main constraint to carrying out interview of the whole population. Given limitations in terms of money, time, efforts and data management, a sampling is a more appropriate method. They argue that sampling not only saves cost and time but can also give more accurate results than a census. In a census survey more staff is required to carry out the task, therefore, supervision of staff and management problems will arise. Sampling theory provides an opportunity to minimize cost and to achieve acceptable results (Casley and Kumar, 1988; Kinnear and Taylor, 1987). However, a sampling procedure involves the following steps: defining the population, sample frame, sample size and sample selection procedure.

3.3.2 Population

Classification of the population is the first step in the sampling procedure. The sector or element under investigation, the sampling unit, the extent of investigation, and the duration of investigation (Kinnear and Taylor, 1987).

The sector under investigation was rice sector. The sampling units were boro rice producers of Jamalpur districts of Bangladesh.

3.3.3 Sampling Frame

The farm management research requires some fundamental information in relation to the objectives of the study. The sampling frame for the present study were 120 and selected purposively as to select the area where the boro rice cultivation was intensive. On the basis of higher concentration of boro rice production, three villages namely Purba Par Dighuli, Sonotia and Megha under Jamalpur Sadar upazila in Jamalpur district were selected for the study.

3.3.4 Sample Size

In a sample survey, a first question that commonly arises is “how large should the sample be?” Casley and Kumar (1988) and Kinnear and Tayler (1987) suggested that a good survey sample should have both a small sampling error and minimum standard error. This can be obtained if one has unlimited resources. However, given constraints, such as finance, time and data management, compromises have to be made in selecting the sample size. As a rule, the larger the sample size the higher the reliability, the lower the error and the greater the confidence one can place on the findings reflecting the characteristics of the population as a whole. But, faced with the inevitable constraints of time and money, the researcher invariably has to compromise between optimum and acceptable levels of confidence, reliability and error. Simple guidelines to determine the sample size provided by Poate and Daplyn (1993) were considered for selecting a representative sample size. 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 total of 120 (40 from each villages) farmers who were cultivating different varieties of boro rice selected as sample by simple random sampling.

3.3.5 Sample Selection Procedure

The investigator wishes to avoid bias in the sample selection process to achieve accuracy in the estimates, which is to have a small standard error (Kinnear and Taylor, 1987).

The best way to avoid bias in the sample selection process is use of simple random sampling in which each unit of the population has an equal chance for selection (Scheaffer, 1979). Either increasing the sample size or imposing various restrictions and modifications on the simple random sampling procedure can achieve an increase in precision of the sampling procedure. At first, boro rice dominated upazila was selected purposively from the district. Then three villages were selected from the upazila by simple random sampling method and the ultimate sampling units were selected by random sampling method. The procedure was comprehensive and representative of the whole population.

3.4 Data Collection Procedure

Primary farm level data has been collected by conducting survey of boro rice producers from the selected areas. The fieldwork also involved gathering data on boro rice production practices, input use, labor utilization, natural and socio-economic constraints, prices and market activities. The methodology consisted of field survey, review of previous studies, and interviews with knowledgeable boro rice producers, and also direct observation by the researchers. In the direct observation, emphasis was placed to assess the existing management practices, input use and marketing system of boro rice producers.

3.4.1 Questionnaire Design

Questionnaire designing is a difficult task during the planning stage of a survey research (Casely and Lury, 1981). The questionnaire was divided into different sections: demographic characteristics, land tenure system, farm resources, farm production, farmer income, harvesting and post-harvest issues and constraints to modern boro rice varieties cultivation etc. The questionnaire developed sought information on socioeconomic characteristics of the sampled farmer such as age, sex, education level, and years in rice farming, land ownership, access to extension services and access to credit services. The inputs for which quantities and prices were collected on included land area under cultivation, household labor, organic and inorganic fertilizer and rice seed. The last part of the questionnaire solicited information on boro rice production constraints and here scale was used to rank them according to the responses. Prior to final data collection the questionnaire was pre-tested on a few respondents to check for the possible errors that could affect the quality and accuracy of data collected.

The questionnaires were in English but questions were asked in the local languages from the respondents.

3.4.2 Questionnaire Pre-test

Questionnaire pre-test was carried out to achieve the stated objectives. The purpose of this survey was to gather quick information on various aspects of the study, organize fieldwork plan, testing the validity of the questionnaire and estimating the various cost components such as financial costs, interview time etc. This primary survey provided an opportunity to understand the existing labor use, input and output costs. During the survey from the month of February to March 2019, interviews were held with a producer on different aspects of the study and field notes prepared. Based on this preliminary information the investigator developed the questionnaire for further in-depth investigations.

3.4.3 Survey

Obtaining accurate information was a key during the fieldwork. To achieve these objectives, farmer were assured absolute privacy, interviews were held in places of their choice and they were assured that the information would be used for academic purposes. Most of the interviews were held at the farm or in the farmer's house during the month of May to July in the year 2019. The interview usually started with an introduction about the background of the researcher, the objectives of the study and the way in which the respondent was chosen and then discussion started with the topics of interest of the farmers. This method has been found useful in establishing confidence with producers; its only disadvantage was increased the time of the interview. The researcher converted the discussion to the related issues of boro rice cultivation practices and problems. Then the questions from the questionnaire were asked and the answers were recorded in the questionnaire.

3.4.4 Data Collection Techniques

Primary data was collected through conducting field survey, while secondary data was gathered from research related statistical papers and other related publications. Due to the absence of producers' records regarding farm activities, data collection depended on a combination of methods, which rely memory recall for basic information such as labor use, wages, input costs.

3.4.4.1 Primary Data Collection technique

As rice farming is seasonal so the researcher must determine to what extent the information for a particular year represents normal or average conditions, particularly for yields, annual production and price level. Farmers generally transplant boro rice from mid-January to mid-February and harvest after three months. Data for the present study collected during the period of May to July 2019. Primary data were collected from farm level boro rice producer. Selected respondents were interviewed personally with the help of pre-tested questionnaires. The primary data collected from 120 boro rice producers and it has been used in estimating production function.

3.4.4.2 Secondary Data Collection technique

The secondary data had been collected from various research documents like thesis paper, articles and other statistical papers. The research materials are collected from the following documents:

- Yearbook of Agricultural Statistics
- Bangladesh Economic Reviews
- Statistical Yearbook of Bangladesh
- The national and international journals, articles and publications and
- Web browsing or Internet

3.5 Processing, Editing and Tabulation of Data

The collected primary data were checked and verified for the sake of consistency and completeness. Editing, encoding and decoding were done before putting the data in computer. All the collected data were summarized and analyzed carefully to eliminate all possible errors. Data were presented in the graphs and tabular form, because it was of simple calculation, widely used and easy to understand. Besides, functional analysis was also adopted to arrive at expected findings. Data entry and analysis was done by using the concerned software Microsoft Excel and STATA.

3.6 Analytical Techniques

The collected data were analyzed with a view to achieving the objectives of the study. Different analytical methods were employed in the present study. Tabular method was used for a substantial part of data analysis. This technique is intensively used for its inherent quality of purporting the true picture of the farm economy in the simplest form.

Relatively simple statistical techniques such as percentage and arithmetic mean or average were employed to analyze data and to describe socioeconomic characteristics of boro rice producers, input use, costs and returns of boro rice production and to calculate undiscounted benefit cost ratio (BCR) to estimate profitability level. In order to estimate the farm level technical efficiency in a manner consistent with the theory of production function, Cobb-Douglas type stochastic frontier production function was used in the present study.

3.6.1 Economic Profitability Analysis

The net economic returns of boro rice were estimated by using the market prices. The prices that 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:

3.6.1.1 Land Preparation Cost

Land preparation considered one of the most important components in the production process. Land preparation for boro rice cultivation included ploughing, laddering and other activities needed to make the soil suitable for planting. It was revealed that the number of ploughing varied from farmer to farmer and place to place.

3.6.1.2 Human Labor Cost (HLC)

Human labor cost was considered one of the major cost components in the boro rice 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 labor cost (both family and hired labor), the recorded man-days per hectare were multiplied by the wage per man-day for a particular operation.

HLC = No. of Labor (man days) * Wage (Tk./man days)

3.6.1.3 Cost of Seed (SC)

Cost of seed depends on its quality and availability. Market prices of seeds of respected boro rice varieties 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.

SC = Quantity (kg) * Price (Tk./kg)

3.6.1.4 Cost of Urea (CU)

Urea is one of the important fertilizers for boro rice cultivation. 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.

CU = Amount per hectare (kg) * Price (Tk./kg)

3.6.1.5 Cost of TSP (CTSP)

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.

CTSP = Amount per hectare (kg) * Price (Tk./kg)

3.6.1.6 Cost of MoP (CMoP)

Mop is another fertilizer that normally used in boro rice cultivation. 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.

CMoP = Amount per hectare (kg) * Price (Tk./kg)

3.6.1.7 Cost of Gypsum (CG)

Gypsum is another fertilizer that were used in small amount in boro rice cultivation. To calculate the cost of Gypsum per hectare, the market price of Gypsum was multiplied by per unit of that input per hectare for a particular operation.

CG = Amount per hectare (kg) * Price (Tk./kg)

3.6.1.8 Cost of Insecticides

Farmers generally used different kinds of insecticides for 2-3 times to keep their rice plants 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.

3.6.1.9 Cost of Irrigation

Boro rice production is irrigation led production system in Bangladesh. So, proper water management helps to increase boro rice production. Cost of irrigation varies from farmers to farmers and land to land. It was calculated based on how many times irrigation needed per hectare and how was its cost.

3.6.1.10 Interest on Operating Capital (IOC)

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 six months was computed for boro rice. 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 / 2

t = Total time period of a production cycle of boro rice

3.6.1.11 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, the rental value of land has been used for cost of land use.

3.6.1.12 Calculation of Returns

3.6.1.12.1 Gross Return (GR)

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

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

3.6.1.12.2 Gross Margin (GM)

Gross margin (GM) 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 total variable cost TVC basis. Per hectare gross margin (GM) was obtained by subtracting variable costs from gross return. That is,

Gross margin (GM) = Gross return (GR) – Variable cost (VC)

3.6.1.12.3 Net Return (NR)

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

Net return (NR) = Total return (TR) – Total production cost (TPC)

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

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

Where,

Π = Profit for boro rice production (Tk./ha)

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

Q_r = Quantity of seed rice (Kg/ha)

P_b = Per unit price of rice (Tk./kg)

Q_b = Quantity of rice (Kg/ha)

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

X_i = Quantity of the i^{th} inputs (Kg/ha)

i = 1, 2, 3………..n and

TFC = Total fixed cost

3.6.1.12.4 Undiscounted Benefit Cost Ratio (BCR)

Average return (AR) 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.

BCR = Total Return (TR) / Total Cost (TC)

3.6.2 Technical Efficiency Analysis

Technical efficiency refers to the ability of a firm to produce the maximum possible output from a given set of inputs and given technology.

