A STUDY ON COMPARATIVE PROFITABILITY ANALYSIS OF AMAN AND BORO RICE PRODUCTION IN SOME SELECTED AREAS OF JHALAKATHI DISTRICT

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*This is to certify that thesis entitled, **"A STUDY ON COMPARATIVE PROFITABILITY ANALYSIS OF AMAN AND BORO RICE PRODUCTION IN SOME SELECTED AREAS OF JHALAKATHI 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 **J.M. Zaved**, Registration No. **12-05126** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: , 2019
Place: Dhaka, Bangladesh

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TO

MY BELOVED PARENTS

ABSTRACT

This study was undertaken to assess the comparative profitability of aman and boro rice production. A total of 60 farmers (30 for aman rice growers and 30 for boro rice growers) were selected randomly from 10 villages of Jhalokati District. Survey data were collected using structured questionnaire in 2018. Tabular technique and statistical analysis were done to achieve the objectives of the study. The Cobb-Douglas production function was used in this study to determine the effects of individual inputs on aman and boro rice production. The major findings of the study were that the cultivation of aman rice and boro rice was profitable from the view point of farmers. The total return per hectare for aman rice and boro rice were Tk. 74848.6 and Tk. 141814 respectively. The gross cost of aman rice was Tk. 59315 and for boro rice it was Tk. 100430.23. Again, the net return of aman rice and boro rice were Tk. 15533.6 and Tk. 41383.77, respectively. The undiscounted Benefit Cost Ratio (BCR) were 1.26 and 1.41 for aman and boro rice production, respectively. The results indicated that boro rice production was more profitable than the aman rice production. It was also evident from the study that per hectare net returns were influenced by most of the factors included in model namely: human labor, seed, fertilizer and manure, insecticides and pesticides, power tiller, and irrigation. These factors were directly or jointly responsible for influencing per hectare net returns for aman and boro rice production. The study also showed that farmers producing aman and boro rice faced some problems, mainly related to production and marketing of the crops. It may be concluded that the farmers should be encouraged to grow more boro rice rather than aman rice as a means of increasing farm income through diversification of crop production in the area under study.

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ABBREVIATIONS AND ACRONYMS

BARI	: Bangladesh Agricultural Research Institute
BBS	: Bangladesh Bureau of Statistic
BCR	: Benefit Cost Ratio
BDT	: Bangladeshi Taka
BER	: Bangladesh Economic Review
DAE	: Department of Agricultural Extension
et al.	: and others (at elli)
GR	: Gross Return
gm	: Gram
ha	: Hectare
HIES	: Household Income and Expenditure Survey
HYV	: High Yielding Variety
IOC	: Interest on Operating Capital
kg	: Kilogram
MoP	: Muriate of Potash
mt	: Metric Ton
NGO	: Non-Government Organization
SRC	: Spices Research Center
t	: Ton
TC	: Total Cost
TFC	: Total Fixed Cost
Tk.	: Taka
TSP	: Triple Super Phosphate
TVC	: Total Variable Cost
US	: United States
USDA	: United States Department of Agriculture
$	: Dollar

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Agriculture is the largest employment sector in Bangladesh. The performance of this sector has an overwhelming impact on major macroeconomic objectives like employment generation, poverty alleviation, human resources development, food security, etc. A plurality of Bangladeshis earn their living from agriculture. Although rice is the primary crops. Rice can be grown and harvested three times a year in many areas. Due to a number of factors, Bangladesh's labor-intensive agriculture has achieved steady increases in food grain production despite the often unfavorable weather conditions. Targeted breeding works well in Bangladesh's diverse environments. The development of more high-yielding, different maturity period, drought-tolerant, salt-tolerant, disease-resistant, submergence-resistant, and possibly nutrient-rich varieties will further boost rice production and nutrition. Effective fertilizer and other crop management strategies will likewise enhance rice production. Hence, the government should increase investment in rice research and extension to further improve yield and reduce the costs of rice production in the long run. Providing a subsidy to reduce the cost of groundwater irrigation will encourage risk-averse and resource-poor farmers to continue to engage in rice production.

1.2 Status of Bangladesh Agriculture

At present, despite some diversification, most of the agricultural production is still concentrated on a limited number of crops and rice continuing to be the most important crop. While cash crops, like sugarcane and jute, have seen their production stagnating or declining over the past decades (BBS, 2018). On the other hand, production of spices and tea has been increased. Production of fruits and vegetables has also improved. In the non-crop sector, poultry, dairy and seafood have seen considerable growth.

Bangladesh is an agricultural country and most of the inhabitants directly or indirectly are involved in agricultural activities for their livelihood. Agriculture has a great contribution to the Gross domestic Product (GDP) of the country. Earlier more than 50% of GDP came from this sector. At the beginning of industrialization, the activities of the population got diversification towards different sectors. As a result, the contribution of the agriculture sector is slowly reducing and now declined to 14.10% of the GDP (BBS 2018). Still agriculture plays a vital role and is taken as the most important sector of the economy. Despite increase in the shares of fisheries, livestock, and forestry, crop sub-sector alone accounts for 55.82 percent share of agricultural GDP in FY 2015-16 (BER, 2017) (Fig 1.1). Although the contribution of crop sub-sector in GDP marginally decreased from 9.49 percent in FY 2016-17 to 9.11 percent in FY 2017 -18.

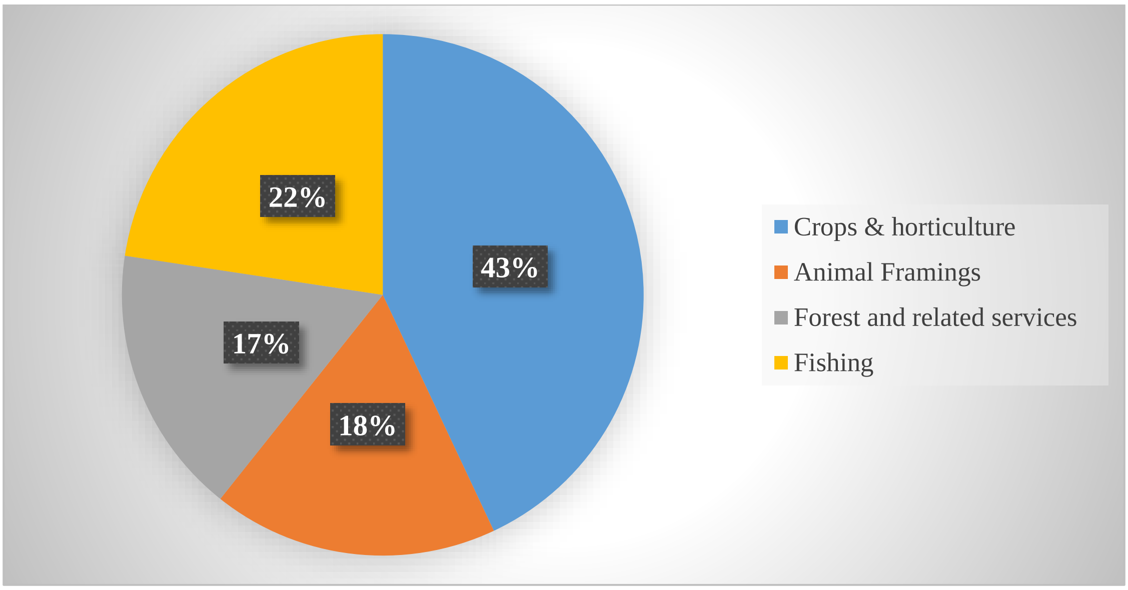

Figure 1.1: Sub-Sectorial Share of Broader Agricultural GDP in 2017-18

Source: BER, 2018

1.3 Importance of Boro Rice

Rice is the amazing food grain that shapes the diets, culture, economy and the way of life in Bangladesh. It is the staple food for entire 155.8 million people. Keeping this in mind, since the independence all the successive governments have given high priority for attaining self-sufficiency in food production. The development of high yielding modern grain 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.

Table 1.1: Area and Production of Rice and Boro Rice by Different Years

Year	Production ('000' MT)	
	Rice	**Boro Rice**
2001-02	25085	11766
2002-03	23834	12222
2003-04	25.187	12838
2004-05	25157	13837
2005-06	27.520	13975
2006-07	27319	14965
2007-08	28931	17762
2008-09	31317	13084
2009-10	31975	18059
20010-11	33542	18617
2011-12	33988	18759
2012-13	33826	18778
2013-14	34356	19007
2014-15	34710	19192
2015-16	34701	18937
2016-17	33804	18014

Source: BBS, 2018

Among the high yielding varieties boro rice varieties have maximum share to the total rice production which is more or less stable over the last decades. Rice is the staple food for the general people of Bangladesh. Accordingly, the demand for rice is constantly rising and 2.3 million people being added each year to its total population. Rice constitutes about 70 percent of total calorie intake for the people particularly for hard working people. Rice covers an area of about 11.53 million hectares and is by far the most important provider of rural employment (HIES, 2005 and BBS, 2006). The area, production and yield rate of rice, in general and boro, in particular, for different years were shown in Table 1.1.

1.4 Importance of Aman Rice

Although, overall adoption of BRRI varieties was apparently low (48% of total areas) in T. Aman season, adoption of BRRI varieties was substantially higher (ranges between 63-81% of total area) in several regions (Rangamati, Sylhet, Faridpur, Dhaka, Chittagonj, and Comilla). Among BRRI varieties, adoption of BRRI dhan49 was higher (11%) followed by BR11 (7%). It was observed that BR11 is still a very popular variety (e.g., covered 22-25% of total areas) in Rangamati and Sylhet regions. Similarly, popularity of BRRI dhan34 in Dinajpur (21%) and BRRI dhan49 in Mymensingh (22%) and Dhaka (37%) was higher. Although, overall adoption of Indian rice varieties was about 21% of total areas; adoption of those varieties was very high (41-56% of total areas) in several regions namely Rangpur, Dinajpur, Bogra, Rajshahi, and Jessore. Overall adoption of modern varieties (MVs) in T. Aman season was about 80%. This result indicates that there is huge scope to increase rice production through increasing adoption of MVs in T. Aman season (Table 1.2). [https://icrea.agr.nagoya-u.ac.jp/jpn/journal/Vol14_20-29-Review-Shelley.pdf]

Among BRRI varieties, BRRI dhan49 was the top yielder (4.60 ton/ha), followed by BRRI dhan52 (4.55 ton/ha) and BR11 (4.53 ton/ha) in T. Aman season whereas average yield of hybrid was 5.70 ton/ha. The productivity of Indian variety was 4.27 ton/ha.

Average yield of BRRI varieties was 4.30 ton/ha and the overall yield of modern varieties (MVs) in this season was 4.56 ton/ha.

Due to an atmospheric depression in the Bay of Bengal during December, more than 508 mm (20 inches) of rain in downpours caused damage to the *Aman* rice crop. Some farmers reported that they had yield loss due to 75 percent lodging during the grain maturing stage caused by heavy rains combined with high speed winds.

Table 1.2: Area and Production of Rice and Aman Rice by Different Years

Year	**Production ('000' MT)**	
	Aman Rice	**Total Production**
2000-2001	11249	25085
2001-2002	10726	23834
2002-2003	11115	25187
2003-2004	11521	26190
2004-2005	9820	25157
2005-2006	810	27520
2006-2007	10841	27326
2007-2008	9662	28931
2008-2009	11613	31317
2009-2010	12207	32727
2010-2011	12792	33988
2011-2012	12798	33988
2012-2013	12897	33826
2013-2014	13023	34356
2014-2015	13.190	34710
2015-2016	13483	34701
2016-2017	13656	33804

Source: BBS, 2018

1.5 Nutritive and Medicinal Value of these Crops

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 (corn) 5%. A detailed analysis of nutrient content of rice suggests that the nutrition value of rice varies based on a number offactors. It depends on the strain of rice, that is between white, brown, red, and black (or purple) varieties of rice, each prevalent in different parts of the world. It also depends on nutrient quality of the soil rice is grown in, whether and how the rice is polished or processed, the manner it is enriched, and how it is prepared before consumption. 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, Vietnam and Kampuchea are rice eaters. Rice is interwoven with Bengali culture. It is the symbol of wealth. The Food Department of the Government of Bangladesh recommends 410 gm of rice/head/day.

Table 1.3: Nutrients from Per 100 gm Rice

Composition	Rice
Calories (k. calorie)	325
Moisture content (percent)	13.3
Carbohydrate (percent)	79
Protein (gm)	6.4
Fat (gm)	0.4
B-carotine (µg)	0
Vitamin B (mg)	0
Thiamin	0.21
Riboflovine	0.09
Vitamin C (mg)	0
Calcium (Ca) (mg)	9
Iron (Fe) (mg)	1

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

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, p. 32). 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 economic development.

The total area of Bangladesh is about 14.845 million hectares of which 53.89 percent is cultivable, 3.16 percent is current fallow land and rest 42.95 percent is covered by homesteads, rivers, tidal creeks, lakes, ponds, roads, etc. (BER, 2015). 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 High Yielding Varieties (HYV) and adopting improved cultural and management practices. In the past, growth of agriculture in Bangladesh has centered on food grain production rice alone comprises over 90 percent of that growth. Massive increase in rice production led to the decline in area of tubers, pulses, spices, oilseeds, roots, and other minor crops (Baset, 2003). Thus Bangladesh has to import spices at the cost of its hard earned foreign currency.

Realizing the importance of minor crops for the improvement of nutritional status of the people, the government of Bangladesh has taken a Crop Diversification Program (CDP) in the Sixth Five-Year Plan (2011-2015). Under the CDP strategy, emphasis was placed to increase production and consumption of those nutrient rich foods. The diversification has not yet taken place adequately within the crop sector, which is still dominated by the production of cereals.

In order to explore the potentials and possibilities of expansion in the acreage and production of the minor crops, it is, therefore, important to examine the past performance of the crops; to analyze the profitability of those crops in order that all these activities would reveal necessary information before farmers, researchers, planners and so on to take unique steps forward to increase both the acreage and production of minor Alliums; specially, aman and boro as they are mostly cultivated and consumed Alliums in Bangladesh.

1.6 Justification of the Study

In the economy of Bangladesh, Agriculture sector is playing very important role. This sector attained modest growth and experienced slow transition during the two decades since independence. The goal of the sector was to replace the traditional and vulnerable agriculture by a modern agriculture capable of sustained growth (SFYP). Thus it is essential to ensure easy availability of agricultural inputs, execution of agriculture extension principles, modernization of research techniques to improve the quality of agricultural product and steps should be taken to apply and extend the use of technologies obtained from agricultural research for sustainable agricultural development.

Aman is an important crop in Bangladesh for its huge production. This year, at the sowing period, favourable weather condition, electricity management and stable market position helped the farmers to bring more area under aman crop. The weather condition was reasonably pretty at sowing stage. Late monsoon throughout the country brought low lying area under aman crop. For this reason the coverage area raised substantially.

The weather condition for boro cultivation was favorable in the growing stage this 2018. But due to flash flood in some northern districts (boro) crop under 40,198 hectares of land was fully damaged for FY 2015-16. In a subjective manner, farmers were interviewed on some points relating to management system of seed, fertilizer and rural electricity supply. They opined that proper management and timely distribution of seed, fertilizer and stable supply of electricity led to higher yield of boro this year. (source: Field Survey 2018)

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 aman and boro rice production.

1.7 Objective of the Study

i. To assess the present socio-economic characteristics of aman and boro rice growing farmers,
ii. To find out the profitability of Aman and Boro rice in the study areas,
iii. To find out the major factors affecting the production, and
iv. To suggest some policy options for the improvement of aman and Boro rice cultivation.

1.8 Organization of the Study

The study consists of 9 chapters. Chapter 1 describes introduction of the study. Relevant review of literature, methodology, description of the study area, socioeconomic characteristics of the sample farmers, results and discussion, major factors affecting to the production processes of aman and boro rice, problems of aman and boro growers and summary, conclusion and recommendations are presented in Chapter 2, Chapter 3, Chapter 4, Chapter 5, Chapter 6, Chapter 7, Chapter 8 and Chapter 9, respectively.

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 comparative profitability of boro and aman rice in Bangladesh. Again, some of these studies may not entirely relevant to the present study, but their findings, methodology of analysis and suggestions have a great influence on the present study. Review of some research works relevant to the present studies, which have been conducted in the recent past, are discussed below.

Boro Rice

Ahmed (2009) conducted a comparative economic analysis of boro rice and potato production in some selected areas of Mymensingh district. Both boro rice and potato were profitable. Potato cultivation was more profitable than boro rice cultivation. Per hectare average yield of boro rice and potato were 6000 kg and 16302 kg, respectively. Per hectare total cost of production, gross margin and net margin of boro rice were Tk. 58202.74, Tk. 39402.2 and Tk. 24117.26, respectively. On the other hand, the corresponding figures for producing potato were Tk. 120221.71, Tk. 155436.23 and Tk. 142403.51, respectively.

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.

Majid and Haque (2007) conducted a study on Monga mitigation for employment and food security increase through early aman rice production and crop diversification in greater Rangpur region of Bangladesh. Introducing of cash crop in potato growing time (early to late November) contributed more productivity (32.4-39.3 MT/ha) than Rice-Non-Rice system as Rice-Rice (13.2 MT/ha). The highest rice equivalent yield associated with early Aman Rice-Potato-Mungbean (37.4 MT/ha) and Early Aman Rice-Potato-Rice (Bolan/older seedling of BRRI Dhan-33) (32.4-32.6 MT/ha). However, early Aman Rice-Potato-Mungbean gave lower productivity than Rice-Potato-Relay Maize/Maize but Mungbean added some biomass in the soil for soil health.

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.

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.

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 reveals 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.

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.

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 bom income and employment.

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.

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.

Aman Rice

Anik and Salam (2017) carried out an experiment that is assessing and explaining vegetable growers' efficiency in the south-eastern hilly districts of Bangladesh. They identifies drivers of production and technical efficiency in okra and eggplant production. The estimated efficiency scores reveal that around 67% and 99% of the production in okra and eggplant, respectively, are lost due to inefficiency factors. Among different production inputs, land has the highest production elasticity. Land fragmentation and land slope are positively associated with inefficiency, whereas extension service, rented in land and credit have negative associations. Compared to the lager farmers, the smaller are relatively efficient. Efficiency level is also sensitive to ethnicity, annual income, education and farming practices. The important policy outcomes of the study are: land reform to ensure land entitlement; land consolidation and farmers' organizations for better access to land; off-farm employment creation; and investment in extension service, especially for the indigenous people and for diffusion of the soil preservation technologies.

Anik *et al.*, (2015) studied on Impact of resource ownership and input market access on Bangladeshi paddy growers' efficiency. The result of the study indicated that a farmer can significantly raise production by increasing quantity of land, total labour and fertilizer in the paddy production. Use of organic manure also significantly contributes in paddy production. Among all the production inputs land has the most dominant impact on production. The estimated mean technical efficiency score of 78% implies that there are substantial scopes to increase paddy production through enhancing farm efficiency. The important efficiency influencing factors are ownership of land and machinery, farm location, access to credit, share of own supplied labour and seed to total requirement and capital constraint. The small farmers are more efficient than the marginal, medium and large farmers. Among different categories of households, higher mean technical efficiency scores are found with the food secured households, households having no earning from outside agriculture, households belonging to lower expenditure group and farmers cultivating paddy only in own land. Finally, the article offers some explanations for these results and suggests some policy options for improving farm efficiency.

Fatema *et al.*, (2014) studied on Comparative economic analysis of T.aman rice unde saline and nonsaline area of Dacope upazilla of Khulna distit of Bangladesh. This study was designed to assess the comparative profitability of T. Aman rice farming in saline and nonsaline area at Dacope Upazila of Khulna district of Bangladesh. In total, 240 farmers were randomly selected for the study among which 120 from saline area and rest 120 from non-saline area. Descriptive statistics, activity budgets, Cobb-Douglas production function model were employed to achieve the objectives of the study. The study confirmed that T. Aman rice production of nonsaline area were profitable than saline area. It was observed that the coefficient of human labour, power tiller and insecticide were positive and had significant impacts on gross returns of T. Aman rice production in nonsaline area. Similarly, the coefficient of seedling, power tiller, human labour, TSP and insecticide were positive and had significant impacts on gross returns of T. Aman rice production in saline area.

Goldman (2013) studied on india’s rice production and it’s technical efficiency. He found that the determinants of technical efficiency that may h elp designing rice production profitably and minimizing farmers' yield gap with given technology and resource constraints and to provide future policy guidelines for researchers and public support services. Farm -level cross section data were collected from one of the intensive rice -growing areas of Dinajpur. A set of statistical and non-statistical stochastic approaches to frontiers have been used to estimate production efficiency.The application of the translog stochastic production frontier model gave th e best fit for technical efficiency analysis. The estimated mean efficiency was 97% for aromatic, 98% for fine, and 85% for coarse rice farmers indicating that there is little scope of increasing yield without breaking the yield frontier particularly for aromatic and fine rice through introduction of high yield potential varieties. For coarse rice varieties, 15 -16% yield could be increased even with the existing varieties, if the management practices of the parameters identified in this study are improved.

Hasan (2008) conducted a study on Technical Efficiency of Rice Farmers in Northern Ghana. Examining the level of farm-specific technical efficiency of farmers growing irrigated and non-irrigated rice in Northern Ghana, this study fitted cross-sectional data into a transcendental logarithmic (translog) production frontier. The study concludes that rice farmers are technically inefficient. There is no significant difference in mean technical efficiencies for non-irrigators (53%) and irrigators (51%). The main determinants of technical efficiency in the study area are education, extension contact, age and family size. Providing farmers with both formal and informal education will be a useful investment and a good mechanism for improving efficiency in rice farming. There is also need for training more qualified extension agents and motivating them to deliver.

Balcombe *et al., (*2006) conducted a study on technical efficiency of rice growers in Bangladesh through Stochastic Frontiers Analysis (SFA) or Data Envelopment Analysis (DEA) The results show evidence of technical inefficiency although this is of a lesser degree than other studies have reported. This is especially the case for MV production. There are also significant differences in the results for the two rice production technologies (LVand MV). He found that based on the conventional assumption for frontier studies that at least some of the farmers in the sample are progressive farmers who differ from others in adapting available knowledge and technologies to local conditions to attain high yields, the technical efficiency estimates suggest that the scope to narrow the 'yield gap' in Barisal district may be less than was anticipated from both earlier studies and characterizations of the area as relatively 'backward' in terms of farming practice. If so, efforts to develop improved technologies, including new varieties and hybrids with higher yield potential should not be neglected. Given the existing technology the sample farmers could on average only enhance their rice production by eight per cent and four per cent for LV and MV growers, respectively.

Kibaara (2005) conducted an economic study on technical efficiency in Kenyan's maize production. There is distinct intra and interregional variability in technical efficiency in the maize producing regions. In addition, technical efficiency varies by cropping system; the mono-cropped maize fields have a higher technical efficiency than the intercropped maize fields. The number of years of school the farmer has had in formal education, age of the household head, health of the household head, gender of the household, use or none use of tractors and off-farm income impact on technical efficiency.

Rahman (2003) examined the Profit efficiency among Bangladeshi rice farmers. Production inefficiency is usually analyzed by its three components—technical, allocative, and scale efficiency. In this study, we provide a direct measure of production efficiency of the Bangladeshi rice farmers using a stochastic profit frontier and inefficiency effects model. The data, which are for 1996, include seven conventional inputs and several other background factors affecting production of modern or high yielding varieties (HYVs) of rice spread across 21 villages in three agro-ecological regions of Bangladesh. The results show that there are high levels of inefficiency in modern rice cultivation. The mean level of profit efficiency is 77% suggesting that an estimated 23% of the profit is lost due to a combination of technical, allocative and scale inefficiency in modern rice production. The efficiency differences are explained largely by infrastructure, soil fertility, experience, extension services, tenancy and share of non-agricultural income.

Coali *et al.*, (2001) carried ot an experiment on Technical, Allocative, Cost and Scale Efficiencies in Bangladesh Rice Cultivation:A Non-parametric Approach. The study showed Applying programming techniques to detailed data for 406 rice farms in 21 villages, for 1997, produces inefficiency measures, which differ substantially from the results of simple yield and unit cost measures. For the Boro (dry) season, mean technical efficiency was 69.4 per cent, allocative efficiency was 81.3 per cent, cost efficiency was 56.2 per cent and scale efficiency 94.9 per cent. The Aman (wet) season results are similar, but a few points lower. Allocative inefficiency is due to overuse of labour, suggesting population pressure, and of fertilizer, where recommended rates may warrant revision. Second-stage regressions show that large families are more inefficient, whereas farmers with better access to input markets, and those who do less off-farm work, tend to be more efficient. The information on the sources of inter-farm performance differentials could be used by the extension agents to help inefficient farmers. There is little excuse for such sub-optimal use of survey data, which are often collected at substantial costs.

Wadud (2000) studied on Farm household efficiency in Bangladesh: a comparison of stochastic frontier and DEA methods. This study compare s estimate s of technical efficiency obtained from the stochastic frontier approach and the Data Envelopment Analysis (DEA) approach using farm level survey data for rice farmers in Bangladesh. Technical inefficiency effects are modelled as a function of farm-specific socio economic factors, environmental factors and irrigation infrastructure. The results from both the approaches indicate that efficiency is significantly influenced by the factor s measuring environmental degradation and irrigation infrastructure.

CHAPTER 3
METHODOLOGY

3.1 Introduction

Methodology is an indispensable and integral part of any study. The reliability of a specific study finding depends to a great extent on the appropriate methodology used in the study. Improper methodology very often leads to misleading result. So, careful considerations are needed by an author to follow a scientific and logical methodology for carrying out the study. The author has great responsibility in describing clearly what sorts of method and procedure is to be followed in selecting the study areas, the sources of data and the analyses as well as interpretations to arrive at a meaningful conclusion. This study was carried out by using a primary data collection from selected aman and boro producers in selected areas of Bangladesh for estimation of technical efficiency and profitability of aman and boro production. The methodological framework is presented in this chapter, which consists of three main sub-sections. The first section describes sampling procedure, sample frame, sample size and survey design. Second section describes data collection procedure, formal and informal survey, and primary and secondary data. Data analysis techniques are described in detail in the third section.

3.2 Sampling Procedure

In an empirical investigation it is impossible to collect information from the whole population. Therefore, researchers are often forced to make inferences based on information derived from a representative sample of the population. The size of the sample, and amount of variation, usually affect the quantity and 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 main characteristics of sampling theory applied in this study are discussed below.

3.3 Selection of the Study Region

Selection of the study region is an important 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 survey and the possible cooperation from the farmers" (Yang, 1965). A preliminary survey in Jhalokati Sadar Upazila, Nalchity Upazila, Rajapur Upazila of Jhalokati district was conducted to achieve the objectives of the present study. On the basis of preliminary information were selected purposively because a large number of farmers grow boro and aman rice of ten (10) villages in these Upazila. The other reasons for selecting the study region were as follows:

i. The area represented the same agro-ecological characteristics

ii. These were typical aman and boro rice growing villages with representative soil condition, topography and patterns

iii. Easy accessibility and good communication system existed in the selected villages

iv. Co-operation from the respondents were expected to be high since the researcher was inhabitant of the area and familiar with the local dialect, living experience, beliefs and other socioeconomic characteristics of the area and

v. No socioeconomic study of this type was conducted previously in this area.

3.4 Sampling Technique

In selecting samples for a study two factors need to be taken into consideration. The sample size should be as large as to allow for adequate degrees of freedom in the statistical analysis. On the other hand, administration of field research, processing and analysis of data should be manageable within the limitation imposed by physical, human and financial resources (Mannan, 2001). However, because of diversity in the technical and human environment, it is necessary to sample several numbers of the population before any conclusion can be drawn. Therefore, the purpose of sampling is to select a sub-set of the population that is representative of the population (Rahman, 1998).

It was not possible to include all the farmers in the area studied due to limitation of time, money and personnel. A simple random sampling technique was followed in the present study for minimizing cost, time and to achieve the ultimate objectives of the study.

Ten villages of Jhalokati Sadar Upazila, Nalchity Upazila, Rajapur Upazila of Jhalokati district were selected. The list of farmers, who cultivated aman and boro rice were collected with the help of agricultural extension personnel. A total of 60 farmers including 30 farmers for aman and 30 farmers for boro rice, were randomly selected from the lists. Thus the selected farmers were interviewed to achieve the ultimate objectives of the study.

3.5 Period of Study

Since farming is seasonal one, a farm business survey should cover a whole crop year in order to have a complete sequence of crops. The researcher must determine to what extent the information for a particular year represents normal or average conditions, particularly for crop yields, annual production and price level. Farmers generally plant aman from mid-June to July and harvest after three months and boro rice cultivation begins at January-February and ends in mid-April-May. The data collection period, therefore, pertained this period of 2018. Besides these, secondary data were collected from different published and un-published sources to fulfill of the objectives of the study.