A technically efficient farm will operate on its frontier production function. Given the stated relationship the firm is technically efficient if it produces on its outer-bound production function to obtain the maximum possible output which is feasible under the current technology. Putting it differently a firm is considered to be technically efficient if it operates at a point on an isoquant rather than interior to the isoquant.

The homogeneity of inputs is a vital factor for achieving technically efficient output. No one would dispute that the output produced from given inputs is a genuine measure of efficiency, but there is room for doubt whether, in a particular application, the inputs of a given firm are really the same as those represented by the corresponding point on the efficient isoquant. But it is important to note that mere heterogeneity of factors will not matter, as long as it is spread evenly over firms, it is when there are differences between firms in the average quality (or more strictly, in the distribution of qualities) of a factor, that a firm's technical efficiency will reflect the quality of its inputs as well as the efficiency of its management. If these differences in quality are physically measurable, it may be possible to reduce this effect by defining a large number of relatively homogeneous factors of production, but in practice it is never likely to be possible to completely eliminate it (Farrell 1957).

3.6.2.1 The Stochastic Frontier Model

The most widely discussed, theoretically reasonable and empirically competent method of measuring efficiency is the stochastic frontier model. It is an improvement on the traditional average production function and on all types of deterministic frontiers in the sense that it introduces in addition to one-sided error component a symmetric error term to the model. This method permits random variation of the frontier across farms, and captures the effects of measurement error, statistical noise arid random shocks outside the firm's control. A one-sided component captures the effects of inefficiency relative to the stochastic frontier.

The stochastic frontier model is also called the 'composed error' model introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). It was later extended and elaborated by Schmidt and Lovell (1979; 1980) and Jondrow *et al.* (1982).

The notion of a deterministic frontier shared by all farms ignores the very real possibility that a farm's performance may be affected by factors entirely outside its control (such as poor machine performance, bad weather, input supply breakdowns, and so on), as well as by factors under its control (inefficiency). But stochastic frontiers consider all the factors while estimating the model and accordingly it separates firm-specific efficiency and random error effect. Thus the efficiency measurements as well as the estimated parameters are unbiased.

3.6.2.2 The Stochastic Frontier with Cobb-Douglas Production Function

The Cobb-Douglas production function is probably the most widely used form for fitting agricultural production data, because of its mathematical properties, ease of interpretation and computational simplicity (Heady and Dillion, 1969; Fuss and Mcfadden, 1978). The Cobb-Douglas function has convex isoquants, but as it has unitary elasticity of substitution; it does not allow for technically independent or competitive factors, nor does it allow for Stages I and III along with Stage II. That is, MPP and APP are monotonically decreasing functions for all X- the entire factor-factor space is Stage II-given $0 < b < 1$, which is the usual case. However, the Cobb-Douglas may be good approximation for the production processes for which factors are imperfect substitutes over the entire range of input values. Also, the Cobb-Douglas is relatively easy to estimate because in logarithmic form it is linear in parameters; it is parsimonious in parameters (Beattie and Taylor, 1985).

A stochastic Cobb-Douglas production frontier model may be written as

$$Y_i = f(X_i,\beta) \exp.(V_i-U_i) \qquad i = 1, 2, 3, \ldots\ldots\ldots.., N$$

Where the stochastic production frontier is $f(X_i,\beta)\exp.(V_i)$, V_i having some symmetric distribution to capture the random effects of measurement error and exogenous shocks which cause the placement of the deterministic kernel $f(X_i,\beta)$ to vary across firms. The technical inefficiency relative to the stochastic production frontier is then captured by the one-sided error component $U_i \geq 0$.

The explicit form of the stochastic Cobb-Douglas production frontier is given by

$$Y = a \prod_{=1} {}^{bi} \exp. (\mathcal{E})$$

Where Y is the frontier output, X is physical input, b the elasticity of Y with respect to X, a is intercept and Ɛ = V-U is a composed error term as defined earlier. For simplicity, we have ignored the subscript. The above model also can be expressed in the following logarithmic form;

$$\ln Y = b_0 + \sum bi \ln Xi + V - U$$

Where b_0 = In a.

The estimation of the model and derivation of technical efficiency is the same as described earlier.

3.6.2.3 Specification of Production Model

We have specified the Cobb-Douglas Stochastic Frontier Production Function in order to estimate the level of technical efficiency. The functional form of stochastic frontier is as follows:

$$Y = \beta_0 X_1^{\beta 1} X_2^{\beta 2} \ldots\ldots\ldots X_6^{\beta 6} e^{Vi-Ui}$$

The above function can converted into a linear double-log form for the present study:

$$\ln Y = \ln\beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + Vi-Ui$$

Where,

Y = Output (kg/ha)

X_1 = Human labour (man days/ha)

X_2 = Land preparation cost (Tk./ha)

X_3 = Irrigation cost (Tk./ha)

X_4 = Seed (Kg/ha)

X_5 = Fertilizers (kg/ha)

X_6 = Cost of insecticides (Tk./ha)

The model of the technical inefficiency effects in the stochastic production frontier equation for present study is defined by

$$Ui = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + Wi$$

Where,

Z_1 = Education level in years

Z_2 = Experience in rice farming

Z_3 = Farm Size

Z_4 = Credit

Z_5 = Training

V is two-sided uniform random variable beyond the control of farmer having $N(0, \sigma v^2)$ distribution, U is one-sided technical inefficiency effect under the control of farmer having a positive half normal distribution $\{Ui \sim |N(0, \sigma u^2)|\}$ and Wi is two-sided uniform random variable. W is unobservable random variable having a positive half normal distribution. The model was estimated simultaneously using STATA. The β and δ coefficients are unknown parameters to be estimated together with the variance parameters which are expressed in following terms-

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

Where γ parameter has value between zero and one.

CHAPTER 4
DESCRIPTION OF THE STUDY AREA

4.1 Introduction

This chapter presents a brief description of the study area. Knowledge of the study area is very important for understanding the location, physical features and topography, soil type, temperature, rainfall, agricultural and economic condition, population, education and other socioeconomic structure available in the area. This chapter aims at describing a brief scenario of previously mentioned characteristics of the study area.

4.2 Location

Jamalpur occupies 2031.98 square kilometer. It is located between 24°34' and 25°26' North and between 89°40' and 90°12' East. It shares an international border with Indian state Meghalayain the North-East. It is surrounded by Kurigram districts in the North, Tangail district in the South, Mymensingh and Sherpur districts in the East, Jamuna River, Bogra, Sirajganj and Gaibandha districts in the West. The main town is situated on the bank of the river Brahmaputra, 140 kilometres (87 mile) north of Dhaka, the national capital. It has seven upazilas.

The study was conducted on three villages namely Purba Par Dighuli, Sonotia and Megha under Jamalpur Sadar Upazila of Jamalpur district. The selected villages are situated around 18-23 km to the Southeast of the Upazila headquarter. The major boro rice producing areas of Bangladesh is shown in map 4.1 and the location of the study areas is shown in Maps 4.2 and 4.3.