3.6 Preparation of Survey Schedule

A set of comprehensive survey schedule was set to collect necessary information from the farmers in such a way that all the factors in the production of aman and boro rice could be included in conformity with the objectives of the study. As the survey mainly depends on the preparation of the survey schedule, it was, therefore, pretested to verify the relevancy of the question and nature of response of the respondents. The necessary adjustments were made and a final survey schedule was developed.

3.7 Data Collection

Primary data has been collected by conducting survey of aman and boro rice producers from the selected areas. The fieldwork also involved gathering data on aman and 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 aman and 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 aman and boro producers.

3.8 Accuracy of the Data

Adequate measures were taken during the period of data collection to minimize the possible errors. The measures taken were-

3.8.1 Built-in-check in the interview schedule;

3.8.2 Field checking; and

3.8.3 Independent re-interviewing of the respondents.

In case of any inconsistency and lapses, the neighboring farmers were asked for necessary verification and data were checked and corrected through repeated visits. In order to ensure consistency and reliability of the parameters being generated out of the data, follow up visits were also made to the field to obtain supplementary information.

3.9 Processing, Editing and Tabulation of Data

The collected data were checked and verified for the sake of consistency and completeness. Editing and coding were done before putting the data in computer. All the collected data were summarized and scrutinized carefully to eliminate all possible errors. Data were presented mostly in the tabular form, because it was of simple calculation, widely used and easy to understand.

Besides, functional analysis was also adopted in a small scale to arrive at expected findings. Data entry was made in computer and analysis was done using the concerned software Microsoft Excel and statistical package FRONTIER 4.1 (Coelli, 1996).

3.10 Analytical Technique

To meet particular research objectives, several 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. Percentage and arithmetic mean or average were employed to analyze data and to describe socioeconomic characteristics of aman and boro rice growers, input use, costs and returns of aman and boro rice production and to calculate undiscounted Benefit Cost Ratio (BCR).

3.10.1 Gross Margin

Gross margin has given an estimate of the difference between total revenue and variable cost.

That is,

GM = TR-VC

Where,

GM = Gross margin

TR = Total return

VC = Variable cost

Gross margin is widely used in short run analysis and farm planning. This analysis is easily understandable for its simplicity. Per hectare total return was calculated by multiplying per hectare total amount of product by annual average farm gate price.

3.10.2 Net Return

Net return analysis considered fixed cost; cost of land rent, interest on operating capital, etc. So per hectare net return was determined by subtracting per hectare total cost (variable cost and fixed cost) of production from per hectare total return. To determine the net returns of aman and boro rice production the following equation was used in the present study:

$$\pi = PrQr + PbQb - \Sigma\,(Pxi.Xi) - TFC$$

Where,

Π = Net return (Tk. /ha)

Pr = per unit price of the product (Tk. /kg)

Qr = Quantity of the product (kg/ha)

Pb = per unit price of by-products (Tk. /kg)

Qb = Quantity of by-products (kg/ha)

Pxi = per unit price of the ith (Variable) inputs (Tk. /kg)

Xi = Quantity of the ith inputs (kg/ha)

i = 1, 2, 3……… n (number of inputs)

TFC = Total fixed cost

3.10.3 Functional Analysis

Apart from the tabular analysis, the functional technique was also followed in this study. Cobb-Douglas production function model was used to estimate the effects of key variables. This model was proved the best-fit and more reliable on theoretical and econometric aspects in real world situation.

For aman, the model specification was as follows:

Yi = α X1i β1 X2i β2X3i β3 X4i β4 X5i β5 X6i β6 e ui

By taking log in both sides the Cobb-Douglas production function was transformed into the following logarithmic form because it could be solved by the Ordinary Least Square (OLS) method:

$$\ln Y_i = \ln \alpha + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + u_i$$

Where,

Y = Gross return (Tk. /ha)

α = Constant or intercept of the function

X_1 = Seed cost (Tk. /ha)

X_2 = Human labor cost (Tk. /ha)

X_3 = Irrigation cost (Tk. /ha)

X_4 =Urea cost (Tk. /ha)

X_5 = TSP cost (Tk. /ha)

X_6 = MOP cost (Tk. /ha)

ln = Natural logarithm

i = 1, 2, 3………, n (n=30)

e = Base of natural logarithm

u_i = Error term

$\beta_1, \beta_2 \ldots\ldots\ldots \beta_6$ = Coefficient of respective variables.

For boro rice the model specification was as follows:

$$Y_i = \alpha X_{1i}^{\beta_1} X_{2i}^{\beta_2} X_{3i}^{\beta_3} X_{4i}^{\beta_4} X_{5i}^{\beta_5} X_{6i}^{\beta_6} X_{7i}^{\beta_7} e^{u_i}$$

By taking log in both sides the Cobb-Douglas production function was transformed into the following logarithmic form because it could be solved by the Ordinary Least Square (OLS) method:

$$\ln Y_i = \ln \alpha + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \beta_7 \ln X_{7i} + u_i$$

Where,

Y = Gross return (Tk. /ha)

α = Constant or intercept of the function

$X1$ = Seed cost (Tk. /ha)

$X2$ = Human labor cost (Tk. /ha)

$X3$ = Irrigation cost (Tk. /ha)

$X4$ = Urea cost (Tk. /ha)

$X5$ = TSP cost (Tk. /ha)

$X6$ = MOP cost (Tk. /ha)

$X7$ = Insecticides and pesticides cost (Tk. /ha)

ln = Natural logarithm

i = 1, 2, 3………, n (n=30)

e = Base of natural logarithm

ui = Error term and

β1, β2............ *β7* = Coefficient of respective variables.

3.11 Major Cost Items

In this section an attempt has been made to estimate the costs and returns of aman and boro rice production. To estimate the net returns of aman and boro rice production, it is essential to estimate the actual costs and returns in appropriate procedures. Input used in the study area were both purchased and family supplied. Thus, the total production costs consisted of cash and non-cash expenses farmers had to pay cash for the purchased inputs like hired labour, seeds, fertilizers, insecticides, fertilizers, irrigation charge, etc. It was easy to calculate the costs of these items. On the other hand, no cash was actually paid for home supplied inputs like family labour, tools and equipment, manures etc. In these cases, family supplied labour costs were estimated by applying the opportunity cost principle Opportunity cost of an item is defined as an income, which an input is capable of earning in an alternative employment in or outside the farm (Bishop and Toussaint, 1958). The input items were valued at the existing market price in the area during survey period or the prices at which the farmers really bought the inputs.

A list of cost items and their estimation procedure has been discussed under the following heads:

(a) Seed cost

(b) Human labour cost

(c) Fertilizer cost

(d) Manures cost

(e) Irrigation cost

(f) Insecticides and pesticides cost

(g) Tillage cost

(h) Tools and equipment cost

(i) Interest on operating capital and

(j) Land use cost.

3.11.1 Cost of Seed

In the selected study region, the farmers used both family supplied and purchased seeds and seedlings of aman and boro rice. Family supplied seed were priced at the prevailing market price and the costs of purchased seed were priced on the basis of actual price paid by the farmers in the study region.

3.11.2 Cost of Human Labor

The most essential input in all kinds of production is human labour. It was mentioned that aman and boro rice production was labour intensive. Human labour was required for different operations like seed bed preparation, seedling preparation, land preparation, manuring, weeding, irrigating, harvesting and so on. It was classified into two categories, family labour and hired labour. Family labour consists of the farm operator himself and other family members. In determining family labour cost, actual man-days devoted by the workers were taken into account. Eight hours of work were equivalent to one man-day. Family labour cost was calculated by applying the principle of opportunity cost. The average wage of the hired labour was taken as the opportunity cost of the family labour.

In pricing the labour no discrimination was made between the family and the hired labour. Family labour was priced at the prevailing wage paid in cash to hired labour. There was no fixed wage rate all over the season and different wage rates were found for different activities in different seasons.

3.11.3 Cost of Fertilizer

In the selected study region farmers used different kind of fertilizers for higher yield of aman and boro rice. They normally used Urea, Triple Super Phosphate (TSP), Murate of Potash (MoP), Di-Ammonium Phosphate (DAP) and Gypsum. Fertilizer costs represented the actual prices paid by the farmers including all incidental charges.

3.11.4 Cost of Manure

In the study region, farmers used cow-dung as manure in their aman and boro rice production. A large quantity of manure was supplied from the farmers' home. While some farmers bought cow- dung from the milk producers. The cost of cow-dung was priced at the prevailing market price.

3.11.5 Cost of Irrigation

In the study region most of the farmers used irrigation water for their aman and boro rice production. Shallow tube-well irrigation was widely applied in the study area. Some farmers had their own shallow tube-well to irrigate their crop field, while others bought irrigation water from the shallow tube-well owners. In the study area, only one payment system was practiced; under this system farmer’s had to pay cash taka for irrigation water charge per unit of land. Irrigation cost was estimated as the actual amount of money paid by the farmers in cash.

3.11.6 Cost of Insecticides and Pesticides

In the study region, most of the farmers used insecticides and pesticides for cultivation of aman and boro rice. Commonly used insecticides and pesticides were Thiovit, Furadan, Heptachlor, Dimecrone, Nogos, etc. The cost of insecticides and pesticides represented the amount of money, which the farmers actually paid to buy the items.

3.11.7 Tillage Cost

In the study region, all the sample farmers used power tiller for land preparation. They mainly used hired power tillers. A power tiller owner supplied fuel as well as driver for land preparation and laddering. Farmers used to pay a fixed rate as service charge for using power tiller. Generally, farmers used no passes for preparing aman land and five to six passes for preparing boro rice land. The wage rate of power tiller was considered as the actual amount of money paid by the farmers in cash. Aman Farmers used human labour for cleaning and laddering their land.

3.11.8 Interest on Operating Capital (IOC)

Interest on operating capital was determined by taking all costs incurred on various operations in the process of cultivation of aman or boro rice excluding those for which interest was already calculated. Interest on operating capital was charged at the rate of 10 percent per annum and was estimated for the duration of six months for aman and boro rice. It was assumed that if the farmers borrowed the money from a bank, they had to pay interest at the same rate. It was estimated by using the following formula:

Interest on operating capital = AIiT

Where,

AI= (Total investment)/ 2

i = Rate of interest

T = Total time period of a cycle

The period of crop cultivation was considered from the time of land preparation to harvest. The interest actually means the average operating costs over the period as all the costs were not incurred at the same time, rather these were used throughout the production period from beginning to the end.

3.11.9 Land Use Cost

Land use cost varied from village to village depending upon the soil type, topography, location and security of the particular crop field.

Land use cost may be calculated using one of the following concepts:

a) Interest on the value of land

b) Valuation of land at its cash rental price per year and

c) Forgoing income from the alternative use.

The second method is the most popular. So, it was used in the present study.

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 essential to understand the location, physical features and topography, soil type, temperature, rainfall, agricultural and economic condition, population, education and other socioeconomic infrastructure available in the area. This chapter aims at present the above-mentioned characteristics of the study area.

4.2 Location

The study was conducted on some villages of three Upazila namely Sadar Upazila, Nalchity Upazila, Rajapur Upazila of Jhalokati district. Nalchity Upazila, Rajapur Upazila are 21 km and 21.5 km respectively from the Jhalokati sadar.

Jhalokati district is bounded on the north and east by Barisal district, on the south by Barguna district and on the west by Pirojpur district. It lies between 22° 20' and 22° 47' north latitudes and between 90°01' and 90° 23' east longitudes. The total area of the district is 706.76 sq. km (272.88 sq. miles). The location of the study area is shown in Map 4.1.

4.3 Physical Features, Topography and Soil Type

The Jhalokathi district is consist of two agro-ecological zones: Ganges Floodplains (12) and Ganges Tidal Floodplains (13). The higher ridges of Ganges Tidal Floodplains (13) are not inundated in the rainy season while the lower ridges and bills are inundated in the rainy season easily. The district is divided into 8 soil groups based on different physical and chemical properties of the soils such as color, texture, consistency, pH, drainage etc.The soil groups are Sara, Gopalpur, Ramgati, Jhalokathi, Barishal, Betagi, Pirojpur, Tidal Alluvium. The dominant texture of the soils of the area is loam, clayey and clay loam.

The drainage condition also varies from one soil group to another soil group. But, the drainage condition of the soils of the area is not good and that ranges from somewhat poorly drained to very poorly drained. The pH of the soils can be neutral, slightly alkaline and slightly acidic. The soil color also varies from one soil group to another. The soil color can be determined by using Munsell Color Chart. The scale of the map that is prepared by SRDI is 1: 50000 and the longitude of the map is from 90°06′E to 90°17′E and the latitude is 22°35′N to 22°47′ N. The land type of the Upazila is actually medium highland to highland. But, the area of medium highland is pretty much higher than the highland of the district.

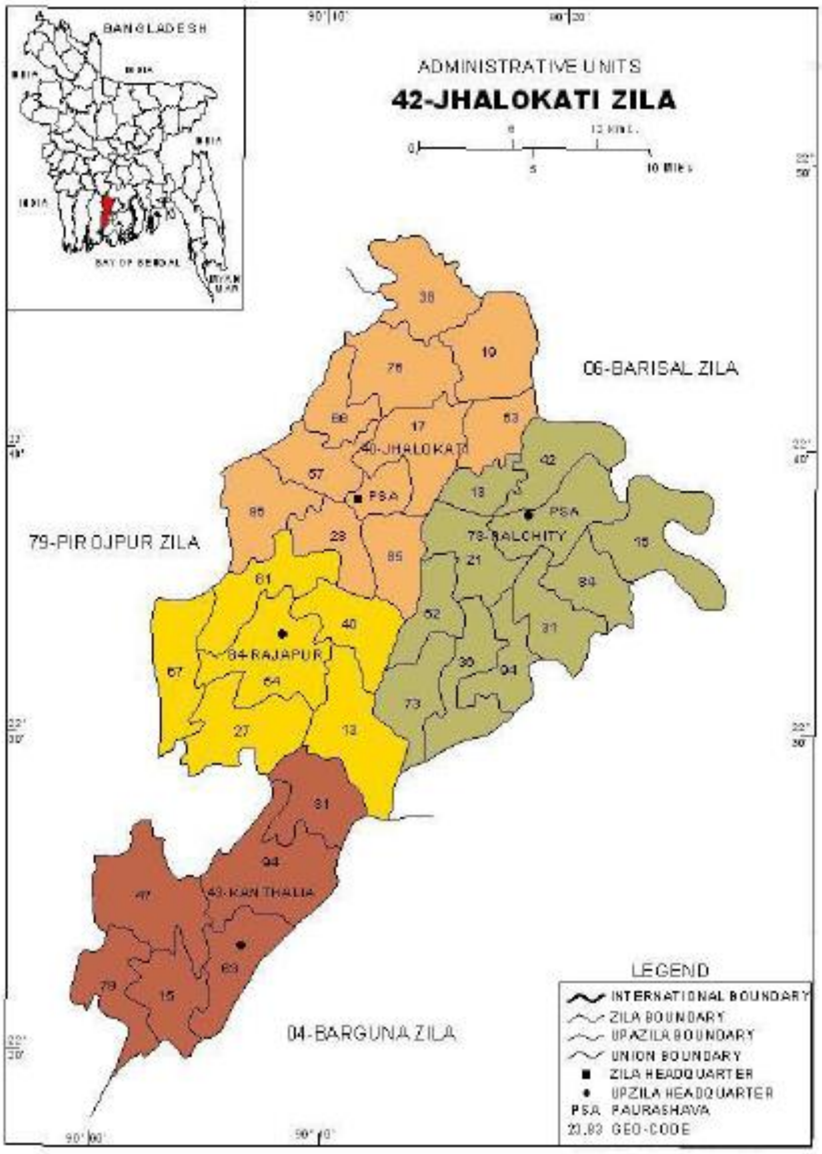

Figure 4.1: Map of Jhalokati

4.4 Area, Population and Household

Jhalokati district is bounded on the north and east by Barisal district, on the south by Barguna district and on the west by Pirojpur district. It lies between 22o20' and 22o47' north latitudes and between 90o01' and 90o23' east longitudes. The total area of the district is 706.76 sq. km (272.88 sq. miles). Jhalokati subdivision was established in 1972 and was turned into a district in 1984. The district consists of 4 upazilas, 32 unions, 396 populated mauzas, 455 villages, 2 paurashavas, 18 wards and 68 mahallas. The upazilas are Jhalokati Sadar, Kanthalia, Nalchity and Rajapur.

Table 4.1: Area, Population and Household in the Study Area

Study Area	Area (sq. km)	Population (000)	Household
Jhalokati	159.45	216348	50315
Nalchity	231.4	193556	43066
Rajapur	164.58	148494	33903

Source: Field Survey, 2018

According to the Population Census 2011, number of households in Jhalokati district is 158139 which is 1.18 percent of total households of the country. The density of population is 966 per sq. km. The percentage of male and female is 50.06 and 49.94, respectively. And total population is 613750. (BBS, 2017).

4.5 Climate

This city has a tropical climate. The summers here have a good deal of rainfall, while the winters have very little. The average annual temperature in Jhalokati is 26.0 °C. The rainfall here averages 2165 mm.The annual average maximum and minimum temperature in Jhalokati district varies from 33.3°C to 12.1°C. The annual average rainfall of this district is 2506 mm. The temperatures are highest on average in May, at around 30.1 °C. January is the coldest month, with temperatures averaging 19.1 °C.

The variation in the precipitation between the driest and wettest months is 437 mm. Throughout the year, temperatures vary by 11.0 °C.

Table 4.2: Temperature, rainfall, humidity during the year 2013-2016

Years	**Temperature (centigrade)**		**Rainfall (millimeter)**	**Humidity (%)**
	Maximum	Minimum		
2013	25.0	10.9	1990	79.2
2014	34.7	10.8	1220	66.2
2015	34.4	13.1	1837	79
2016	34.2	11.2	1850	81

Source: Bangladesh Meteorological Department

4.6 Agriculture and Economic Condition

Agriculture work signifies all activities of holder and his/her labour force doing planning, management, and operation of a holding.

Main Crops: Transplanted Aman is the major rice crop preceded by aus and boro on more than half the area. Other crops include khesari, masur, mong, sesame, chilies, gram, jute, sweet-potato, turmeric, onion, aman, mustard, and potato and betel leaf.

Main Fruits: The most common fruits are found in this area is mango (*Mangifera indica*), jackfruit (*Artocarpus heterophyllus*), black berry (*Syzygium cumini*), banana (*Musa sapienrum*) and amra (*Spondia pinnata*). The most characteristic feature of the landscape is undoubtedly the palm, the commonest species being the country date or khejur (*Phoenix sylvestris*), the betelnut palm (*Arca catechu*), the coconut palm (*Cocos nucifera*) and the palmyra palm (*Borassus flabellifer*).

The economy of Jhalakati is predominantly agricultural. Out of total 133,204 holdings of the district, 96616 holding are farms that produce varieties of crops namely local and HYV rice vegetables, spices, cash crops, pulses, oilseeds, betel leaves and others. Various fruits like banana, guava, coconut, etc. are grown. Guava is grown in the northern part of the Jhalakati sadar upazila.

Fish of different varieties abound in this district. Varieties of fish are caught from rivers, tributary channels and creeks and even from paddy fields during rainy season. Some prawn and Hilsha fish are available in the district. Various types of timber and forest trees are grown in this district.

4.7 Occupation

Jhalakati is famous for business center for different kinds of consumable goods and agriculture. Non-farm activities are also significant in this district.

Table 4.3: Number of Establishments and Population Engaged by Activity

Activity	**Establishments**			**Persons Engaged**		
	Total	**Urban**	**Rural**	**Total**	**Male**	**Female**
Mining and quarrying	0	0	0	0	0	0
Manufacturing	1159	255	904	4729	4386	343
Electricity, gas and water supply	6	4	2	46	44	2
Construction	3	3	0	8	8	0
Wholesale & retail trade	8704	3061	5643	15232	14982	250
Hotels and restaurants	1881	446	1435	4063	3923	140
Transport, storage and communication	142	29	113	346	335	11
Bank, insurance and financial institution	194	108	86	1457	1360	97
Real estate and renting	268	192	76	503	495	8
Public administration and defence	200	144	56	1311	1259	52
Education	1087	97	990	7202	6114	1088
Health and social works	227	73	154	837	686	151
Community, social and personal services	3283	521	2762	5567	5337	230

Source: Census of Economic Activities 2011-2013

The following table-1 shows total establishments in the urban and rural areas and persons engaged by sex and activity in Jhalakati.

According to the above table, there are 17,152 establishments in the district in which 41,301 persons are engaged in different types of non-farm activities. Female participation in non-farm activities is very poor. They constitute about 5.74 % as against 94.26 % of the males. Wholesale & retail trade emerges as the single largest activity (50.75%) with 8704 establishments and 15,232 persons engaged (36.88%) in Jhalakathi district.

4.8 NGO Activities

Operationally important NGOs are BRAC, ASA, CARE, Abirvab, Annesha, JDS, Parshi, South Bengal Development Society, Social Welfare Organisation, Popular Development Society, CIDA, Proshika, Palli Unnayan Sangstha etc.

4.9 Transport, Communication and Marketing Facilities

Palanquin, boat and bullock-cart are the traditional transports found in the rural area of Jhalokati district. These means of transport are either extinct or nearly extinct. Now-a-days, all the upazilas are connected with the district headquarters with metaled roads. Bus, minibus, three wheelers ply over the district. Farmers carry their product mainly by van and by hackney carriage. There are some local bazaars and big hats in the study area and around the study area. The hats are operated twice a week on different days. Farmers sell their product directly to those markets.

4.10 Concluding Remarks

From the above discussions it is found that the location of the study area near to the district. Physical features and topography, soil type, temperature and rainfall are favourable for cultivating boro and aman rice. Therefore, various types of agricultural crops were cultivated in the study area. Communication are good for marketing of agricultural crops.

CHAPTER 5

SOCIO-ECONOMIC CHARACTERISTICS OF SAMPLE FARMERS

5.1 Introduction

The aim of this chapter is to present a brief description of the socio-economic characteristics of the farmers producing aman and boro. Socioeconomic aspects of the farmers can be looked upon from different points of view depending upon a number of variables related to their level of living, 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 farmers due to limitation of time and resources. Socioeconomic condition of the sample farmers is very important in case of research planning because there are numerous interrelated and constituent attributes characterizes an individual and profoundly influences development of his/her behavior 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.

5.2 Composition of the Family Size

Family size is significant in connection to generation of enough nourishment grain for ranch family. In this study family has been characterized as the all-out number of people living respectively and taking meals from a similar kitchen under the influence of one leader of the family. The relatives considered as spouse, children, unmarried little girl, father, mother, sibling and different relatives who live for all time in the family.

Table 5.1: Average Family Size and Distribution of Members According to Sex of the Sample Farmers

Particulars	**Aman Rice Growers**		**Boro Rice Growers**		**All Farmers**		**National Average Family Size**
	Number	Percent	Number	Percent	Number	Percent	
Male	2.43	58.98	2.87	59.79	2.65	59.42	4.06
Female	1.69	41.02	1.93	40.21	1.81	40.58	
Total	4.12	100	4.8	100	4.46	100	

Source: Field Survey, 2018

5.3 Age Distribution of the Farm Families

Age of aman and boro rice farm family members was calculated from their birth to the time of the interview. Farm family members were grouped into three categories according to their ages (Table 5.2). In case of amon, it can be seen from the table that 6.67 percent family members belonged to the age group below 15 years, 73.33 percent family members were in the age group between 15 -59 years and only 20 percent of the family members were above 59 years of age. In case of boro rice, it can be seen from the table that 8.33 percent family members belonged to the age group below 15 years, 68.33 percent family members were in the age group between 15-59 years and only 23.33 percent of the family members were above 59 years of age. In both aman and boro rice farm families the highest number of family members were in the age group between 15 to 59 years and the lowest number of family members belonged to the age group of above 59 years (Table 5.2).

Table 5.2: Distribution of Family Members by Age Groups

Particulars	**Aman Rice Growers**				**Boro Rice Growers**		**All Farmers**
	Number	Percent	Number	Percent	Number	Percent	
Below 15	2	6.67	3	10	5	8.33	
15-59	22	73.33	19	63.33	41	68.33	
Above 59	6	20	8	26.67	14	23.33	

Total	30	100	30	100	60	100

Source: Field Survey, 2018

5.4 Educational Status of Farm Families

Education has its own merits and it contributes to economic and social development, as 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. It helps person to make right decision regarding his farm business. It makes a man more capable of managing scarce resource and hence to earn maximum profit (Miah, 1990). The educational status of aman and boro rice farm family members is given in Figure 5.1.

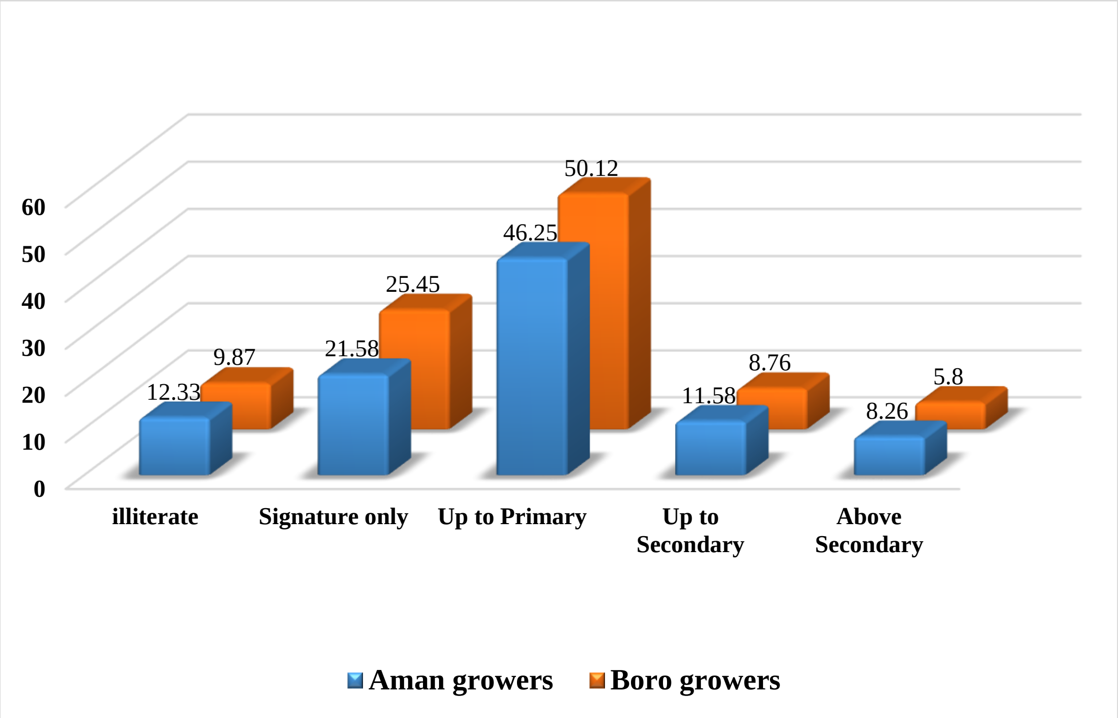

Figure 5.1: Educational Status of the Farm Families
Source: Field Survey, 2018

In case of aman families, it can be seen from the figure 5.1, that 12.33 percent family members were illiterate, 21.58 percent were capable to sign, 46.25 percent had primary education, 11.58 percent had secondary education and 8.26 percent had higher secondary education and above.

In case of boro rice farm families, it can be seen from the above figure that 9.87 percent family members were illiterate, 25.45 percent were capable to sign, 50.12 percent had primary education, 8.76 percent had secondary education and 5.8 percent had higher secondary education and above. Moreover, it was found that literacy rate of aman and boro rice farm families was 87.67 percent and 90.13 percent, respectively.

5.5 Occupational Status of the Sample Farmers Family

The occupation of the study population aged 16 years or more showed that, in aman season, about 59 percent were engaged in agriculture as a main occupation and about 25 percent were engaged in agriculture as a subsidiary occupation.

On the other hand, boro season, about 68 percent were engaged in agriculture as a main occupation and about 12 percent were engaged in agriculture as a subsidiary occupation (Figure 5.2**)**. Household activities and study are not directly included in Gross Domestic Product (GDP).