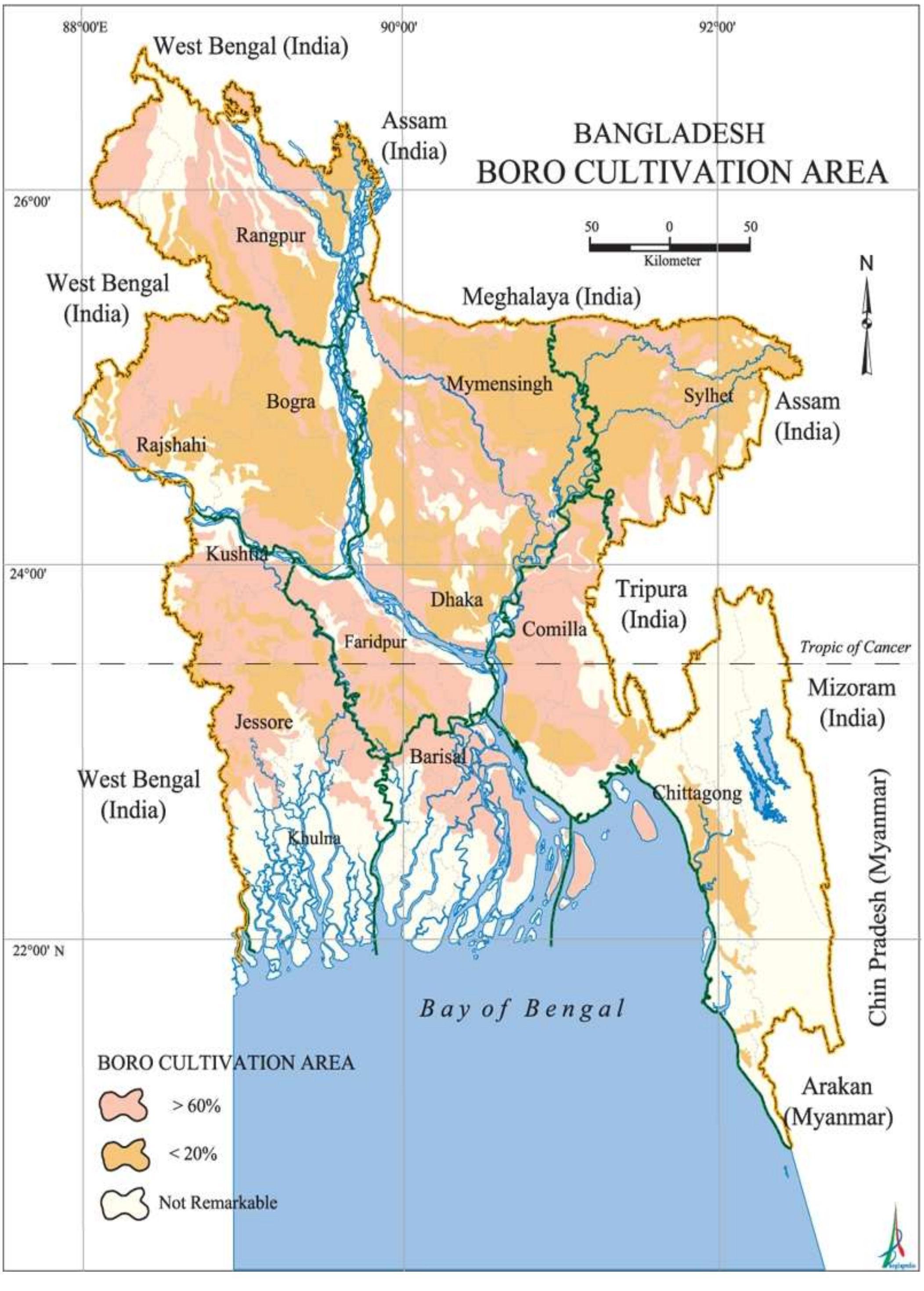


Figure 4.1: Map of major Boro rice cultivation areas in Bangladesh

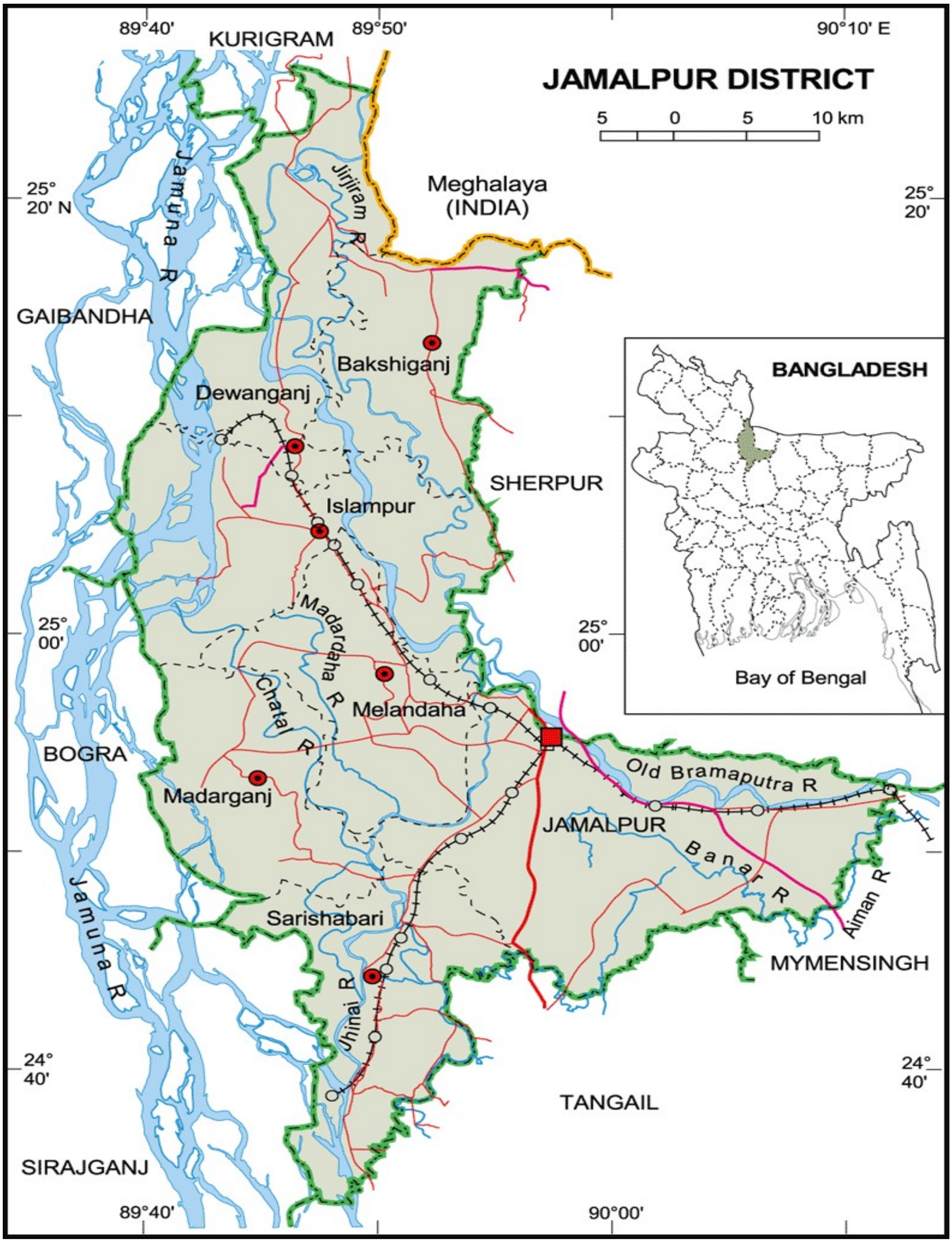


Figure 4.2: Map of Jamalpur district (study area)

Figure 4.3: Map of unions of Jamalpur Sadar upazila

4.3 Physical Features, Topography and Soil Type

Jamalpur district occupies two agro-ecological zone (AEZ) namely Young Brahmaputra-Jamuna Floodplain (AEZ-8) and Old Brahmaputra Floodplain (AEZ-9). The western part Jamalpur district is under AEZ-8 and comprises of the area of Brahmaputra sediments. It has a complex relief of broad and narrow ridges, inter-ridge depressions, partially in filled cut-off channels and basins. This area is occupied by permeable silt loam to silty clay loam soils on the ridges and impermeable clays in the basins which are neutral to slightly acidic in reaction. General soil types include predominantly Grey Floodplain soils. Organic matter content is low in ridges and moderate in basins. Most of the area of Jamalpur district is under AEZ-9 and the region occupies a large area of Brahmaputra sediments before the river shifted to its present Jamuna channel about 200 years ago. The region has broad ridges and basins. Soils of the area are predominantly silt loams to silty clay loams on the ridges and clay in the basins. General soil types predominantly include Dark Grey Floodplain soil. Organic matter content is low on the ridges and moderate in the basins; top soils are moderately acidic but sub soils neutral in reaction. General fertility level is low. Land topography and soil classification are shown in the table 4.1 and table 4.2 respectively.

Table 4.1: Land Topography in Survey Areas (land area in acre)

Upazila	High land	Medium land	Low land	Total land
Bakshiganj	16157	16734	17593	50484
Dewanganj	11634	20059	9304	40997
Islampur	29425	26675	2750	58800
Jamalpur Sadar	42031	64980	13964	120975
Madarganj	19223	27520	4177	50920
Melandaha	20402	34517	8842	63761
Sarishabari	7616	39431	3004	50051
Total	**146488**	**229916**	**59634**	**435988**

Source: District Statistics (BBS, 2011)

Table 4.2: Broad soil classification (land area in acre)

Upazila	Total	Soil classification			
		Doash	**Bele**	**Etel**	**Other**
Bakshiganj	43685	16157	21454	8581	4292
Dewanganj	50090	16287	24499	9304	0
Islampur	65315	26713	19925	12162	12367
Jamalpur Sadar	121009	78589	2829	31569	4927
Madarganj	60062	34235	3982	2568	10500
Melandaha	67322	38173	15906	9543	0
Sarishabari	69229	30067	5372	10907	3705
Total	**476710**	**240221**	**93967**	**84634**	**35791**

Source: District Statistics (BBS, 2011)

4.4 Population, household and population density

The total area, population and density of population of the selected upazilas are presented in Table 4.3. According to the district statistics the highest population density (1235 per sq.km) is in Sharishabari and the lowest population density (845 sq. km) is in Islampur Upazilla. According to the Population Census 2011, number of households in Jamalpur district is 563367. The density of population is 1084 per sq. km. The percentage of male and female is 49.23 percent and 50.77 percent respectively. However, number of households in Jamalpur Sadar Upazila is 152174, and the population density is 1209 per square kilometer. The household is 152174 which is 27.01 percent of district total household and the population of sadar upazila is 26.83 of district total population.

Table 4.3: Number of household, population and density

Upazila	Household	Population (000)			Density
		Male	Female	Both sex	per sq. km.
Bakshiganj	52222	107718	111212	218930	919
Dewanganj	60716	126623	131510	258133	965
Islampur	74963	148439	149990	298429	845
Jamalpur Sadar	152174	301912	313160	615072	1209
Madarganj	63704	130339	133269	263608	1170
Melandaha	79390	154110	159072	313182	1212
Sarishabari	80198	159583	165737	325320	1235
Total	**563367**	**1128724**	**1163950**	**2292674**	**1084**

Source: District Statistics (BBS, 2011)

4.5 Climate, Temperature and Rainfall

The climate, temperature and rainfall are very important factors for production of boro rice and other agricultural crops. There was no local arrangement of meteorological station for recording temperature, rainfall, humidity and other meteorological elements in the study area. However, Mymensingh Meteorological Station provides data on climatic condition of Jamalpur district. The district is remarkable for its high temperature, humidity and coldness. Maximum and minimum mean temperature during winter varies from 23.4°C to 10.8°C. During the boro season the maximum and minimum mean temperature varies from 29.80°C to 20.80°C. It is basically warm and humid in region. The annual total rainfall of the study is about 2153 mm. The variation in the precipitation between the driest and wettest months is 398 mm. The average temperatures vary during the year by 10.1 °C. The monthly rainfall, monthly average minimum temperature and maximum temperature of the study area in 2018 presented in Table 4.4, Table 4.5 and Table 4.6 respectively.

Table 4.4: Monthly Total Rainfall at Mymensingh Station (In Millimeter)

Mymensingh Sub-Station												
Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rainfall (mm)	0	10	34	269	490	305	307	221	144	122	36	18

Source: BBS, 2018

Table 4.5: Monthly Average Minimum Temparature at Mymensingh Station (In ^{0}Celceus)

Mymensingh Sub-Station												
Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Min. Temp. (^{0}C)	11.7	16.6	20.2	21.5	23.2	25.8	26.7	26.9	26.0	22.7	17.4	13.4

Source: BBS, 2018

Table 4.6: Monthly Average Maximum Temparature at Mymensingh Station (In^{0}Celceus)

Mymensingh Sub-Station												
Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Max. Temp. (^{0}C)	22.7	27.2	31.2	30.4	30.3	33.6	31.8	32.7	32.7	30.9	29.3	26.0

Source: BBS, 2018

4.6 Land utilization and Occupation

Total cultivable land in Jamalpur districts is 329775 hectares. Rice is the main crop grown in the study areas. Besides, jute, brinjal, wheat, sugarcane, chili, pulses are grows well in the areas.

It is evident from the study that, cropping pattern in the study areas are almost same. Land under cropped in the study areas are given in Table 4.7. It is evident from the table that almost half of the lands are utilized as double cropped land in the study areas. It also cleared from the table that near about half of the cultivated lands are under irrigation in the study areas.

Agriculture is the main source of income of the people of the study area. A small number of people were engaged in service, business and rural transportation. The main occupation of the landless farmers was wage labour, van, petty business, fishing etc. The cropping intensity of Jamalpur district is 190 and the study area Jamalpur Sadar upazila is 195.

Table 4.7: Land utilization (temporary cropped area in acre)

Upazila	Current Fallow	Temporary Cropped Area			Productivity of Crop
		Single	Double	Triple	
Bakshiganj	74	1251	14956	12851	190
Dewanganj	690	3222	3940	20424	182
Islampur	1251	3632	16743	18992	179
Jamalpur Sadar	526	15120	49890	25220	195
Madarganj	186	8381	14893	19364	189
Melandaha	101	6124	33481	12003	195
Sarishabari	163	1407	34179	13702	193
Total	**2991**	**39137**	**168082**	**122556**	**190**

Source: District Statistics (BBS, 2011)

4.7 Transportation, Communication and Marketing Facilities

Transportation and communication is the pre-condition for the development of a particular region or a country. The selected areas for the study are well communicated with the different places of Bangladesh. The road network of this area facilitates the local people to market their agricultural as well as other products to the nearby and distance market places. Most of the roads in the study areas are concreted and some of the roads are muddy. Due to well communication with the different markets, usually farmers do not deceive from having good prices of their produced commodities. The modes of transportation of this area are rickshaw, van, bullock carts, truck, by-cycle and motorcars. There are many hats, which are sit on more than one day in a week and the local bazars are held on every morning and afternoon. After the marketing facilities, transportation and communication system of the study area is well.

CHAPTER 5
SOCIO-ECONOMIC PROFILE OF SAMPLE FARMERS

5.1 Introduction

The purpose of this chapter is to present a brief description of the socio-economic characteristics of the boro rice farmers. Socioeconomic standpoints of the farmers can be looked upon from different points of view. This activities depend upon a number of variables related to their livelihood status, the socio-economic environment in which they live and the nature and the extent of the farmers participation in national development activities. It was not possible to collect all the information regarding the socio-economic characteristics of the sample boro rice farmers due to limitation of time and relevant resources. Socioeconomic condition of the sample farmers is very important in case of research planning because there are many interrelated and constituent attributes characterizes an individual and profoundly influences development of their behaviour and personality. People differ from one another for the variation of socioeconomic aspects. However, for the present research, a few of the socioeconomic characteristics have been taken into consideration for discussion. Data on several types of socio-economic variables were collected to know the socio-economic profile of the sample boro rice farmers. The general profile of boro rice farmers such as age, family size, involvement in agriculture, education status, farm size and tenurial status, sources of annual income, credit received for boro rice cultivation, agricultural training and selling pattern of boro rice are discussed in this chapter.

5.2 Age

Age of boro rice farmers was calculated from their birth to the time of the interview. Farmers were grouped into four categories according to their ages (Table 5.1). It can be seen from the table that 14 farmers belonged to the age group 15-30 years which was 11.67 percent of total farmers, 48 farmers were in the age group between 31-45 years which was 40.00 percent of the total farmers and representing highest percentage, 45 farmers belonged to age group between 46-60 years which was 37.50 percent.

And rest of the 13 farmers belonged to age category above 60 years and it was 10.83 percent of the total sample boro rice growers. The table (Table 5.1) revealed that most of the boro rice growers were in age group in between 31-45 that represent an active group for rice production.

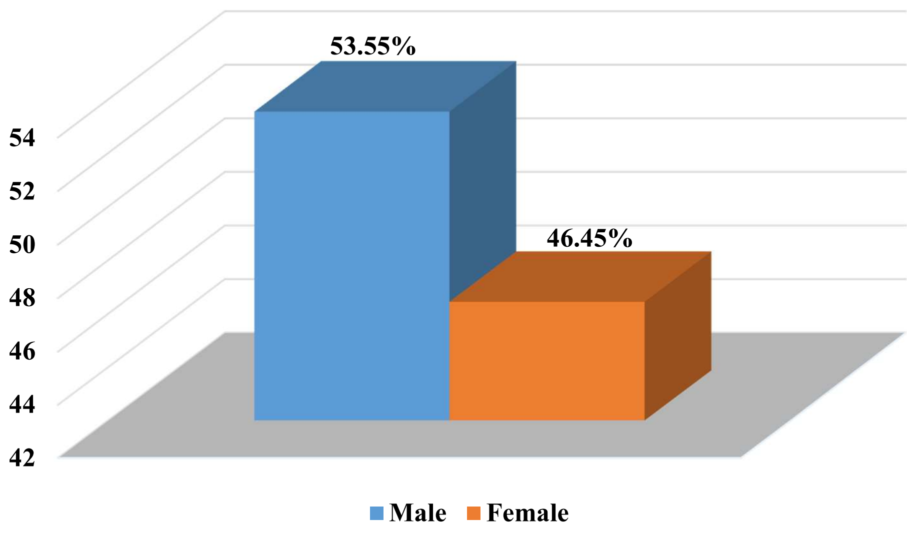
Table 5.1: Age Distribution of Sample Boro Rice Farmers

Age Group (years)	All Farmers	
	Number of Farmer	**Percent (%)**
15-30	14	11.67
31-45	48	40.00
46-60	45	37.50
Above 60	13	10.83
Total	**120**	**100.00**

Source: Field Survey, 2019

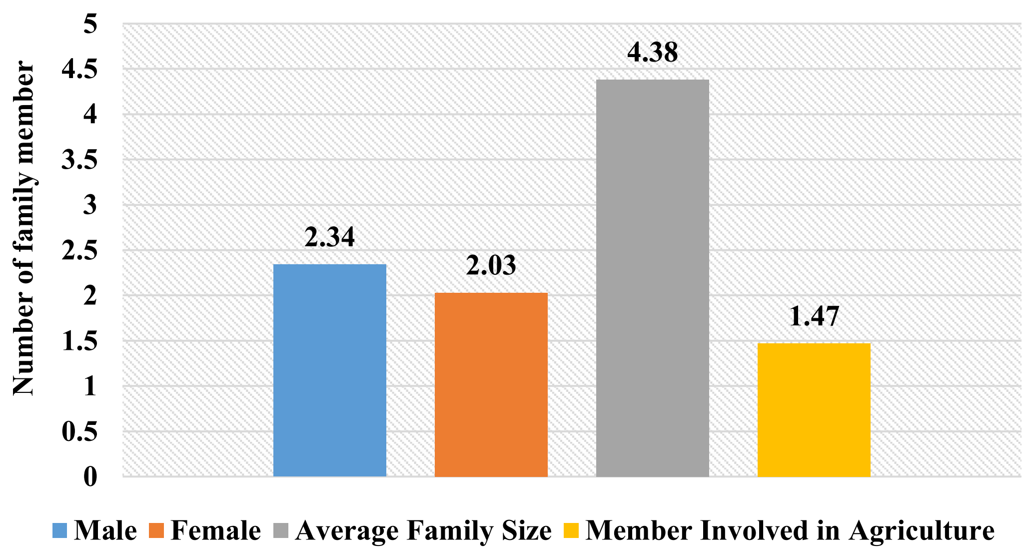
5.3 Average Family Size and Member Involved in Agriculture

Family size is important in every aspect of society and the relation to production of enough food grain for farm family. In this study, family has been defined as the total number of persons living together and taking meals from the same kitchen under the control of one head of the family. The family members considered as wife, sons, unmarried daughters, father, mother, brothers and other relatives who live permanently in the family. The average family size for boro rice growers were 4.38 persons. Among the family members of sample 120 boro rice growers about 53.55 percent family members were male and 46.45 percent were female (Figure 5.1). The average numbers of male and female members were 2.34 and 2.03 respectively. The average family size was 4.38 people in all farmers, which is lower than the national average family size 4.4. The study revealed that on an average 1.47 persons involved in agricultural activities (Figure 5.2).



Source: Field Survey, 2019

Figure 5.1: Percentage of Family Members According to Gender



Source: Field Survey, 2019

Figure 5.2: Average Family Size and Member Involved in Agriculture of Sample Farmers

5.4 Educational Status

Table 5.2 showed that, in the study area (Jamalpur Sadar upazila), about 14.17 percent of the study population were found to have no education or illiterate, about 35 percent were found to have read and write only, about 23.33 percent were found to have primary level education and only 17.50 percent people were found to have high school level education, about 7.50 percent were found to have college level education and only 2.50 percent were attained or completed graduation level of education. Education has a great impact on and it contributes to economic and social development, as commonly known that education is the backbone of a nation. It plays a vital role in the acquisition of information about the innovation in various production processes of agriculture sector. Education helps every person to make right decision regarding his farm production and farm business. It makes a man more capable of managing scarce resources and hence to earn maximum profit (Miah, 1990). But in the present study revealed that the proportion of attainment of post-secondary college level education were very negligible.

Table 5.2: Educational Status of Sample Boro Rice Farmers

Educational level	All Farmers	
	Number of Farmer	**Percent (%)**
Illiterate	17	14.17
Read and Write only	42	35.00
Primary level passed	28	23.33
High school level passed	21	17.50
College level passed	9	7.50
Graduate	3	2.50
Total	**120**	**100.00**

Source: Field Survey, 2019

5.5 Farm Size Distribution and Tenurial Status

In the study area, the highest proportions 50.83 percent of the boro rice growers were under marginal farm size (upto 1.49 acre), 30 percent were under small farm size (upto 2.49 acre), 14.17 percent were under medium farm size (upto 7.49 acre) and lowest proportions 5 percent were under large farm size (above 7.50 acre). From the sample 120 boro rice farmers, 52.50 percent farmers were operated their own land or farm for boro rice cultivation, 31.67 percent farmers were under own operated cum share cropping and rest of the 15.83 percent farmers were involved in share cropping for boro rice cultivation. Though maximum farmers were operated their own land or farm but they were marginal farmer.

Table 5.3: Farm size distribution and tenurial status of sample farmers

Items	All Farmers	
	Number of Farmer	**Percent (%)**
Farm Size Distribution:		
a) Marginal Farm (0.05-1.49 acre)	61	50.83
b) Small Farm (1.50-2.49 acre)	36	30.00
c) Medium Farm (2.50-7.49 acre)	17	14.17
d) Large Farm (7.50 acre and above)	6	5.00
Total	**120**	**100.00**
Tenurial Status:		
a) Own operated	63	52.50
b) Own operated cum Share cropping	38	31.67
c) Share cropping	19	15.83
Total	**120**	**100.00**

Source: Field Survey, 2019

5.6 Sources of Annual Income

The study found that sample farmers annual income sources were both on farm and off farm activities. On farm income earned from both rice and non-rice sectors. Rice sector contributed 13.72 percent of on farm income and it was Tk. 5321.75. On the other hand, off farm income were earned from home yard crops, livestock, poultry and fisheries sectors. The contribution of these sectors to annual income were 1.08 percent, 17.14 percent, 0.89 percent and 21.63 percent respectively, and in monetary term by Tk. 419.92, Tk. 6650, Tk. 346.08 and Tk. 8391.67 respectively. The study found that 54.46 percent of the total annual income came from farm activities and 45.54 percent from off farm activities. It was revealed that, the on farm activities contributed the highest percentage (54.46%) to farmer annual income (Table 5.4).

Table 5.4: Sources of Annual Income of Sample Farmers

Sources of income	Amount (Tk.)	Percent (%)
A. On farm income	21129.42	54.46
a) Income from rice	5321.75	13.72
b) Income from non-rice	15807.67	40.74
➢ Home yard crops	419.92	1.08
➢ Livestock	6650.00	17.14
➢ Poultry	346.08	0.89
➢ Fisheries	8391.67	21.63
B. Off-farm income	17670.83	45.54
Total (A+B)	**38800.25**	**100.00**

Source: Field Survey, 2019

5.7 Agricultural Training

Among the respondent farmers in Jamalpur Sadar upazila, 30.83 percent farmers got training on different agricultural technologies of boro rice farming whereas, 69.17 percent farmers did not get training on different agricultural technologies of boro rice cultivation (Table 5.5).

These training had improved their perceptions of good seed use, use of modern varieties, application of insecticides and pesticides, water management, and so on.