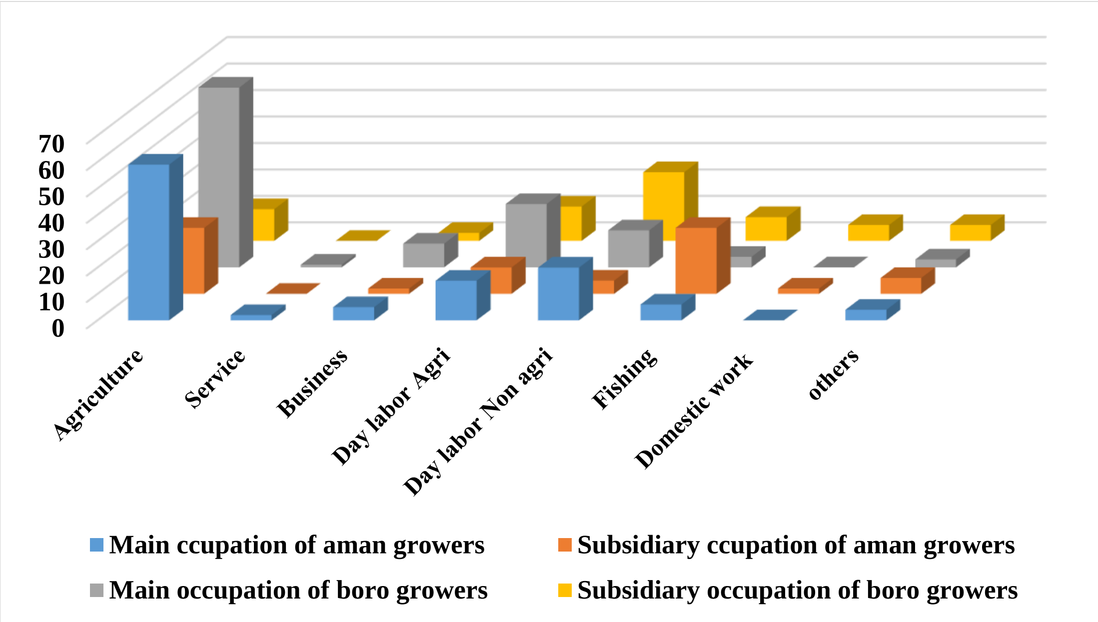

Figure 5.2: Occupation of the Household Members by Occupational Category

Source: Field Survey, 2018

5.6 Agricultural Training

Among the respondent farmers of anan rice, only 23.33 percent farmers' got training on different agricultural technologies of aman rice whereas, 76.67 percent farmers have no idea about training on different agricultural technologies. On the other hand, 60 percent of respondent farmer got training on boro rice production whereas, (Table 5.3). These training have improved their perceptions of good seed use, use of resistant varieties, application of insecticides and pesticides, water management, and so on.

Table 5.3: Agricultural Training of the Respondent Farmers by Crop

Membership in any organization	**Aman Rice Growers**		**Boro Rice Growers**	
	No.	%	No.	%
Yes	23	76.67	25	83.33
No	7	23.33	5	16.67
Total	30	100	30	100

Source: Field survey, 2018.

5.7 Membership

Among the respondent farmers, 76.67 percent aman rice growers were found to have membership in different NGOs and/or farmers' organizations whereas 83.33 percent of boro rice growers had membership in different NGOs and/or farmers' organizations (Table 5.4).

Table 5.4: Membership of the Respondent Farmers by Crop

Membership in any organization	**Aman Rice Growers**		**Boro Rice Growers**	
	No.	%	No.	%
Yes	23	76.67	25	83.33
No	7	23.33	5	16.67
Total	30	100	30	100

Source: Field survey, 2018.

5.8. Annual Family income

a) Agricultural work

Sector	Average annual Income	Mean
Crops	69458.58	159275.75
Poultry	21458.67	
Animal Production	16758.5	
Fisheries	51600	

Crops, poultry, animal production and fisheries are the main agricultural income source of the sample. Most of the framer generate in by agriculture sector. Crop production was the main source of income among them average yearly income from crop production found TK 69458.58. Now a day’s fisheries has been developed in the study area. Farmers Tk 51600 yearly income from poultry. The mean value of annual family income by agriculture was Tk 159275.75.

b) Non-Agriculture work

Main non agriculture was found day labor, Auto driver, manufacturing, domestic worker, construction, small business, foreign remittance, services. Annual average income by non-agriculture source was found Tk 1, 25,171.4. The total average annual income was found Tk 2, 84,447.15.

5.9. Annual Family Expenditure

Sample farmer, annual average expenditure was found Tk2, 45,889.6. Main family expenditure was use for food consumption. Others main cost were child’s education cost, clothing cost, medicine cost transportation, festival cost, entrainment cost etc Average annual family savings was found Tk 38557.55.

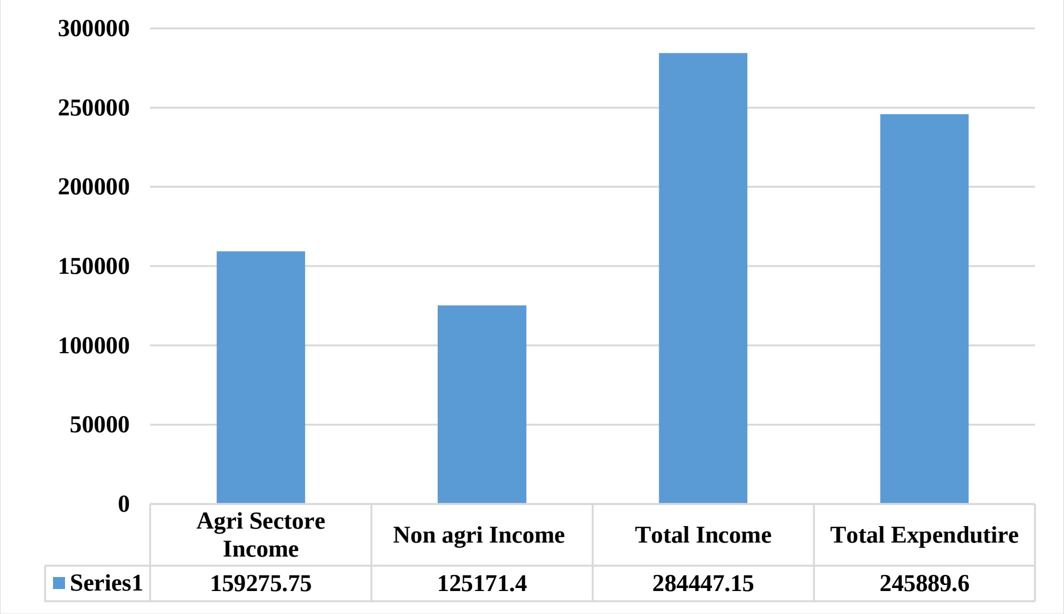

Figure 5.3: Annual Family Income and Expenditure by Study Area
Source: Field survey, 2018

5.10 Concluding Remarks

From the above discussions it is clear that there are some variations in socioeconomic characteristics between the aman and boro rice growers. But the magnitude of the variations was not large. There are substantial indications suggesting that both aman and boro rice growers were progressive.

CHAPTER 6
RESULTS AND DISCUSSION

6.1 Introduction

The costs, returns and profitability of aman and boro rice production are projected in this section. For calculating the costs and returns of aman and boro rice 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, tillage, fertilizer and manure, irrigation water 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 of aman and boro rice varies depending upon the quality and availability of seeds. It can be seen from Table 6.1 that per hectare use of aman seed was 58.27 kg and average cost of aman seed per hectare was estimated Tk. 4193. Per hectare use of boro rice seed was 54.53 kg and average cost of rice seed per hectare was estimated Tk. 5138.7 (Table 6.2). Seed cost constituted 7.07 and 5.12 percent of total cost of producing aman and boro rice, respectively. It was clear that cost of seed was relatively higher for aman than that of boro rice.

6.2.2 Cost of Human Labour

Human labour was the most important and largely used input in producing both aman and boro rice production. It shared a large portion of total cost of aman and boro rice production. It can be seen from Table 6.1 that the amount of human labour used for aman cultivation was 64 man-days per hectare. While this was 105 man-days per hectare for boro production (Table 6.2). Total cost of human labour was estimated Tk. 22400 and Tk. 36750 covering 37.76 and 40.11 percent of total cost of aman and boro rice production, respectively (Table 6.1and Table 6.2).

6.2.3 Cost of Fertilizer

It was found that farmers used different kind of fertilizers in producing their enterprises. Commonly used fertilizers were Urea, TSP, MOP, Gypsum. There were some variations in the application of fertilizers between enterprises. It can be seen from Table 6.1 that per hectare use of Urea, TSP, MOP and Gypsum for aman production were 186 kg, 73 kg, 12 kg, whose costs were estimated at Tk. 3720, Tk. 2190, Tk. 240 and Tk. 150, respectively. Per hectare use of Urea, TSP, MOP and Gypsum for boro production were 259 kg, 126.5 kg, 112.8 kg and 39.1 kg whose costs were Tk. 5180, Tk. 3795, Tk. 2256 and Tk. 469.2, respectively (Table 6.2). It was found that farmers paid the highest percentage (51 percent) of fertilizer cost for Urea and lowest percentage (2 percent) of fertilizer and manure cost for Gypsum for aman production (Figure 6.1) and they paid the highest percentage (38 percent) of fertilizer cost for TSP and lowest percentage (3.5 percent) of fertilizer and manure cost for Gypsum for boro rice production (Figure 6.2).

6.2.4 Cost of Manure

It was observed in the present study area that farmers used cow dung for producing their enterprises. They bought a large portion of cowdung from the milk producers. It was found that cow dung application was 100 var and 170 var per hectare for aman and boro rice production, respectively. And the cost of cowdung for aman and boro rice production was Tk. 1000 and Tk. 1700 (Table 6.2).

6.2.5 Cost of Irrigation

Irrigation is considered as the leading input of production. Right doses application of irrigation water help to increase bulb diameter, number of cloves, number of leaves, and plant height. As a result, yield per hectare is being increased. It appears from Tables 6.1 and 6.2 that per hectare cost of irrigation water of aman and boro rice production was Tk. 1000 and Tk. 31554.56 covering 1.69 and 21.62 percent of total cost, respectively.

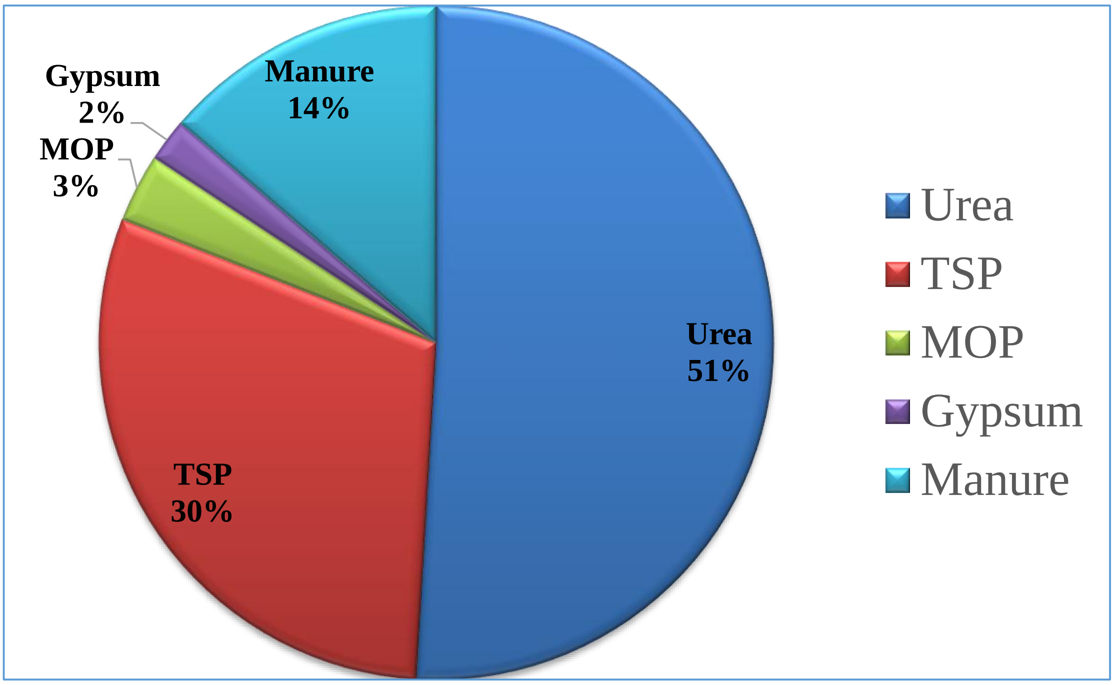

Figure 6.1: Percentage of Fertilizer and Manure Cost for Aman Production
Source: Field Survey, 2018

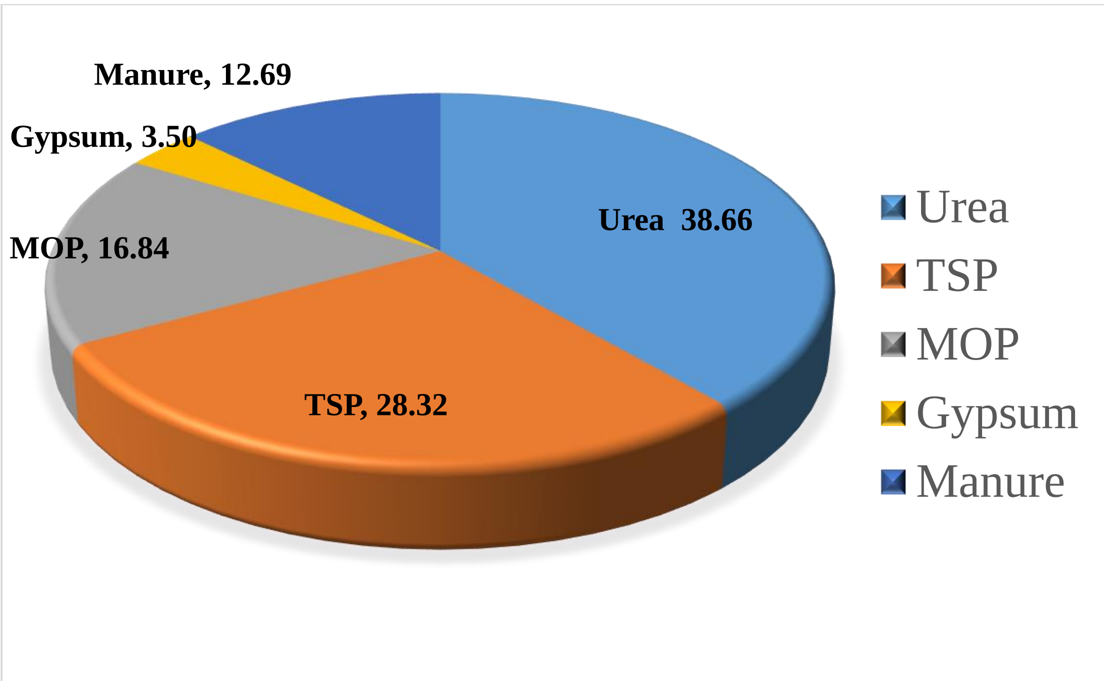

Figure 6.2: Percentage of Fertilizer and Manure Cost for Boro Production
Source: Field Survey, 2018

6.2.6 Cost of Insecticides and Pesticides

Aman and boro rice growers used about same kinds of insecticides and pesticides to keep their crop free from diseases. It was found that per hectare cost of insecticides and pesticides for aman and boro rice production were Tk. 3168 and Tk. 1995.33 covering 5.34 and 1.99 percent of total cost, respectively (Table 6.1 and Table 6.2).