Table 5.5: Agricultural Training of the Respondent Farmers

Training received	All Farmers	
	Number of Farmer	**Percent (%)**
Yes	37	30.83
No	83	69.17
Total	**120**	**100.00**

Source: Field Survey, 2019

5.8 Credit for Boro Rice Cultivation

Among the respondent farmers 31 farmers were taken credit for boro rice cultivation and it was 25.83 percent of total sample farmers. The rest of respondent (74.17 %) did not take any credit for boro rice cultivation. The loan taker farmers were classified in five different categories based on the amount of credit they received. About 16.13 percent farmers received loan ranged from Tk. 5000 to Tk. 10000, 25.81 percent ranged from Tk. 10001 to Tk. 15000, 29.03 percent ranged from Tk. 15001 to Tk. 25000 and only 9.68 percent farmers ranged from Tk. 25001 to above. The study found that 9 farmers had taken loan ranged between Tk. 15001 to Tk. 20000 and it was the highest percentage (29.03 percent) among the loan taker farmers (Table 5.6).

Table 5.6: Distribution of credit for Boro rice cultivation

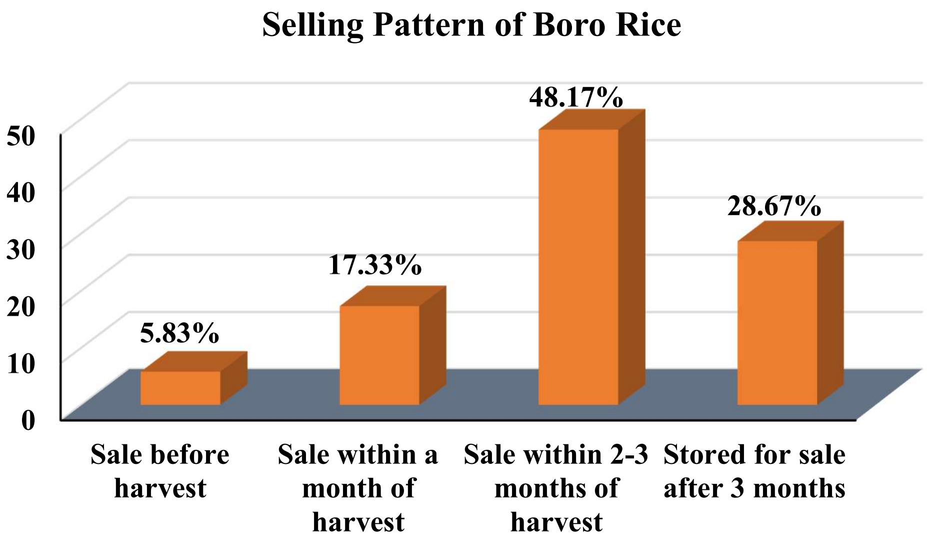
Credit received	All Farmers	
	Number of Farmer	Percent (%)
Yes	31	25.83
No	89	74.17
Total	**120**	**100.00**

Amount of Loan (Tk.)	Credit taking Farmers	
	Number of Farmer	Percent (%)
5000-10000	5	16.13
10001-15000	8	25.81
15001-20000	9	29.03
20001-25000	6	19.35
25001-above	3	9.68
Total	**31**	**100.00**

Source: Field Survey, 2019

5.9 Selling Pattern of Boro Rice of the Sample Farmers

The study found that selling pattern of boro rice differed according to the economic status of sample farmers. Among the respondent farmers 5.83 percent sold before harvest, 17.33 percent sold within a month of harvest, 48.17 percent sold within 2 to 3 months of harvest and 28.67 percent stored for sale after 3 months of harvest. However, the maximum farmers (48.17 percent) sold their boro rice 2 to 3 months of harvest (Figure 5.2).



Source: Field Survey, 2019

Figure 5.3: Selling Pattern of Boro Rice of the Sample Farmers

5.10 Conclusion

From the above discussions it is clear that there are some variations in socioeconomic characteristics among the boro rice farmers. But the magnitude of the variations was not large. There are substantial indications suggesting that boro rice growers of the study area were progressive.

CHAPTER 6
PROFITABILITY ANALYSIS OF BORO RICE CULTIVATION

6.1 Introduction

The main purpose of this chapter is to assess the costs, returns and profitability of boro rice cultivation. 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 and ratio of return to total cost. The costs of all items were calculated to identify the total cost of production. For calculating the costs and returns of boro paddy production, the costs items were classified into two groups; (i) variable cost; and (ii) fixed cost. Variable cost included the cost of all variable factors like seed, human labour, land preparation, fertilizer and manure, irrigation and insecticides and pesticides. On the other hand, fixed cost was calculated for land use cost and interest on operating capital. On the return side, gross return, gross margin, net return, and undiscounted benefit cost ratio (BCR) were determined in this section.

6.2 Variable Cost

6.2.1 Cost of Seed

Cost of seed varied widely depending on its quality and availability. Per hectare total cost of seed for boro rice cultivation were estimated to be Tk. 1554.80, which constituted 1.35 percent of the total cost of production (Table 6.2).

6.2.2 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 both seed sowing and transplanting of boro rice cultivaton. For land preparation in boro rice cultivation, no. of tiller was required 4 with Tk. 1500 per tiller per acre of land. Thus, the average land preparation cost of boro rice production was found to be Tk. 4236.96 per hectare, which was 3.69 percent of total cost (Table 6.2).

6.2.3 Cost of Human Labour

Human labour cost is one of the major cost components in the rice production process. It is one of the most important and largely used inputs for producing boro rice. It is generally required for different operations such as seedbed and final land preparation, sowing, weeding, fertilizer and insecticides application, irrigation, harvesting and carrying, threshing, cleaning, drying, storing etc. The quantity of human labour used in boro rice cultivation was found to be about 121.97 man-days per hectare and average price of human labour was Tk. 396.24 per man-day. Therefore, the total cost of human labour was found to be Tk. 48329.22 which represent 42.05 percent of total cost of production (Table 6.1).

Table 6.1: Per Hectare Human Labour Cost of Boro Rice Cultivation

Operations	Total Labour (man-days)	Total Cost (Tk./ha)	Percentage of Total Cost (%)
Seedbed Preparation and Seed Sowing	5.53	2191.21	4.53
Land Preparation	13.05	5170.93	10.70
Transplanting	24.41	9672.22	20.01
Fertilizer, Manure and Pesticide Application	7.57	2999.54	6.21
Irrigation	6.26	2480.46	5.13
Weeding	14.14	5602.83	11.59
Harvesting and Carrying	38.03	15069.01	31.18
Threshing, Drying and Storing	12.98	5143.19	10.64
Total	**121.97**	**48329.22**	**100.00**

Source: Field Survey, 2019

Regarding the operation wise distribution of human labour, it was found that the highest percentage of human labour was employed for harvesting, while seedbed preparation and irrigation constituted the lowest percentage of human labour use for boro paddy production (Table 6.1).

6.2.4 Cost of Manures

It was observed in the present study that farmers used cow dung and excreta of chicken for producing agricultural products. They bought a large portion of cow dung from the cow farms. It was found that cow dung application was measured by gari per hectare for boro rice production. According to the respondent farmer, 1 gari cow dung equivalent to almost 100 to 200 kg. And the cost of manures for boro rice production was Tk. 1958.42 (Table 6.2).

6.2.5 Cost of Urea

In the study area, farmers used urea as one of the main fertilizer for boro rice production. On an average, farmers used 268.27 kg urea per hectare. Per hectare cost of urea was Tk. 4292.32, which represents 3.73 percent of the total cost (Table 6.2).

6.2.6 Cost of MoP

The application of MoP per hectare was found 123.60 kg and per hactre cost was Tk. 1730.40, which represents 1.57 percent of the total cost (Table 6.2).

6.2.7 Cost of TSP

Among the different kinds of fertilizers used, the rate of application of TSP was 156.28 kg per hectare. The average cost of TSP was Tk. 3750.72 per hectare which representing 3.26 percent of the total cost (Table 6.2).

6.2.8 Cost of Gypsum

Among the different kinds of fertilizers used, the rate of application of Gypsum was 53.69 kg per hectare. The average cost of Gypsum was Tk. 644.28 per hectare which representing 0.56 percent of the total cost (Table 6.2).

6.2.9 Cost of Insecticides

Generally, farmers used different kinds of insecticides to keep their rice plants free from pests and diseases. The average cost of insecticides for boro rice production was found Tk. 1746.70 which was 1.52 percent of the total cost (Table 6.2).

6.2.10 Cost of Irrigation

Cost of irrigation is one of the most important costs for boro rice production. Production of boro rice largely depends on irrigation. Proper water management help to increase the number of tiller, number of leaves and plant height. As a result yield per hectare is being increased. The average cost of irrigation was found to be Tk. 6487.75 per hectare, which represents 5.64 percent of the total cost (Table 6.2).

6.2.11 Total Variable Cost (TVC)

Therefore, from the above different cost items it was clear that the total variable cost of boro rice production was Tk. 74731.57 per hectare, which was 65.02 percent of the total cost (Table 6.2).

6.3 Fixed Cost

6.3.1 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 boro rice production period of six months. Rental value of land had been used as cost of land use. On the basis of the data collected from the boro rice farmers the land use cost was found to be Tk. 36463.53 per hectare, and it was 31.73 percent of the total cost of production (Table 6.2).

6.3.2 Interest on Operating Capital (IOC)

It may be noted that the interest on operating capital was calculated by taking into account all the operating costs incurred during the production period of boro rice.

Per hectare interest on operating capital was Tk. 3736.58 boro rice production, and it was 3.25 percent of total cost of production (Tables 6.2).

Table 6.2: Per Hectare Cost of Boro Rice Cultivation

Items of Cost	Quantity (Kg/ha)	Rate (Tk./Kg)	Cost (Tk./ha)	Percentage of Total Cost
Variable Costs (VC):				
➢ Land preparation			4236.96	3.69
➢ Human labour	121.97 [a]	396.24[b]	48329.22	42.05
➢ Seed	38.87	40.00	1554.80	1.35
➢ Manures	1958.42	1.00	1958.42	1.70
➢ Urea	268.27	16.00	4292.32	3.73
➢ TSP	156.28	24.00	3750.72	3.26
➢ MoP	123.60	14.00	1730.40	1.51
➢ Gypsum	53.69	12.00	644.28	0.56
➢ Cost of Insecticides			1746.70	1.52
➢ Cost of Irrigation			6487.75	5.64
A. Total Variable Cost (TVC)			**74731.57**	**65.02**
Fixed Costs (FC):				
➢ Interest on operating capital @ of 10% for 6 months			3736.58	3.25
➢ Rental value of land			36463.53	31.73
B. Total Fixed Cost (TFC)			**40200.11**	**34.98**
Total cost (A+B)			**114931.68**	**100.00**

(Note: a = No. of man-days; b = Tk./man-days)

Source: Field survey, 2019.

6.3.3 Total Fixed Cost (TFC)

Therefore, from the above different cost items it was clear that the total fixed cost of boro rice production was Tk. 40200.11 per hectare, which was 34.98 percent of the total cost (Table 6.2).

6.4 Total Cost (TC) of Boro Rice Production

Total cost was calculated by adding all the variable cost and fixed cost. In the present study per hectare total cost of production of boro rice was found Tk. 114931.68 (Table 6.2).

6.5 Returns of Boro Rice Cultivation

6.5.1 Gross Return

Per hectare gross return was calculated by multiplying the total amount of product with respective per unit price. Table 6.3 revealed that the average yield of boro rice per hectare was 6940.00 kg and the average price of rice was Tk. 16.00. Therefore, the gross return was found Tk. 120600.43 per hectare (Table 6.3).

6.5.2 Gross Margin

Gross margin is the gross return that calculated over variable cost. The gross margin was calculated by deducting the total variable cost from the gross return. The gross margin for the present study was found to be Tk. 45868.86 per hectare (Table 6.3).

6.5.3 Net Return

Net return or profit from the boro rice was calculated by deducting the total production cost from the gross return. On the basis of the study the net return was estimated as Tk. 5668.75 per hectare (Table 6.3).

6.5.4 Benefit Cost Ratio (Undiscounted)

Benefit Cost Ratio (BCR) is a relative measure, which is used to compare benefit per unit of cost. The benefit cost ratio (BCR) for the study was 1.05 which implies that one taka investment in boro rice production generated Tk. 1.05. So, from the above calculation it was found that boro rice cultivation is profitable in Bangladesh (Table 6.3).

Table 6.3: Per Hectare Cost and Return of Boro Rice Cultivation

Measuring Criteria	**Quantity (kg/ha)**	**Rate (Tk./kg)**	**Cost (Tk./ha)**
A. Main Product Value	6940	16.00	111040
B. By product Value			9560.43
Gross Return (GR): (A+B)			**120600.43**
Total Variable Cost (TVC)			74731.57
Total Cost (TC)			114931.68
Gross Margin(GM): (GR-TVC)			45868.86
Net Return (NR): (GR-TC)			5668.75
BCR (undiscounted): (GR/TC)			**1.05**

Source: Field Survey, 2019

6.6 Conclusion

It is easy to understand from the above discussion about the different cost items and their application doses of farmer level, yields and returns per hectare of boro rice cultivation. Boro rice cultivation is a labour and irrigation intensive enterprise. It is most essential to use modern inputs such as seeds, fertilizers, human labour, power tiller, pesticides and irrigation efficiently. Efficient use of these inputs are the most important to increase production and profitability. On the basis of above discussions it could cautiously be concluded here that cultivation of boro rice is a profitable and it would help farmers to increase their income earnings.

CHAPTER 7

TECHNICAL EFFICIENCY OF BORO RICE CULTIVATION

7.1 Introduction

Technical efficiency reflects the ability of a farmer to obtain the maximum possible output from a given level of inputs and production technology. The estimation of efficiency with the help of production function has been a popular medium of applied econometric analysis. It is a relative concept, since each farmers production performance is compared to a best-practice input-output relationship or production frontier. A farmer is technically inefficient in the sense that if it fails to produce maximum output from a given level of inputs. Technical inefficiency is then 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 boro rice farmers through technical efficiency analysis. The technical efficiency in production was estimated by using the stochastic frontier production function.

7.2 Stochastic Frontier Production Function

Maximum likelihood estimation (MLE) begins with writing a mathematical expression known as the Likelihood Function of the sample data. The likelihood of a set of data is the probability of obtaining that particular set of data, given the chosen probability distribution model. This expression contains the unknown model parameters. The values of these parameters that maximize the sample likelihood are known as the Maximum Likelihood Estimates. The maximum likelihood estimates for parameters of the Cobb-Douglas stochastic frontier production function and technical inefficiency effect model for boro rice cultivation for all sample farmers and the variance parameters of the study such as sigma square (σ^2), gamma (γ) and log-likelihood function are shown in Table 7.1.

Table 7.1: Maximum likelihood estimation of stochastic Cobb-Douglas production frontier and technical inefficiency model for Boro rice cultivation

Variables	Parameter	Coefficients	Std. Error	t-Statistic
Stochastic Frontier:				
Constant (X_0)	β_0	1.1650**	0.5634	2.07
Human Labour (X_1)	β_1	-0.0606**	0.0256	-2.37
Land Preparation (X_2)	β_2	0.0593***	0.0122	4.87
Irrigation (X_3)	β_3	0.0679**	0.0297	2.28
Seed (X_4)	β_4	-0.0487^{NS}	0.0548	-0.89
Fertilizers (X_5)	β_5	0.0554**	0.0216	2.57
Insecticides (X_6)	β_6	0.0280^{NS}	0.0189	1.48
Technical Inefficiency Model				
Constant	δ_0	1.9040***	0.6025	3.16
Education (Z_1)	δ_1	-0.0180***	0.0059	-3.05
Experience (Z_2)	δ_2	-0.0009^{NS}	0.0006	-1.50
Farm size (Z_3)	δ_3	-0.0970***	0.0286	-3.39
Credit (Z_4)	δ_4	0.0305^{NS}	0.0971	0.31
Training (Z_5)	δ_5	-0.0070^{NS}	0.0080	-0.88
Variance Parameters				
Model Variance ($\sigma^2_s = \sigma^2_v + \sigma^2_u$)		0.0360***	0.0080	4.50
Gamma ($\gamma = \sigma^2_u / \sigma^2_s$)		0.7305***	0.0991	7.37
Log Likelihood Function		135.60		

Note: ^{NS} represent Non-Significant, ***, ** and * indicates significant at 1, 5 and 10 percent level respectively.

Source: Field Survey, 2019

7.2.1. Human Labour (X_1)

The regression coefficients of human labour (X_1) was -0.0606. The regression coefficients of Human labour (X_1) was negative and significant at 5 percent level of significance. Which implied that, other factors remaining the same, if cost on human labour was increased by 1 percent then the yield of boro rice would be decreased by 0.0606 percent.

7.2.2 Land Preparation Cost (X_2)

The regression coefficients of land preparation cost (X_2) was 0.0593. The regression coefficients of land preparation cost (X_2) was positive and significant at 1 percent level of significance. Which implied that, other factors remaining the same, if cost on land preparation was increased by 1 percent then the yield of boro rice would be increased by 0.0593 percent.

7.2.3 Irrigation (X_3)

The regression coefficients of irrigation (X_3) was 0.0679. The regression coefficients of irrigation (X_3) was positive and significant at 5 percent level of significance. Which implied that, other factors remaining the same, if cost on irrigation was increased by 1 percent then the yield of boro rice would be increased by 0.0679 percent (Table 7.1).

7.2.4 Seed (X_4)

The regression coefficients of seed (X_4) was -0.0487. The regression coefficients of seed (X_4) was negative and non-significant.

7.2.5 Fertilizers (X_5)

The regression coefficients of fertilizers (X_5) was 0.0554. The regression coefficients of fertilizers (X_5) was positive and significant at 5 percent level of significance. Which implied that, other factors remaining the same, if cost on fertilizers was increased by 1 percent then the yield of boro rice would be increased by 0.0554 percent.

7.2.6 Cost of Insecticide (X_6)

The regression coefficients of insecticides (X_6) was 0.0280. The regression coefficients of insecticides (X_6) was positive and non-significant.

7.3 Technical Inefficiency Model

In the technical inefficiency model, the coefficient of education, experience, farm size, credit and training were -0.0180, -0.0009, -0.0970, 0.0305 and -0.0070 respectively. The negative coefficient of education implied that educated farmers are technically more efficient than less educated farmers and this coefficient is statistically significant at 1 percent level of significance. The negative coefficient of experience implied that experienced farmers are technically more efficient than non-experienced farmers. Although this coefficient is not statistically significant. The negative coefficient of farm size implied that large farmers are technically more efficient than small farmers. This coefficient was statistically significant at 1 percent level of significance. The coefficients of credit was positive and it revealed that this factor had no impact on the technical inefficiency. And the coefficient of credit is not statistically significant. That is, this factor did not reduced or increased technical inefficiency of producing boro rice. The coefficient of training was negative and it indicated that training of farmers helped in reducing technical inefficiency, although this coefficient is not statistically significant (Table 7.1).

The gamma (γ) parameter associated with the variance in the stochastic frontier model was estimated at 0.7305, which indicated that inefficiency effects have a significant contribution in determining the level and variability of output of boro rice farms. The existence of technical inefficiency is confirmed by the gamma value, indicating that approximately 73% of the variations in the current production level are due to the difference in technical efficiency of boro rice farmers. The remaining 27% derived from random factors beyond the farmer's control. The significant value of gamma (γ) and σ^2 indicated that there was significant technical inefficiency effects in the production of boro rice.

7.4 Distribution of Technical Efficiency

Table 7.2 Frequency Distribution of Technical Efficiency of Boro Rice Farms

Efficiency (%)	No. of farms	Percentage of farms
0-40	0	0.00
41-50	2	1.67
51-60	5	4.17
61-70	8	6.67
71-80	10	8.33
81-90	19	15.33
91-100	76	63.33
Total number of farms	120	100.00
Minimum	0.48	
Maximum	0.97	
Mean	0.87	
Standard Deviation	8.36	

Source: Field Survey, 2019

Table 7.2 showed the frequency distribution of farm specific technical efficiency for boro rice farmers. It revealed that average estimated technical efficiencies for boro rice was 87 percent which indicated that boro rice production could be increased by 13 per cent with the same level of inputs without incurring any further cost. Increase of only farm management skills result a substantial increase of output for boro rice. It was observed that 63.33 per cent of sample farmers were found to have received outputs which were very close to the maximum frontier outputs maintaining the efficiency level more than 91 per cent. On the other hand 15.33 per cent of sample farmers obtained 81 to 90 per cent technical efficiency level. The minimum and maximum technical efficiencies were observed 48 and 97 percent respectively, where standard deviation was maintained at 8.36.

7.5 Conclusion

It is easy to understand from the above discussion about the different inputs items and their efficiency level at farmer level. Yields and returns per hectare of boro rice cultivation depends on efficient use of these inputs. On the basis of above discussions it could cautiously be concluded here that cultivation of boro rice is a profitable and there is scope to increase production by reducing farm level technical efficiencies.

CHAPTER 8

PROBLEMS OF BORO RICE CUTIVATION

8.1 Introduction

Boro rice farmers faced a lot of problems in production. The problems they faced were social and cultural, financial and technical. This chapter aims at represent some socioeconomic problems and constraints of producing boro rice. The problems and constraints faced by the farmers were identified according to opinions given by them. Some problems and constraints related to boro rice cultivation are discussed in the present chapter.

8.2 Low Price of Output

Most of the farmers had to sell a large portion of their product at the harvest period to meet various obligations like, household's expenditure and repayment of loan. But the price of boro rice during the harvest time remained low because of huge supply. So the farmers could not get reasonable return from their products. The study found that 94.17 percent boro rice growers reported for this problem (Table 8.1).