6.2.7 Tillage Cost

In the study area power tiller has widely been used. Table 6.1 and Table 6.2 shows that per hectare power tiller cost of aman and boro rice production was Tk. 4860 and Tk 3146. Tillage cost covered 8.19 percent of total cost of producing aman rice and 3.13 percent of total cost of producing boro rice.

6.3 Fixed Costs

6.3.1 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 aman and boro rice. Per hectare interest on operating capital was Tk. 1574 and Tk. 2380 for aman and boro rice production, respectively (Table 6.1 and Table 6.2).

6.3.2 Land Use Cost

Land use cost was a fixed cost for aman and boro rice production. Average rental value of land per hectare for the study year was considered as land use cost. Per hectare value was estimated at Tk. 14820 for aman and Tk. 28820 for boro rice growers. Land use cost covered 24.99 and 28.70 percent of total cost for aman and boro rice production, respectively (Table 6.1 and Table 6.2).

Table 6.1: Per Hectare Cost and Return of Aman Rice

Cost Items	**Quantity**	**Price Per Unit (Tk.)**	**Costs/Returns (Tk ha-1)**	**% of total**
A. Gross Return				
Main product (Rice)	3917	17.8	69722.6	93.15
By-product (Straw)			5126	6.85
Total return			74848.6	100
B. Gross Cost				
C. Variable Cost				
Seedlings			4193	7.07
Irrigation	2 times	500	1000	1.69
Power tiller	2 times		4860	8.19
labour	64	350	22400	37.76
Urea	186	20	3720	6.27
TSP	73	30	2190	3.69
MOP	12	20	240	0.40
Gypsum			150	0.25
Fertilizers cost			6300	10.62
Manure	100	10	1000	1.69
Insecticides			3168	5.34
Total			42921	72.36
D. Fixed Cost				
land use cost	14820	1	14820	24.99
Interest on operating capital @12%			1574	2.65
Total			16394	27.64
E. Total costs			59315	100.00
F. Gross Margin (A-C)			31927.6	
G. Net Return (A-E)			15533.6	
H. Undiscounted BCR			**1.26**	

Source: Field Survey, 2018

Table 6.2: Per Hectare Costs and Return of Boro

Cost Items	**Quantity**	**Price Per Unit (Tk.)**	**Costs/Returns (Tk ha-1)**	**% of total**
A. Gross Return				
Main product (Rice)	6971	20	139420	98.31
By-product (Straw)			2394	1.69
Total return			141814	100
B. Gross Cost				
C. Variable Cost				
Seedlings			5138.7	5.12
Irrigation	8 times	1100	8800	8.76
Power tiller	2 times	1573	3146	3.13
Hired labour	105	350	36750	36.59
Urea	259.00	20	5180.0	5.16
TSP	126.50	30	3795	3.78
MOP	112.8	20	2256	2.25
Gypsum	39.1	12	469.2	0.47
Fertilizers cost			11700.2	11.65
Manure	170	10	1700.0	1.69
Insecticides			1995.33	1.99
Total			69230.23	68.93
D. Fixed Cost				
Land use cost	28820		28820	28.70
Interest on operating capital @12 %			2380	2.37
Total			31200	31.07
E. Total costs			100430.23	100.00
F. Gross Margin (A-C)			72583.77	
G. Net Return (A-E)			41383.77	
H. Undiscounted BCR			**1.41**	

Source: Field Survey, 2018

6.4 Total Cost

In order to estimate total cost per hectare all the resources used in aman and boro rice production has been recaptured together. It can be seen from Table 6.1 and Table 6.2 that per hectare total cost of production of aman and boro rice were Tk. 59315 and Tk. 100430.23, respectively.

6.5 Yield and Gross Return

Per hectare average yield of aman and boro rice were estimated 3917 kg and 6971 kg, respectively. Gross return per hectare was calculated by multiplying the total amount of products by average farmgate price. By product was included. Per hectare gross return of aman and boro rice were Tk. 74848.6 and Tk. 141814,respectively (Table 6.1 and Table 6.2). Figure 6.3 shows that per hectare gross return of boro was higher than that of aman rice.

6.6 Gross Margin

Gross margin is the gross return over variable cost. Gross margin is obtained by deducting total variable cost from gross return. Per hectare gross margin was estimated Tk. 31927.6 and Tk. 72583.77 for aman and boro rice, respectively (Table 6.1 and Table 6.2). It is evident from Figure 6.3 that gross margin of aman was higher than that of boro rice.

6.7 Net Return

Net return is a very useful tool to analyze or compare performance of enterprises. It is calculated by subtracting total cost from total return. Per hectare net return of aman and boro rice were Tk. 15533.6 and Tk. 41383.77, respectively (Table 6.1 and Table 6.2). Figure 6.3 shows that per hectare net return of aman was higher than that of boro rice.

6.8 Benefit Cost Ratio (Undiscounted)

Benefit cost ratio (BCR) is a relative measure, which is used to compare benefit per unit of cost. In the study, BCR of aman and boro rice was calculated as a ratio of gross return and gross cost. Undiscounted Benefit cost ratio of aman and boro rice production per hectare came out to be 1.26 and 1.41 respectively, which implies that Tk. 1.26 and Tk. 1.41, respectively for corresponding crop will be achieved by expending every Tk. 1.00 (Table 6.1 and Table 6.2).

6.9 Comparative Profitability of Aman and Boro Rice

In this section, a comparison has been made to assess per hectare relative profitability of growing aman and boro rice. The summary results having per hectare yield, gross return, gross margin, net return and BCR of aman and boro rice were presented in Table 6.3. It is evident that both aman and boro rice enterprises were profitable. Moreover, boro rice cultivation was more profitable than aman rice cultivation (Table 6.3 and Figure 6.3).

Table 6.3: Comparative Cost and Return of Aman and Boro Rice Farming

Particulars	**Aman Rice (Per ha)**	**Boro Rice (Per ha)**
Average Yield (KG)	3917	6971
Gross return (TK)	74848.6	141814
Total variable cost (TK)	42921	69230.23
Fixed Cost (TK)	16394	31200
Total Cost (TK)	59315	100430.23
Gross Margin (TK)	31927.6	72583.77
Net Return (TK)	15533.6	41383.77
BCR(Undiscounted)	**1.26**	**1.41**

Source: Field Survey, 2018

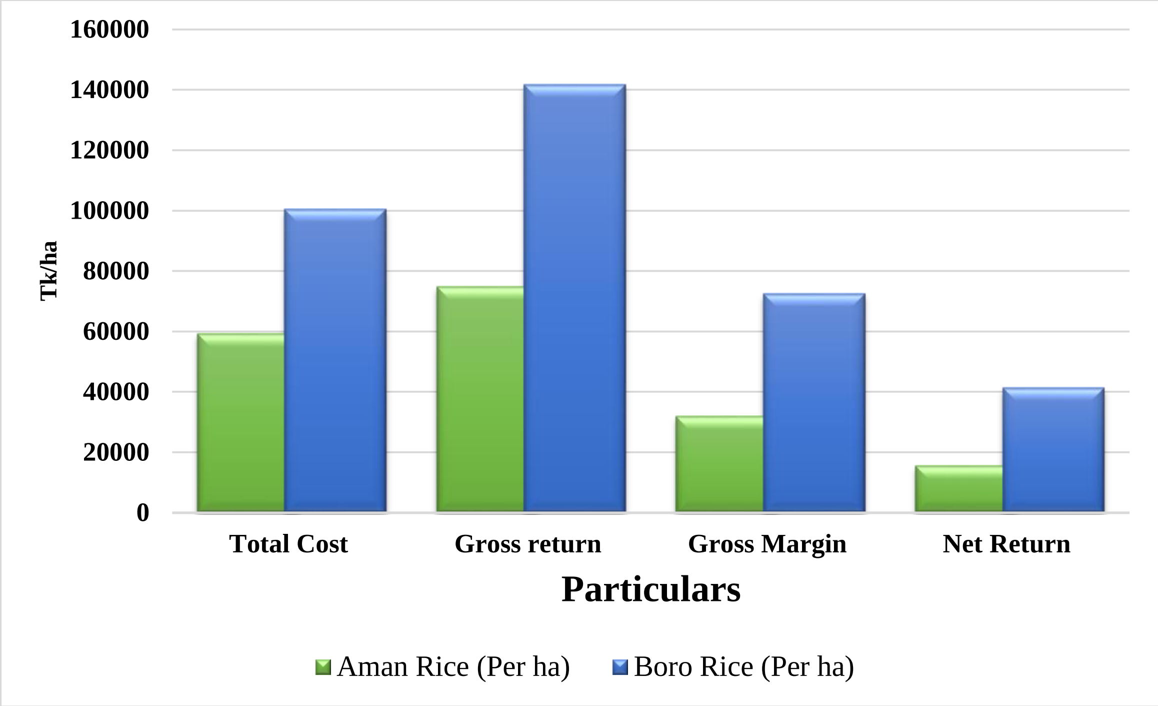

Figure 6.3: Gross Cost, Gross Return, Net Return and Gross Margin of these Crops
Source: Field Survey, 2018

6.10 Concluding Remarks

On the basis of above discussions, it could thoughtfully be concluded here that cultivation of both aman and boro rice were found profitable. However, cultivation of boro was estimated more profitable than that of aman rice. Cultivation of boro other than would help growers to increase their income.

CHAPTER 7

MAJOR FACTORS AFFECTING THE PRODUCTION PROCESSES OF AMAN AND BORO RICE

7.1 Introduction

The focus of this chapter to identify and assess the effects of some important variables of production on gross return of aman and boro rice in the framework of production function analysis. For the purpose Cobb-Douglas production function model, as stated in Sub-section 3.9.3, has been chosen to determine the effects of selected variables on aman and boro rice production.

7.2 Functional Analysis

Production function is a relation (or mathematical function) specifying the maximum output that can be produced with given inputs for a given level of technology. It applies to a firm or as an aggregate production function to the economy as a whole (Samuelson and Nordhaus, 1995).

Considering the effects of explanatory variables on yield of boro rice, seven explanatory variables namely, Seed cost (X1), human labour (X2), Irrigation cost (X3), Urea cost (X4),TSP cost (X5), MOP cost (X6) and Insecticides cost (X7), were chosen as key independent factors to estimate the quantitative effect of inputs on yield of boro rice. And for aman rice insecticide cost were excluded. All these variables have been estimated as per hectare monetary values. However, other important variables such as management, land quality, soil type, sowing time and weather, etc. were excluded in the analysis due to paucity of reliable data.

Another special advantage of using Cobb-Douglas production function was that the regression under OLS in logarithm, yields coefficients which represents partial elasticities of production and if all the inputs related to the production are taken into account, the sum of the elasticities indicates whether the production process as a whole yields increasing, constant or decreasing returns to scale. In fact, it is widely used by many researchers in their economic studies. The advantages of the model are that it is simple to calculate and the elasticity of production can directly be obtained from the coefficient.

For Aman, the following Cobb-Douglas production function was used in the present study:

$$Y_i = \alpha X_{1i}^{\beta 1}\, X_{2i}^{\beta 2}\, X_{3i}^{\beta 3}\, X_{4i}^{\beta 4}\, X_{5i}^{\beta 5}\, X_{6i}^{\beta 6}\, e^{ui}$$

By taking log in both sides the Cobb-Douglas production function was transformed into the following logarithmic form because it could be solved by the ordinary least square (OLS) method:

$$\ln Yi = \ln \alpha + \beta 1 \ln X1i + \beta 2 \ln X2i + \beta 3 \ln X3i + \beta 4 \ln X4i + \beta 5 \ln X5i + \beta 6 \ln X6i + ui$$

For Boro Rice, the following Cobb-Douglas production function was used in the present study:

$$Y_i = \alpha X_{1i}^{\beta 1}\, X_{2i}^{\beta 2}\, X_{3i}^{\beta 3}\, X_{4i}^{\beta 4}\, X_{5i}^{\beta 5}\, X_{6i}^{\beta 6}\, X_{7i}^{\beta 7} e^{ui}$$

By taking log in both sides the Cobb-Douglas production function was transformed into the following logarithmic form because it could be solved by the ordinary least square (OLS) method:

$$\ln Yi = \ln \alpha + \beta 1 \ln X1i + \beta 2 \ln X2i + \beta 3 \ln X3i + \beta 4 \ln X4i + \beta 5 \ln X5i + \beta 6 \ln X6i + \beta 7 \ln X7i + ui$$

Where,

Y = Gross return (Tk. /ha)

α = Constant or intercept of the function

X1 = Seed cost (Tk. /ha)

X2 = Human labor cost (Tk. /ha)

X3 = Irrigation cost (Tk. /ha)

X4 = Urea Cost (Tk. /ha)

X5 = TSP cost (Tk. /ha)

X6 = MOP cost (Tk. /ha)

X7 = Insecticide cost (Tk. /ha) (for boro rice)

β1, β2............ *β7* = Coefficient of respective variables

ln = Natural logarithm

i = 1, 2, 3………, n (n=30)

e = Base of natural logarithm

ui = Error term.

7.3 Estimated Value of the Production Function Analysis

Estimated values of the coefficients and related statistics of the Cobb-Douglas production functions of aman and boro rice are presented in the Table 7.1.

Table 7.1: Estimated Values of Coefficients and Related Statistics of Cobb-Douglas Production Function Model

Exploratory Variables	Aman Rice		Boro Rice	
	Estimated Coefficient	t-value	Estimated Coefficient	t-value
Constant	6.685***	24.6	1.2375	1.06
Seed Cost (X1)	-0.010	-0.55	-0.0051	-0.05
Human Labour Cost (X2)	0.026	0.36	0.140**	1.94
Irrigation Cost (X3)	0.054***	2.95	0.168***	3.25
Urea Cost(X4)	0.099*	1.72	0.0161	0.11
TSP Cost(X5)	0.145**	2.09	0.379***	3.39
MOP Cost(X6)	0.033	1.34	-0.101*	-1.74
Insecticide Cost (X7)	-	-	0.0563	1.51
Return to Scale (Σβi)	0.347		0.654	

Source: Field Survey, 2018

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

7.4 Interpretation of the Results

7.4.1 Aman Rice

Seed Cost (X1): The magnitude of the regression coefficient of seed cost was 0.010 with a negative sign. It was insignificant.