8.3 Shortage of Human Labour

Boro rice cultivation is labour intensive enterprise. Most of the human Labour was used during seedbed preparation, seedling transplantation and harvesting period of boro rice. Non-availability of human labour was found in different stages of production such as transplanting, intercultural operations and harvesting. The study found that 91.67 percent of boro growers reported for this problem (Table 8.1).

8.4 Lack of Operating Capital

The farmers of the study area had capital constraints. For cultivation of boro rice, a huge amount of cash capital was required to purchase various inputs like, human labour, seed, fertilizers and pesticides etc. In the study area 88.33 percent boro rice farmers reported that they did not have sufficient amount of money for purchasing the required quantity of inputs for rice cultivation (Table 8.1).

Table 8.1: Problems Faced by the Farmer in Producing Boro Rice

Name of the Problems	Problems of Boro Rice Cultivation at Jamalpur District		
	Rank	**Number of Farmers**	**Percent (%)**
Low Price of Output	1	113	94.17
High Price of Inputs	4	94	78.33
Shortage of Human Labour	2	110	91.67
High Cost of Irrigation	5	83	69.17
Lack of Quality Seed	6	78	65.00
Attack of Pest and Disease	7	61	50.83
Lack of Operating Capital	3	106	88.33
Adulteration of Fertilizers	9	11	9.17
Natural Calamities	8	19	15.83
Poor storage facilities in house	10	6	5.00

Source: Field Survey, 2019

8.5 High Inputs Price

Inputs plays a vital role in any production process. In the study region non-availability of inputs like seeds, fertilizers, insecticides, human labour etc. at fair price was a problem in the way of producing boro rice. During the production period the price of some inputs tend to risen due to their scarcity. It found from study that 78.33 percent boro rice farmers reported that they had to purchase some inputs at a high price during the production period (Table 8.1).

8.6 High Cost of Irrigation

Irrigation is the leading input for boro rice production. Yield of boro rice varied with the application of irrigation water. Availability of irrigation water was not a serious problem in the study area because of portable irrigation devices. But farmers reported that they had to pay higher charge for water management. The study showed that 69.17 percent boro rice growers reported this problem (Table 8.1).

8.7 Lack of Quality Seed

Quality seed is the pre-condition for expected production. Lack of quality seed was one of the most important limitations of producing boro rice in the study area. From the study it was evident that about 65 percent boro rice growers reported this problem. Farmers told that they were cheated by buying so called quality seeds from the local markets and from the seed dealers (Table 8.1).

8.8 Attack of Pest and Diseases

The boro rice growers were affected by the problem of attack of pests and diseases. Pests and diseases attack reduce crop yield and increase cost of production. In the study area 50.83 percent boro rice growers reported this problem (Table 8.1).

8.9 Natural Calamities

It was found from the study that boro rice growers faced some acute problems related to the nature in their production process. Natural calamities like hailstorm, excessive rainfall, caused substantial damage to the crop in the field. The study showed that almost 19.83 percent boro rice growers in the study area were reported this problem (Table 8.1).

8.10 Adulteration of Fertilizers

Chemical fertilizers, insecticides and pesticides are the most important inputs of boro rice production.

They were being intensively used in boro rice cultivation in the study area. Many farmers reported to had been cheated by applying adulterate fertilizers and pesticides in their rice field. It was found from the study that 5 percent boro rice growers faced this problem (Table 8.1).

8.11 Poor Storage Facilities in House

As the production of boro rice was ample it created storage problem for the farmers. This problem was acute for farmers those operated large farm. From the study it was revealed that about 19.83 percent were reported for this problem (Table 8.1).

8.12 Conclusion

The above discussions as well as the results presented in Table 8.1 indicated that boro rice growers in the study area have currently been facing some major problems in conducting boro rice farming. These are the major constraints for the production of boro rice in the study area. Initiative should be taken to reduce or eliminate these problems for the sake of better production of boro rice. Government's policy of agricultural loan disbursement should be implemented properly so that the capital shortage for the cultivations can overcome. Proper attention need for better distribution of subsidy for the boro rice farmers. Government should monitor the procurement system at the time of harvesting so that the farmers get the fair price for their product.

CHAPTER 9

SUMMARY, CONCLUSION AND RECOMMENDATIONS

9.1 Introduction

The present chapter focuses on the summary in the light of the discussions made in the earlier chapters. Conclusion has been made on the basis of study result. Policy recommendations are illustrated for improvement of the existing problems of boro rice production in Bangladesh. The section 9.2 presents a summary of the major findings of the study, conclusion, policy recommendations, limitation and scope for further study are given in Section 9.3, 9.4, 9.5 and 9.6, respectively.

9.2 Summary

Bangladesh is the country with distinct agricultural setting. It is the most populous country in the world with 163.7 million populations with high population density of 1103 person per sq. km. Sixty six percent population lives in rural areas. Agriculture is main occupation of the working population with 40.6 percent being engaged in these activities. Contribution of agriculture in GDP is more than 13.60 percent. In Bangladesh, rice is the major staple food and it covers about 74.85 percent of the total cropped area (15.03 million hectares). Annual consumption of rice is 134.02 kg/capita/annum in Bangladesh. Rice production plays an important role in achieving food security of Bangladesh. Rice is cultivated in almost all agro-ecological regions of Bangladesh. The total area and production of rice in Bangladesh during 2017-18 were 11.63 million hectares and 36.28 million metric tones respectively. Per hectare yield of rice is about 3.17 MT in 2017-18 and it was about 2.82 MT in 2010-11 fiscal year. However, the increased yields of 0.35 MT per hectare during 2017-18 fiscal year due to use of quality seeds of modern varieties and appropriate technologies. In boro season is the main rice production period in Bangladesh and it covered about 4.76 million hectares of total rice cropped area and production was 18.91 million metric tones (MT), which is 8.67 percent higher than 2016-17 fiscal year (BBS, 2018). National average rice productivity is still poor because of low yielding traditional varieties.

The composition of area allocated to traditional rice still covers 1.63 million hectares which is 14.10 percent of total rice production area. Although, the cropping intensity is 194 percent of the country is the higher of the world, the decreasing land-man ratio is more frequently reminds about the intensive use of land.

As rice is the main staple food of Bangladesh the consumption of this can upgrade nutritional status of the people of Bangladesh. Boro rice production is labour intensive, so cultivation of this crop can create more employment opportunity to rural people of Bangladesh. In order to find out the problems, potentials and possibilities of expansion the production of boro rice the present study has been conducted. For the study three villages of Jamalpur Sadar Upazila in Jamalpur district were selected for the study. In total 120 farmers for boro rice were randomly selected. Data were collected by comprehensive interview schedules. Simple statistical techniques as well as Cobb-Douglas production function were used to process and analysis the data to achieve the objectives of the study. Socioeconomic condition of sample household considered composition of family size and household earning members, educational status, occupational status, and sources of income of the sample farmers. The sample of 120 household in each study area comprised average family size 4.38, where male and female members were 2.34 and 2.03 respectively. In the study area about 14.17 percent of the study population were found to have no education or illiterate, about 35 percent were found to have signature only, about 23.33 percent were found to have primary level education and only 17.50 percent people were found to have high school level education, about 7.50 percent were found to have college level education and only 2.50 percent were attained or completed graduation level of education. The study found that sample farmers annual income sources were both on farm and off farm activities. On farm income earned from both rice and non-rice sectors. Rice sector contributed 13.72 percent of on farm income and it was Tk. 5321.75. On the other hand, off farm income were earned from home yard crops, livestock, poultry and fisheries sectors. The contribution of these sectors to annual income were 1.08 percent, 17.14 percent, 0.89 percent and 21.63 percent respectively, and in monetary term by Tk. 419.92, Tk. 6650, Tk. 346.08 and Tk. 8391.67 respectively. The study found that 54.46 percent of the total annual income came from farm activities and 45.54 percent from off farm activities. It was revealed that, the on farm activities contributed the highest percentage (54.46%) to farmer annual income.

The 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 and ratio of return to total cost. The average land preparation cost of boro rice cultivation was found to be Tk. 4236.96 per hectare. . The quantity of human labour used in boro rice production was found to be about 121.97 man-days per hectare and average price of human labour was Tk. 396.24 per man-day. Therefore, the total cost of human labour was found to be Tk. 48329.22 representing 42.05 percent of total cost. Per hectare total cost of seed for boro rice production were estimated to be Tk. 1554.80. On an average, farmers used Manures, Urea, TSP, MoP and Gypsum were 1958.42 kg, 268.27 kg, 156.28 kg, 123.60 kg and 53.69 kg respectively, per hectare. The average cost of insecticides for boro rice production was found to be Tk. 1746.70 whereas the average cost of irrigation was found to be Tk. 6487.75 per hectare. The total variable cost of boro rice production was Tk. 74731.57 per hectare, which was 65.02 percent of the total cost. The average yield of boro rice per hectare was 6940 kg and the average price of boro rice was Tk. 16.00 per kg.. The gross return, gross margin and net return were found to be Tk. 120600.43, Tk. 45868.86 and Tk. 5668.75 per hectare. Undiscounted Benefit Cost Ratio (BCR) was found to be 1.05 which implies that one taka investment in boro rice production generated return as Tk. 1.05.

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 human labour (X_1) was -0.0606 which was negative and significant at 5 percent level of significance. The regression coefficients of land preparation cost (X_2) was 0.0593 which was positive and significant at 1 percent level of significance. The regression coefficients of irrigation (X_3) was 0.0679 which was positive and significant at 5 percent level of significance. The regression coefficients of seed (X_4) was -0.0487 which was negative and non-significant. The regression coefficients of fertilizers (X_5) was 0.0554 which was positive and significant at 5 percent level of significance and the regression coefficients of insecticides (X_6) was 0.0280 which was positive and non-significant. On the other hand, in the technical inefficiency model, the coefficient of education, experience, farm size, credit and training are -0.0180, -0.0009, -0.0970, 0.0305 and -0.0070 respectively.

The negative coefficient of education implied that educated farmers are technically more efficient than less educated farmers and this coefficient is statistically significant at 1 percent level of significance. The negative coefficient of experience implied that experienced farmers are technically more efficient than non-experienced farmers. Although this coefficient is not statistically significant. The negative coefficient of farm size implied that large farmers are technically more efficient than small farmers. This coefficient was statistically significant at 1 percent level of significance. The coefficients of credit was positive and it revealed that this factor had no impact on the technical inefficiency. And the coefficient of credit was statistically insignificant. That is, this factor did not reduced or increased technical inefficiency of producing boro rice. The coefficient of training was negative and it indicated that training of farmers helps to reduce technical inefficiency, although this coefficient is not statistically significant. Farmers faced a lot of problems in producing boro rice that affecting their efficiency level. Public and private initiatives should be taken to reduce or eliminate these problems for the sake of better production of boro rice.

9.3 Conclusion

Boro rice are extensively cultivated food grain in Jamalpur Sadar Upazila under Jamalpur district and it is one of the important cereal crop grown by farmers mainly for food and market purpose. The results of the present study helps to draw a conclusion that some substantial scope evidently exists in the study area to increase the productivity of boro rice. The economic profitability analysis of the study demonstrates that Bangladesh enjoys low profitability of boro rice cultivation due to low price of yield. However, boro rice cultivation is labour and irrigation intensive enterprise. So cultivation of boro rice increased the production cost of farmers and at the same time can help in increasing farm income through high yield and can create new employment opportunities for other unemployed people. The regulatory management practices of boro rice farms in the study area were not found efficient enough. Farmers were not known about the application of inputs in right time with proper doses. Therefore, they made over or under use of some farm inputs.

Thus, proper strategic management training in accordance with boro rice farmer's problems, requirements, objectives and resource base can lead to feasible production practices and sustainable income from boro rice cultivation.

9.4 Recommendations

On the basis of the results of the study it was evident that boro rice was low profitable enterprise because of low yield price of rice in Bangladesh, though yield per hectare was good. Some problems and constraints bared to attain the above mentioned objectives of the study. The policy makers should take necessary measures to solve these problems and constraints. According to the findings of the study some policy recommendations are likely to be useful for policy formulation. On the basis of the findings of the study, the following specific recommendation are made for the development of boro rice production. In view of actual field position and experiences gained so far, it is understood that there was an imbalance use of farm inputs in the study area. So public and private interventions might be required for ensuring proper use of farm inputs like balanced use of fertilizers, increasing use of organic and bio-fertilizers and finally providing training to the farmers on using appropriate doses of fertilizer, combinations of fertilizers and other inputs. Moreover, farmers reported that they were suffered from adulterated fertilizers. Thus public initiative should be taken to maintain fertilizer quality. Besides the above discussion the following recommendations may be given on the basis on study findings:

1. Quality seeds in right quantity are recognized to be one of the key elements for enhancing agricultural production. So, emphasis should be given on creating facilities and infrastructure support for quality boro rice seed production and marketing.

2. Proper water management is the main factor behind the growth of rice plants and yield. So adequate measure should be taken to improve irrigation water management system.

3. Agricultural labour shortage is becoming a great problem in Bangladesh. So adequate measure should be taken to enhance farm mechanization.

4. Operating capital is a problem for the boro rice farmers of the study area. So institutional credit program should be launched aiming at particularly the marginal, small and medium farmers. The commercial banks should be encouraged to provide loans at a low interest rate to enable farmers to operate their farming.

5. Farmers could not get reasonable prices for boro rice. Because the agricultural marketing system in Bangladesh is not well developed. So appropriate steps should be taken to develop good market structure to ensure fair price for the boro rice growers by determining floor price and ceiling at the beginning of boro season.

6. Government should take necessary steps to explore the possibility of export in the different countries of the world. In this case, government should purchase boro rice from the farmers at the harvesting period and export to the concerned countries as per demand.

9.5 Limitations of the Study

The study is being a field level study it suffered from a number of limitations. There are some limitations of the study as the study conducted on the farmers of the country through interview schedules. The limitations of the study are discussed below:

a) The researcher had to rely fully on the memory and sincerity of the farmers for the accuracy and reliability of data. Because most of the farmers did not keep any written documents of their farm business activities. So possibility of errors could not fully be ruled out.

b) The study was conducted in a limited area of an Upazila taking into account very limited number of sample due to limitation of time and resources for the research.

Despite of the above limitations, the findings of this study was interpreted cautiously to generalize for the country as a whole so that the findings of the present study may provide some valuable information to the boro rice growers, policy makers, extension workers and researchers.

9.6 Scope for Further Study

The present study is deliberate to provide some valuable information for the guidance of rice farmers, extension workers, decision makers and researchers. The present study is not free from criticisms, due to limitations of time and resources this study could not cover some important areas. Moreover, the weaknesses of the present study, obviously, open opportunities for further research. The probable opportunities are given bellow:

a) A study may be undertaken for better understanding not only to study profitability of boro rice but also with other crops.
b) A further study can be undertaken by taking into account different farm sizes to assess the impact of profitability of boro rice on income and employment generation.
c) A study can be undertaken by taking other varieties of boro rice or may be conduct individually to assess their profitability, comparative profitability and level of efficiency.

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APPENDICES

Appendix A

Table 1: Summary of Regression Analysis

lyield	Coef.	Std. Err.	t-value
lhumanlabor	-0.060571	0.0255685	-2.37
llandpreparation	0.0592859	0.0121697	4.87
lirrigation	0.0679113	0.0297212	2.28
lseed	-0.0486898	0.0547913	-0.89
lfertilizers	0.0554369	0.0215927	2.57
linsectecides	0.0279818	0.0189341	1.48
_cons	1.164985	0.5634588	2.07

Table 2: Age Distribution of Sample Boro Rice Farmers

Age Group (years)	All Farmers	
	Number of Farmer	Percent (%)
15-30	14	11.67
31-45	48	40.00
46-60	45	37.50
Above 60	13	10.83
Total	**120**	**100.00**

Table 3: Farm size distribution and tenurial status of sample farmers

Items	All Farmers	
	Number of Farmer	Percent (%)
Farm Size Distribution:		
e) Marginal Farm (0.05-1.49 acre)	61	50.83
f) Small Farm (1.50-2.49 acre)	36	30.00
g) Medium Farm (2.50-7.49 acre)	17	14.17
h) Large Farm (7.50 acre and above)	6	5.00
Total	**120**	**100.00**
Tenurial Status:		
d) Own operated	63	52.50
e) Own operated cum Share cropping	38	31.67
f) Share cropping	19	15.83
Total	**120**	**100.00**

Table 4: Agricultural Training of the Respondent Farmers

Training received	All Farmers	
	Number of Farmer	Percent (%)
Yes	37	30.83
No	83	69.17
Total	**120**	**100.00**

Appendix B

Department of Agricultural Economics

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

Interview Schedule

Technical Efficiency of Boro Rice Cultivation In Jamalpur District

1. Identification of Respondent:

Sample No.: ---------------------

Name: -- Village: -------------------------

Upazilla/Thana: --- District: -------------------

2. Socio-economic Characteristics of Respondent:

(A) General Information:

Age (Years)	
Main Occupation	
Others Occupation	
Experience in rice Cultivation (Years)	
Educational Qualification	

Educational code: 0= Illiterate, 1= Read and write, 2= Primary level passed, 3= High school level passed, 4= Graduate, 5= Child (bellow 10 years).

(B) Family Structure:

Number Family Member		
Gender:	Male	
	Female	
Number of Children (below 10 years)		
Members involved in agriculture		

Gender code: 1= male, 2= female

3. Land holding and tenancy:

Category of land	Area (decimals)
a) Homestead	
b) Own land	
c) Land under sharecropping	
d) Leased out land	
e) Leased in land	
f) Total rice cultivated area	
g) Others (specify):	

1 katha= ----------------decimals, 1 bigha= ---------------decimals, 1 kani= -------------------decimals, 1 hactare= -----------------decimals, 1 acre= ------------decimals, 1 paki= ------------------decimals.

4. **Information about annual income:**

A. Income from rice:

Items	Quantity (mounds)	Price (Tk./mound)	Total income (Tk.)
Value of rice			

B. Income from non-rice/off farm:

Items	Total income (Tk.)
a) Home yard crops	
b) Livestock	
c) Poultry	
d) Fisheries	
e) Others (specify):	

5. **Primary disposal pattern of Boro rice:**

Items	Quantity (mounds)
Total production of Boro rice	
Paid as kind (harvesting and threshing)	
Used for family consumption and seed	
Sold**	

Selling pattern of Boro rice of farm households:

Items	Quantity (mounds)
Sale before harvest	
Sale within a month of harvest	
Sale within 2-3 months of harvest	
Stored for sale after 3 months	

6. **Availability of cash capital for farming operation: Yes/ No**

7. **If loan is needed, institutional loan is available: Yes/ No**
   (if yes then the amount of loan taken in Tk. ------------------------------)

8. **Sources of seed:**

Cultivated land area (decimals)	
Name of cultivated variety/varieties	
Owned source seed (kg.)	
Purchased seed (kg.)	
Amount of seeds/seedlings (number/kg./decimal)	
Price of seeds/seedlings (Tk./decimal/kg.)	

9. Plot-wise information about varieties grown:

Sl. No.	Name of variety	Plot area (decimals)	Plot yield (mounds)	Yield (t/ha)	Straw value (Tk./plot)
1					
2					
3					
4					
5					

10. Varieties grown during last five years in Boro season:

Sl. No.	Name of previously grown variety	Name of currently grown variety
01		
02		
03		
04		
05		

11. Reasons for cultivating existing varieties:

01	
02	
03	
04	
05	

12. Reasons for not cultivating modern varieties (MV):

01	
02	
03	
04	
05	

13. Inputs use patterns of rice cultivation:

A) Labor cost:

Size of plot= ---------decimals

Sl. No.	**Items**	**Family labor (man-days)**	**Hired labor (man-days)**	**Labor wage (Tk. Per man-days)**	**Total cost (Tk.)**
01	Land preparation				
02	Labor for transplanting				
03	Fertilizer application				
04	Manure application				
05	Labor for weeding				
06	Labor for irrigation				
07	Pesticide application				
08	Harvesting & carrying				
09	Drying and Storing				
Total					

B) **Cost of land preparation:**

Items	Medium (put tick mark)	Owned	Hired	Cost (1 ploughing/bigha)	Total cost (Tk.)
Ploughing	Plough/power tiller/tractor				
Laddering	Plough/power tiller/tractor				
Contract land preparation					

C) **Irrigation cost:**

Items	Medium or ways (put tick mark)	Cost (Tk./ plot)	Total cost (Tk.)
No. of irrigation			
Types of irrigation	STW/ DTW/ Electricity operated/ Surface irrigation		
Cost of fuel/electricity in case of own machine			

D) Fertilizer cost:

Organic fertilizers	
Items	**Amounts (Kg.)**
a) Cow dung	
b) Excreta of chickens	
c) Ash	
d) Vermicompost	
e) Compost	
f) Others (specify):	
Inorganic fertilizers	
Items	**Amounts (Kg.)**
a) Urea	
b) MoP	
c) TSP	
d) DAP	
e) Gypsum	
f) Zinc sulphate	
g) Magnesium sulphate	
h) Boric acid/Boron	
i) Others (specify):	

- Fertilizer price (**Tk./Kg**): Urea-------------, TSP------------, MoP-------------, DAP-----------, Gypsum------------, Zinc sulphate-----------, Boric acid-----------, Magnesium sulphate---------, Compost-----------, Vermicompost-----------, Farm yard manure------------.

E) Other costs:

Items	Amounts (kg.) or (ml)	Price (Tk/kg) or (Tk/ml)	Total cost (Tk)
Pesticides			
Herbicides			
Cost of harvesting, carrying if contracted.			
Others (specify):			

14. Major problems of Boro rice cultivation:

Rank	Problems

15. What are the suggestion(s) to overcome the above problems?

Rank	Suggestions

Name of Interviewer: ---

Date: -------/-------/----------