Human Labour Cost (X2): The magnitude of the regression coefficient of labour cost was 0.026 with a positive sign. It was insignificant.

Irrigation Water Cost (X3): It can be seen from Table 7.1 that regression coefficient of irrigation cost was 0.054. It was positive and was significant at 1 percent level. This indicated that an increase in one percent of irrigation cost, remaining other factors constant, would result in an increase in the gross return by 0.054 percent.

Urea Cost (X4): It can be seen from Table 7.1 that regression coefficient of urea cost was 0.099. It was positive and was significant at 10 percent level. This indicated that an increase in one percent of urea cost, remaining other factors constant, would result in an increase in the gross return by 0.099 percent.

TSP Cost (X5): It can be seen from Table 7.1 that regression coefficient of TSP cost was 0.145. It was positive and was significant at 5 percent level. This indicated that an increase in one percent of TSP cost, remaining other factors constant, would result in an increase in the gross return by 0.145 percent.

MOP Cost (X6): The magnitude of the regression coefficient of MOP cost was 0.033 with a positive sign. It was insignificant.

Coefficient of Multiple Determination (R2): It is evident from Table 7.1 that the value of the Coefficient of multiple determination (R2) was 0.90. It indicated that about 90 percent of the variations of the gross returns are explained by the explanatory variables included in the model.

Returns to Scale (Σβi): The summation of all the regression coefficients of the estimated production function of aman was 0.347 (Table 7.1). This implied that the production function exhibits increasing returns to scale. That is, the farmers were operating their aman farming in the first stage of production function. In this case, if all the variables specified in the production function were increased by one percent, gross return would increase by 1.066 percent.

7.4.2 Boro Rice

Seed Cost (X1): The magnitude of the regression coefficient of seed cost was 0.005 with a negative sign. It was insignificant.

Human Labour Cost (X2): It can be seen from Table 7.1 that regression coefficient of human labour cost was 0.140. It was positive and was significant at 5 percent level. This indicated that an increase in one percent of labour cost, remaining other factors constant, would result in an increase in the gross return by 0.140 percent.

Irrigation Water Cost (X3): It can be seen from Table 7.1 that regression coefficient of irrigation cost was 0.168. It was positive and was significant at 1 percent level. This indicated that an increase in one percent of irrigation cost, remaining other factors constant, would result in an increase in the gross return by 0.168 percent.

Urea Cost (X4): The magnitude of the regression coefficient of seed cost was 0.016 with a positive sign. It was insignificant.

TSP Cost (X5): It can be seen from Table 7.1 that regression coefficient of TSP cost was 0.379. It was positive and was significant at 1 percent level. This indicated that an increase in one percent of TSP cost, remaining other factors constant, would result in an increase in the gross return by 0.379 percent.

MOP Cost (X6): It can be seen from Table 7.1 that regression coefficient of MOP cost was 0.101. It was negative and was significant at 10 percent level. This indicated that an increase in one percent of MOP cost, remaining other factors constant, would result in decrease in the gross return by 0.101 percent.

Insecticide Cost (X7): The magnitude of the regression coefficient of insecticide cost was 0.056 with a positive sign. It was insignificant.

Coefficient of Multiple Determination (R^2): It is evident from Table 7.1 that the value of the Coefficient of multiple determination (R^2)) was 0.90. It indicated that about 90 percent of the variations of the gross returns are explained by the explanatory variables included in the model.

Returns to Scale (Σβi): The summation of all the regression coefficients of the estimated production function of boro was 0.654 (Table 7.1). This implied that the production function exhibits increasing returns to scale. That is, the farmers were operating their boro farming in the first stage of production function. In this case, if all the variables specified in the production function were increased by one percent, gross return would increase by 0.654 percent.

7.5 Concluding Remarks

Cobb-Douglas production function model revealed that the key variables included in the model were individually or jointly responsible for variation in gross return of aman and boro rice. It also revealed that aman growers allocated their resources in the zone of increasing returns, which indicates that there was a bright prospect to earn more returns by making optimum use of more inputs in the production. On the other hand, boro rice growers allocated their resources in the zone of decreasing returns, which indicates that they were operating boro rice farming in the rational zone of production.

CHAPTER 8

PROBLEMS OF AMAN AND BORO RICE GROWERS

8.1 Introduction

Farmers faced a lot of problems in producing aman and boro rice. The problems were price stability, social and cultural, financial and technical. Main problem for boro rice is price and market stability. This chapter aims at represent some socioeconomic problems of producing aman and boro rice. The problems faced by the farmers were identified according to opinions given by them. The major problems and constraints related to aman and boro rice cultivation are discussed below:

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 harvest time price of aman and boro rice remained low because of ample supply. So they could not get reasonable return for their products. It can be seen from Table 8.1 that 90 percent aman and 83.33 percent boro growers reported this problem.

8.3 High Price of Inputs

Non-availability of inputs like seeds, fertilizers, insecticides, human labour etc. at fair price was a problem in the way of producing enterprises. During the production period price of some inputs tend to rise due to their scarcity. It appears from Table 8.1 that 80 percent aman and 96.66 percent boro growers reported that they had to purchase some inputs at a high price during the production period.

8.4 High Cost of Irrigation

Irrigation is the leading input for crop production. Yield of aman and boro rice varies with the application of irrigation water. Availability of irrigation water was not a problem in the study area because of portable irrigation devices. But farmers reported that they had to pay higher charge for irrigation water. Table 8.1 shows that 40 percent aman and 33.33 percent rice growers reported this problem.

8.5 Lack of Quality Seed

Lack of quality seed was one of the most important limitations of producing aman and boro rice in the study area. From Table 8.1 it is evident that about 70 percent aman and 30 percent boro growers reported this problem. Farmers told that they were cheated by buying so called hybrid seeds from the local markets and from the seed dealers.

8.6 Shortage of Human Labour

Most of the human Labour is being used during seed/seedling plantation and harvesting period of aman and boro rice. Aman and boro rice are labour intensive spices. Non-availability of human labour was found in different stages of production such as planting, intercultural operates and harvesting. Table 8.1 shows that 83.33 percent of aman and 90 percent of boro growers reported this problem.

8.7 Inadequate Extension Service

During the investigation some tanners complained that they did not get any extension services regarding improved method of aman and boro rice cultivation from the relevant officials of the Department of Agricultural Extension (DAE). As an agricultural extension personnel block supervisor’s the mam advisor of technical knowledge to the fanners about their farming problems. But in the study area about 13.33 percent aman and 10 percent boro growers (Table 8.1) reported that they hardly ever got help from the block.

8.8 Attack of Pest and Diseases

The growers of aman and boro rice were also 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 56.67 percent aman and 30 percent boro growers reported this problem (Table 8.1).

8.9 Lack of Operating Capital

The farmers of the study area had capital constraints. For cultivation of aman and boro rice a huge amount of cash money was needed to purchase various inputs like, human labour, seed, fertilizers, pesticides, etc. In the study area 86.67 percent aman and 43.33 percent boro farmers reported that they did not have sufficient amount of money for purchasing the required quantity of inputs for the relevant enterprises (Table 8.1).

8.10 Natural Calamities

It was found that aman and boro rice growers faced some acute problems relating to the nature in their production process. Natural calamities like drought hail storm, excessive rainfall, caused substantial damage to the crop in the field. Farmers said that excessive rainfall during the harvesting period reduces both the quantity and storability of aman and boro rice. Table 8.1 shows that 26.67 percent aman and 20 percent boro growers reported this problem.

Table 8.1: Problems Faced by Aman and Boro Rice Growers

Name of the Problems	Aman Rice Growers			Boro Rice Growers		
	Number	Percent	Rank	Number	Percent	Rank
Low Price of Output	30	100	1	30	100	1
High Price of Inputs	28	93.33	2	25	83.33	2
High Cost of Irrigation	25	83.33	3	15	50	5
Lack of Quality Seed	22	73.33	4	25	83.33	2
Shortage of Human Labour	22	73.33	4	18	60	4
Lack of Operating Capital	20	66.67	5	20	66.67	3
Attack of Pest and Diseases	19	63.33	6	10	33.33	7
Inadequate Extension Service	16	53.33	7	20	66.67	3
Natural Calamities	15	50	8	10	33.33	7
Lack of Scientific Knowledge of Farming	14	46.67	9	12	40	6
Adulteration of Fertilizers, Insecticides and Pesticides	12	40	10	10	33.33	7
Lack of Quality Tillage	10	33.33	11	8	26.67	9
Theft	5	16.67	12	9	30	8

Source: Field survey.2018

8.11 Lack of Scientific Knowledge of Farming

Although modem agricultural technologies have been using in the study area; a large number of fanners have no adequate knowledge of right doses and methods of using modern inputs and technologies of producing their enterprises. In the study area 23.33 percent aman and 16.67 percent boro growers were encountered this problem (Table 8.1).

8.12 Lack of Quality Tillage

Deeply ploughing is essential for successful crop production. Most of the farmers, who use hired power tiller, reported that hired power tiller owners did not till deeply. Nevertheless, they did not use all the tines when they till others land. Table 8.1 shows that 0 percent aman and 40 percent boro growers reported this problem.

8.13 Adulteration of Fertilizers, Insecticides and Pesticides

Chemical fertilizers, insecticides and pesticides are the most important inputs of aman and boro rice production. They were being intensively used in aman and boro rice production in the study area. Many farmers reported to have been cheated by applying adulterate fertilizers and pesticides in their crop field. It can be seen from Table 8.1 that 23.33 percent aman and 20 percent rice growers faced this problem.

8.14 Theft

During the harvesting period, stealing of aman and boro rice from the crop field and from the farmers' premises was also a limiting factor of aman and boro rice production in the study area. Table 8.1 shows that 10 percent aman and 3.33 percent boro growers reported the problem of theft of aman and boro rice.

CHAPTER 9

SUMMARY, CONCLUSION AND RECOMMENDATIONS

9.1 Introduction

The key findings of the study are summarized in this chapter. Section 9.2 presents a summary of the major findings of the study. Conclusion, policy recommendations, limitations of the study and scope for further study are given in Section 9.3, 9.4, 9.5 and 9.6, respectively.

9.2 Summary

Bangladesh is an agricultural country. Agriculture is the main source of income and employment in this country. The country is characterized by high population growth rate, unfavorable land-man ratio and low growth rate in agricultural production. To meet these challenges, the country has to enhance agricultural production through following intensive method of cultivation and diversifying the production of crops. Agriculture sector continues to play a very important role in the economy of Bangladesh. Agriculture contributes about 16.50 percent of the GDP and provides 47.30 percent employment for its labour force. Total area of Bangladesh is about 14.845 million hectares of which 53.89 percent is cultivated, 3.16 percent is current fallow land, rest 42.95 percent is covered by homesteads, rivers, tidal creeks, lakes, ponds, roads, etc.

Climatic condition of Bangladesh is friendly for agricultural crops. In 2011-12, 44,000 hectares of land were cultivated for aman and the production was 234000 MT with an average yield rate of 5.32 MT/ha. Whereas, the area under boro rice was 4812150 hectares and production were 18759000 MT with an average yield rate of 3.91 MT/ha.

Agriculture of Bangladesh is still dominated by rice production. According to the BBS final estimate, the volume of food grains production in FY 2012-13 stood at 372.66 lakh MT of which aus accounted for 21.58 lakh MT, aman 128.97 lakh MT, boro 187.78

lakh MT, wheat 12.55 lakh MT and maize 21.78 lakh MT. In FY 2013-14 food grains production stood 381.73 lakh MT of which aus accounted for 23.26 lakh MT, aman 130.23 lakh MT, boro 190.06 lakh MT, wheat 13.02 lakh MT and maize 25.16 lakh MT. In FY 2011-12, total area under spices is 3.25 lakh hectares with the total production of about 17.55 lakh metric tons in our country (BBS, 2014). Spices covers almost 2.16 percent of total cropped area in Bangladesh (BBS, 2014).

According to Bangladesh Bureau of Statistics 2014, in FY 2011-12, annual production of aman and boro rice were 2.34 and 187.59 lakh metric tons, respectively. Despite having large population, there is a large gap between demand and supply, every year for meeting deficit, Bangladesh has to import a large volume of aman and rice at the cost of hard-earned foreign currency.

Aman and rice production are labour intensive, so cultivation of these two crops can create more employment opportunity to rural people of Bangladesh. In order to find out the problems, potentials and possibilities of expansion in both the acreage and production of aman and boro rice the present study is conducted with the following objectives:

i. To assess the present socio-economic characteristics of aman and boro rice growing farmers,

ii. To find out the profitability of Aman and Boro rice in the study areas,

iii. To find out the major factors affecting the production, and

iv. To suggest some policy options for the improvement of aman and Boro rice cultivation.

Villages of Jhalokati Sadar Upazila, Nalchity Upazila, Rajapur Upazila of Jhalokati District were selected for the study. In total 60 farmers, 30 for aman and 30 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 analyze the data to achieve the objectives of the study.

In case of socioeconomic characteristics, it was found that average family size of aman and boro rice growers was 4.12 and 4.46, respectively and sex ratio was 1.43 and 1.59 for aman and boro rice, respectively. The highest percentage of people was in the age group of 15-59. Literacy rate of aman and boro rice growing families were 87.67 and 90.13 percent, respectively. Percentage of above secondary education was 19.84 and 14.56 respectively. In the study area, 59 percent of aman and 68 percent of boro rice grower's sole occupation was agriculture and average farm size of aman and boro growers were 0.95 and 1.63 hectare, respectively.

Relative profitability analysis was done to compare costs and returns of aman and boro production. It was observed that human labour use per hectare was 64 man-days and 105 man-days for aman and boro rice respectively. Per hectare cost of human labour for aman and boro rice production were Tk. 22400 and Tk. 36750, which represented 37.76 percent and 40.11 percent of the total cost, respectively. Per hectare tillage cost of aman rice production and boro production was Tk. 4860 and Tk. 3146, which represented 8.19 percent and 3.13 percent of the total cost, respectively. Total amount of seed requirement per hectare for aman and boro rice production was 58.27 kg and 54.53 kg, respectively. Per hectare cost of seed was estimated Tk. 4193 and Tk. 5138.7 covering 7.07 percent and 5.12 percent of the total cost of producing aman and boro rice, respectively.

Per hectare use of Urea, TSP, MoP and Gypsum for aman production were 186 kg, 73 kg, 12 kg whose costs were estimated at Tk. 3720, Tk. 2190, Tk. 240, and Tk. 150, respectively. Per hectare use of Urea, TSP, MoP, and Gypsum for boro rice production were 259 kg, 126.5 kg, 112.8 kg and 39.1 kg whose costs were Tk. 5180, Tk. 3795, Tk. 2256 and Tk. 469.2, respectively. Per hectare cost of manure for aman and boro rice production was Tk. 1000 and Tk. 1700 covering 1.69 percent and 1.69 percent of the total cost, respectively.Per hectare irrigation water charge of aman and boro rice cultivation was calculated Tk. 1000 and Tk. 31554.56 covering 1.69 percent and 21.62 percent of the total cost, respectively. Per hectare insecticides and pesticides costs of aman and boro rice cultivation was estimated Tk. 3168 and Tk. 1995.33, which constituted 5.34 percent and 1.99 percent of the total cost, respectively.

Land use cost per hectare was Tk. 14820 for aman and Tk. 28820 for boro rice cultivation. It constituted 24.99 percent and 28.70 percent of the total cost of aman and boro rice production, respectively. Interest on operating capital of aman and boro rice cultivation was Tk. 1574 and Tk. 2380 covering 3.99 percent and 3.79 percent of the total cost, respectively. Per hectare fixed cost of aman and boro rice production was Tk. 16394 and Tk. 31200, respectively.

Per hectare gross cost of aman and boro rice production were Tk. 59315 and Tk. 100430.23, respectively. Per hectare gross margin of aman and boro rice growers were Tk. 31927.6 and Tk. 72583.77, respectively. Per hectare net return of aman and boro rice production were calculated Tk. 15533.6 and Tk. 41383.77, respectively. Undiscounted benefit cost ratio of aman and boro rice production were 1.26 and 1.41, respectively.

Cobb-Douglas Production Function model was applied on the basis of the best-fit and significant effects of resources on gross returns. For aman enterprise seven explanatory variables were taken into account to explain variations in production. And for boro rice enterprise seven explanatory variables were taken into account to explain variations in production. The coefficient of multiple determination, R^2, was 0.94 in case of aman production function. This indicates that 94 percent of the variation of output of aman was explained by the explanatory variables included in the model. The F-value (93.07) of the equation was highly significant, which indicates good fit of the model. The summation of the estimated coefficients was 1.066, which implies increasing returns to scale.

The coefficient of multiple determination, R^2, was 0.94 in case of boro production function. This indicates that 94 percent of the variation of output of boro rice was explained by the explanatory variables included in the model. The F-value (4.49) of the equation was highly significant, which indicates good fit of the model. The summation of the estimated coefficients was 1.066, which implies increasing returns to scale. The present study also identified some problems of aman and boro rice production. The major problems faced by the farmers were low price of output, high price of input, lack of quality seed, lack of operating capital, shortage of human labour, inadequate extension service etc.

9.3 Conclusion

From the results of the present study, it can be concluded that considerable scope apparently exists in the study area to increase the productivity of aman and boro rice to increase income of the growers. Aman and boro rice are extensively cultivated spices and food grain in Jhalokati Sadar Upazila, Nalchity Upazila, Rajapur Upazila of Jhalokati District. The study revealed that boro growing was relatively more profitable than aman rice production. The economic profitability analysis demonstrates that Bangladesh enjoys profitability of many non-rice crops, implying that Bangladesh has more profitable options other than production of rice. Furthermore, both aman and boro rice are labour intensive enterprises. They are nutritive also. So, cultivation of these two crops can help in increasing farm income, employment and nutritional status of farmers. The controlling practices of aman and boro rice enterprises in the study area were not found efficient enough. Farmers were not known about the application of inputs in right time with right doses. Therefore, they made over or under use of some inputs. Thus, well planned management training in accordance with their problems, needs, goals and resource base can lead to viable production practices and sustainable income from aman and boro rice cultivation.

9.4 Policy Recommendations

On the basis of the findings of the study it was manifest that both aman and boro rice were profitable enterprises and they can generate income earnings and employment opportunity to the rural people of Bangladesh. But some problems and constraints revealed to attain the above-mentioned objectives. The policy makers should, therefore, take necessary actions according to the findings of the study; some policy recommendations may be advanced which are likely to be useful for policy formulation:

i. Quality seeds of improved varieties in appropriate quantity are recognized to be one of the prime elements for enhancing agricultural production. Emphasis should be given on creating facilities and infrastructure support for hybrid aman and boro rice seed production, marketing and development.
ii. Lack of operating capital is a problem for the resource poor farmers of the study areas. Favorable institutional credit program should be launched aiming at particularly the small and medium farmers. Specialized and commercial banks should be encouraged to provide loans at a low interest rate to enable farmers to operate their farming on commercial basis.
iii. Farmers could not get reasonable prices for aman and boro rice. Marketing costs are high because of inadequate information, infrastructure, high price risks etc. So appropriate steps should be taken to ensure (i) fair price (ii) quality of agricultural products (iii) floor price and (iv) stability of production.
iv. Shortage of human labour was a major problem for the aman and boro rice farmers of the study areas. Government and other authorities should take initiative for lessen these problems.
v. Adequate training on recommended use of quality seed, fertilizer dose, insecticides, water management practices, etc., should be provided to the aman and boro rice farmers which will enhance production as well as resource use efficiency by improving the technical knowledge of the farmers.

9.5 Limitations of the Study

As a microeconomic study, the study is suffered from a number of limitations. So, the findings of the study should be considered with a note of a caution. The limitations of the study are:

i. Maximum of the farmers did not keep any written documents of their farm activities. So that, information gathered mostly through their memories of the farmers which were not always accurate.
ii. In the resource and time constraints, broad and in-depth study got hampered to some extent. Therefore, the findings of this study should be interpreted cautiously to generalize for the country as a whole.

9.6 Scope for Further Study

Although the present study is intended to provide some valuable information for the guidance of farmers, extension workers, policy makers etc., it is not free from criticisms. Due to limitation of time and resources this study could not cover some important areas.

The weaknesses of the present study, of course, open roads for further research which are given below:

i. A broad-based study in this line may be undertaken for better understanding not only to study relative profitability of these two enterprises but also with other crops.
ii. The study of other varieties of boro rice may be conducted individually with aman to assess their comparative profitability.
iii. Acreage response, growth and instability of aman and boro rice production can be studied with respect to Bangladesh.
iv. A further study can be undertaken by taking into account different farm sizes to assess the impact of profitability of aman and boro rice on income and employment opportunity.

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APPENDICES

Yield response function for Boro

$$lnY_i = \alpha + \beta_1 In(seed) + \beta_2 \ln(Labour) + \beta_3 In(irrigation) + \beta_4 \ln(Urea) + \beta_5 ln(TSP) + \beta_6 \ln(Gypsum) + \beta_7 \ln(MOP) + \beta_8 \ln(Inseticide)$$

Where, Yield= ton/ha, Seed = kg/ha, labour= man-days/ha, Irrigation=number /ha, Urea=Kg/ha, TSP=kg/ha, Gypsum=kg/ha, MOP=kg/ha, Inseticides=Tk/ha

Ln= logarithmic, $\beta_1 \ldots \ldots \ldots \ldots \ldots \ldots . \beta_8$ = The parameters need to be estimated

Result

Regression

Source	SS	df	MS
Model	.229534518	8	.028691815
Residual	.012425674	21	.000591699
Total	.241960192	29	.008343455

Number of obs = 30
F(8, 21) = 48.49
Prob > F = 0.0000
R-squared = 0.9486
Adj R-squared = 0.9291
Root MSE = .02432

lny1	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]
lnseed	-.0051291	.0988539	-0.05	0.959	-.210707 .2004489
lnlab	.1404228	.0722487	1.94	0.065	-.0098266 .2906721
lnirri	.167558	.0516056	3.25	0.004	.0602383 .2748776
lnur	.0161384	.1452637	0.11	0.913	-.2859541 .3182309
lntsp	.3793236	.1118835	3.39	0.003	.146649 .6119982
lngyp	.0610546	.0446054	1.37	0.186	-.0317074 .1538165
lnmop	-.101636	.0584832	-1.74	0.097	-.2232585 .0199864
lninset	.0562937	.037248	1.51	0.146	-.0211679 .1337552
_cons	-1.237547	1.17273	-1.06	0.303	-3.676372 1.201278

Test of heterogeneity for Dependent variable (Yield)

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of lny1

chi2(1) = 2.94

Prob > chi2 = 0.0862

Test of heterogeneity for Independent variable (variable in right side of equation)

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

$H_0: \sigma_1^2 = \sigma_1^2 = \cdots \ldots \ldots = \sigma^1$

$H_A: \sigma_1^2 \neq \sigma_1^2 \neq \cdots \ldots \ldots \neq \sigma^1$

Ho: Constant variance

Variables: lnseed lnlab lnirri lnur lntsp lngyp lnmop lninset

chi2(8) = 15.20

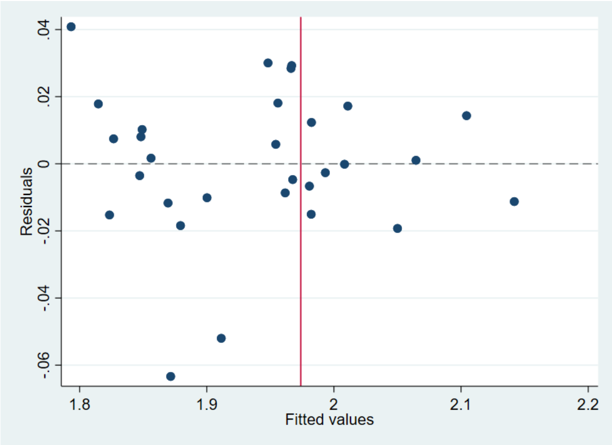
Prob > chi2 = 0.0554

```
White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(29)     =     30.00
         Prob > chi2  =    0.4140

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	30.00	29	0.4140
Skewness	7.64	7	0.3658
Kurtosis	2.11	1	0.1465
Total	39.74	37	0.3488



Result showed that heterogeneity exists

Test of multicollinearity

Variable	VIF	1/VIF
lnirri	6.02	0.166146
lntsp	5.56	0.179792
lnlab	2.39	0.417816
lninset	1.50	0.668049
lnur	1.27	0.785322
lnseed	1.26	0.790877
lngyp	1.22	0.817204
Mean VIF	2.75	

Result showed that no multicollinearity exist in the independent variables

After removing the heteroskedasticity problem, the regression with robust standards errors the problem of heteroscedasticityi

```
Linear regression                               Number of obs     =         30
                                                F(7, 22)          =      93.07
                                                Prob > F          =     0.0000
                                                R-squared         =     0.9413
                                                Root MSE          =     .02542
```

lny1	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnseed	-.0317207	.0745805	-0.43	0.675	-.1863911	.1229497
lnlab	.1246556	.0701328	1.78	0.089	-.0207909	.2701022
lnirri	.184795	.0433989	4.26	0.000	.0947911	.2747989
lnur	.0012048	.138901	0.01	0.993	-.2868582	.2892679
lntsp	.3657456	.1150433	3.18	0.004	.1271604	.6043308
lngyp	.0728001	.0549021	1.33	0.198	-.0410598	.1866601
lninset	.0652836	.0449418	1.45	0.160	-.02792	.1584872
_cons	-1.546889	.8810972	-1.76	0.093	-3.374173	.2803947

not present anymore.

Wald test:

```
 ( 1)  lnseed = 0
 ( 2)  lnlab = 0
 ( 3)  lnirri = 0
 ( 4)  lnur = 0
 ( 5)  lntsp = 0
 ( 6)  lngyp = 0
 ( 7)  lninset = 0

       F(  7,    22) =   93.07
            Prob > F =    0.0000
```

The selected variable have significant influence on the yield increasing

Joint hypothesis test showed that all variable have jointly response to the yield

```
 ( 1)  lnseed + lnlab + lnirri + lnur + lntsp + lngyp + lninset = 0
```

lny1	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
(1)	.7827641	.1435964	5.45	0.000	.4849633	1.080565

.

Yield response function for Aman

regress lnyield lnseed lnlab lnirr lnurea lntsp lnmop, vce(robust)

Source	SS	df	MS
Model	.040865547	6	.006810925
Residual	.014039478	23	.000610412
Total	.054905026	29	.001893277

Number of obs = 30

F(6, 23) = 13.69

Prob > F = 0.0000

R-squared = 0.7443

Root MSE = .02471

Lnyield	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
lnseed	-.0099299	.0180287	-0.55	0.587	-.0472252	.0273654
lnlab	.0258388	.0719995	0.36	0.723	-.1231036	.1747812
lnirr	.0539758	.0182746	2.95	0.007	.0161718	.0917797
lnurea	.0988427	.0573833	1.72	0.098	-.0198637	.2175491
lntsp	.1454272	.0696081	2.09	0.048	.0014319	.2894224
lnmop	.0327969	.0245549	1.34	0.195	-.0179988	.0835925
_cons	6.684948	.2717869	24.60	0.000	6.122714	7.247182

Test of heteroscedaisity test

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnyield

         chi2(1)      =     0.26
         Prob > chi2  =   0.6131

. estat hettest lnseed lnlab lnirr lnurea lntsp lnmop

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: lnseed lnlab lnirr lnurea lntsp lnmop

         chi2(6)      =     0.57
         Prob > chi2  =   0.9969
```

No heteroscedaisity exist

Test of multicollinearity

Variable	VIF	1/VIF
lnlab	5.05	0.198137
lnirr	2.88	0.347458
lntsp	2.80	0.356655
lnurea	2.11	0.473492
lnseed	1.32	0.758448
lnmop	1.09	0.917692
Mean VIF	2.54	

```
. correlate lnseed lnlab lnirr lnurea lntsp lnmop
(obs=30)
```

	lnseed	lnlab	lnirr	lnurea	lntsp	lnmop
lnseed	1.0000					
lnlab	0.3380	1.0000				
lnirr	0.2700	0.7934	1.0000			
lnurea	0.2675	0.6927	0.5924	1.0000		
lntsp	0.0486	0.7493	0.5976	0.6365	1.0000	
lnmop	-0.1102	-0.0128	-0.1515	-0.0786	-0.0614	1.0000

VIF value is less than 10 so no multicollinearity exist

Wald test for all variable

```
( 1)  lnseed = 0
( 2)  lnlab = 0
( 3)  lnirr = 0
( 4)  lnurea = 0
( 5)  lntsp = 0
( 6)  lnmop = 0
( 7)  lninsect = 0

      F(  7,    22) =   12.51
           Prob > F =    0.0000
```

Joint test for all variable

```
. lincom lnseed + lnlab + lnirr + lnurea + lntsp + lnmop + lninsect

 ( 1)  lnseed + lnlab + lnirr + lnurea + lntsp + lnmop + lninsect = 0
```

lnyield	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
(1)	.3505598	.0777959	4.51	0.000	.1892211	.5118986

.