Project ID 750

Competitive Research Grant

Sub-Project Completion Report

on

Cost and Return Analysis of Sugarcane Production with Intercrops in Bangladesh

Project Duration

May 2017toSeptember 2018

Agricultural Economics Division
Bangladesh Sugarcrop Research Institute

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Acronyms

BCR- Benefit Cost Ratio

BSRI- Bangladesh Sugacrop Research Institute

BSFIC- Bangladesh Sugar & Food Industries Corporation

DAE- Department of Agricultural Extension

FAO- Food and Agriculture Organization

FGD- Focus Group Discussion

GDP- Gross Domestic Product

GR- Gross Return

MLE- Maximum Livelihood Estimate

NAP- National Agricultural Policy

NGOs- Non Government Organization

NSAPR- National Strategy for Accelerated Poverty Reduction

SDG- Sustainable Development Goal

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Executive Summary

Sugarcane is one of the major cash crops of Bangladesh and it is the main source of sugar, *goor* and cane juice. Sugarcane and sugar production are passing crisis period during the last two decade. The farmers show apathy toward the crop as it is difficult for the grower's especially poor growers to wait such a long time to get economic return. Sugarcane cultivation with intercrops can be major patter which can enhance sugarcane area as well as an effective way to earn more profit compare to other crops.That's why the project **"Cost and Return Analysis of Sugarcane Production with Intercrops in Bangladesh"** has been taken to determine the level of input use and estimate cost and return of sugarcane production with intercrops; to determine technical efficiency and to identify the problems of sugarcane cultivation in Bangladesh. The goal of the project is to create an update financial database of sugarcane production with intercrops in Bangladesh by 2018. Duration of the project is from May, 2017 to September, 2018. Twelve districts were selected as survey area based on the highest sugarcane growing areas considering intercrops in mill zone, *goor* zone and chewing area. Neyman Allocation Method was followed for sample selection. Thus, a total of 1800 sugarcane and sugarcane with intercrops cultivating farmers were interviewed for collecting field level data for the study. Additionally, data was collected through Focus Group Discussion (FGD) and Key Informant Interview (KII) using semi structured checklist. Primary data was collected through interviewing sugarcane farmers using a structured pre-tested interview schedule randomly. To estimate the cost return analysis simple accounting method and for technical efficiency analysis stochastic frontier model was used in this study.

Per hectare costs of production of mill zone, *goor* zone and chewing zone were Tk.1,48,509, Tk.1,96,320, Tk.2,69,724 on cash cost basis and Tk.2,15,860, Tk.2,68,452, Tk.3,49,196 on full cost basis respectively. Gross return of sugarcane was Tk.2,18,400, Tk.3,40,000 and Tk.6,60,000 of mill zone, *goor* zone and chewing zone respectively. Highest BCR was found in chewing zone(2.45) followed by *goor* zone (1.73) and mills zone(1.47) . Benefit Cost Ratio sugarcane+carrot, sugarcane+garlic sugarcane+potato, sugarcane+lentil, sugarcane+mungbean, sugarcane+coriander, sugarcane+potato (chewing zone) and sugarcane+tomato were 2.19, 1.87, 1.74, 1.76, 1.79, 1.63, 3.23 and 3.23 respectively.

The mean technical efficiency of chewing zone, goor zone and mill zone was 0.73, 0.65 and 0.63, respectively. This implied that, on an average, the producers in the study areas were producing sugarcane for about 63-73% of the potential level(stochastic) frontier production levels, given the levels of their inputs and technology currently being used. This also indicated that there existed an average level of technical inefficiency of 27-47%.

Long duration crop, lack of clean/ certified seed, pest and diseases, irregular supply of fertilizers and insecticides, lack of proper knowledge, lack of adequate operating capital, high price of input, low product price, labour scarcity in the peak period, scarcity of *purzi* were the main constraints of sugarcane farmers.
There is a little scope horizontal expansion of sugarcane area in our country due to limitation of cultivable land and competition with other crops. Hence, steps should be taken to make farmers' aware for cultivation of sugarcane with intercrops to increase productivity. Therefore, both government and donors should continue their emphasis to sugarcane with intercrop cultivation to make self sufficiency in sugar and *goor*.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project: Cost and Return Analysis of Sugarcane Production with Intercrops in Bangladesh**

2. Implementing organization: Agricultural Economics Division, Bangladesh Sugarcrop Research Institute

3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

Principal Investigator: **Dr. Sayeeda Khatun**
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4. Sub-project budget (Tk):

   4.1 Total: Tk. 24,06,310/-

   4.2 Revised (if any): 24,06,310/-

5. Duration of the sub-project: 17 months

   5.1 Start date (based on LoA signed): 8 May 2017

   5.2 End date: 30 September 2018

6. **Justification of undertaking the sub-project**:

6.1 Importance of Agriculture in Bangladesh

Bangladesh is a developing country in the world with high density of population and unfavorable land-man ratio. Most of the people depend on agriculture. Agriculture being a crucial sector of the economy, it is indispensable to develop this sector for attaining economic growth and poverty alleviation. Since provision of food security, improving the living standard and generation of employment opportunities of the huge population of the country are directly linked to the development of agriculture, there has been continuous effort by the government for the overall development of this sector. Agriculture plays a vital role in the economy.It employsmore than 43 percent of the totallabour force is engaged in agriculture sector(BBS 2017). This sector not only employs most of the national labour force but also supplies food for human and animal consumption, raw materials for industrial production and some value added commodities for export. In order to ensure food security and to reduce poverty, the present government is committed to achieve self-sufficiency in food through increased crops production, sustainable growth of agriculture sector and employment opportunity as envisaged in National Strategy for Accelerated Poverty Reduction (NSAPR), National Agricultural Policy (NAP) and Sustainable Development Goal (SDG). With a view to developing the agricultural sector, the government has taken a number of steps. These include, enhancing the production of food grains, development and expansion of thevarieties of crops adaptable for the weather and environment of particular region and producing crops suitable for aparticular kind of land i.e. salt, flood and drought prone area. In 2016-17, it contributed around 14.17 percent of the Gross Domestic Product (GDP). Among them, only crop sector contributed around 7.69 percent (Table 1.1). Rice is the main food crop of Bangladesh which occupies 75 percent of total cropped area and the remaining 25 percent is devoted to other crops which include wheat, jute, sugarcane, oilseeds, pulses, vegetables, spices and condiments etc. Infact, the entire growth in crop production can be explained by the growth in food grain production, particularly rice. However, production of other crops such as sugarcane, vegetables, pulses, oilseeds and fruits are rather disappointing. Currently, Bangladesh has been producing only around 4.21 million tons of sugarcane, 0.37million tons of pulses, 0.93 million tons of edible oilseeds (BBS, 2017) which are far less than the requirements of total consumption of the country. It indicates unadjusted food plan which causes not only imbalanced food supply but also malnutrition problem. In addition, the country is compelled to import sugars, oils, pulses, etc. from abroad. Therefore, crop diversification is essential in order to achieve the goal of overall nutritional self-sufficiency, balanced food supply, production of industrial raw materials and so on. Furthermore, it is also needed to encourage the production of cash crop.

Table 1.1 Agricultural sector and sub-sector share of GDP of Bangladesh at current prices (Base: 1995-96)

Sector/sub-sector	2013-14	2014-15	2015-16	2016-17
1. Agriculture	12.81	12.21	11.55	10.98
a. Crops	9.21	8.73	8.15	7.69
b. Livestock	2.16	2.07	2.01	1.93
c. Forestry	1.44	1.42	1.39	1.37
2. Fisheries	3.30	3.20	3.22	3.19
Total	**16.11**	**15.41**	**14.77**	**14.17**

Sources: BBS, 2017

7.2 Sugarcane in Bangladesh

In Bangladesh, sugarcane is the second most important cash crop after jute. It is not only the most important cash crop but also an important food cum industrial crop and the main raw material for sugar and *goor* industries of Bangladesh, although it ranks second among cash crops but fourth among the major field crops in the country which covers about 2.05 percent of the cultivable land. More than 0.60 million farm families are dependent on sugar industries for their subsistence. At present, 15 sugar mills are in operation under Bangladesh Sugar and Food Industries Corporation (BSFIC). Most of the sugar mills of Bangladesh are located in the North Western zones of the country where concentration of sugarcane cultivation is higher. The capacity of these 15 sugar mills is 0.21 million metric ton of sugar production. To produce this amount of sugar it needs 0.40-0.45 million of sugarcane,but at this moment, in mills zone, 0.22-0.26 million metric ton sugarcane is produced. Out of them 0.10-0.12 million metric ton cane is crushed for sugar production and rest cane is used for *goor,* seed and juice purposes. As a result, a large amount of cane is shortage for crushing. To increase the cane crushing/supply to the mills, sugarcane area and production should be increased. Currently, on an average, sugarcane is grownin 0.10 million hectare of land of which almost 50% is located in the mill zones, where sugarcane is mostly utilized for sugar production and remaining 50% is situated in the non-mill zone, which is used for *goor* and juice production (BFIC, DAE).

In 2007-08, Bangladesh produced 7.37 million tons of sugarcane. Out of that 2.29 million tons (31%) were used by sugar mills to produce 0.16 to 0.20 million tons of sugar; 4.03 million tons (55%) were used to produce 0.30 million tons of *goor* and remaining 1.05 million tons (14%) were used for seed and chewing purposes (Figure 1.2). Per capita consumption of sugar and *gur* in Bangladesh is less than 10 kg per annum. But in India, China, Thailand, Brazil, Pakistan and EU it is 19, 10, 36, , 54, 23 and 34 kg respectively (World Sugar, 2009). According to Food and Agricultural Organization (FAO) per head annual necessity of sugar is 13 kg (Ali and Ali, 1990) and as such

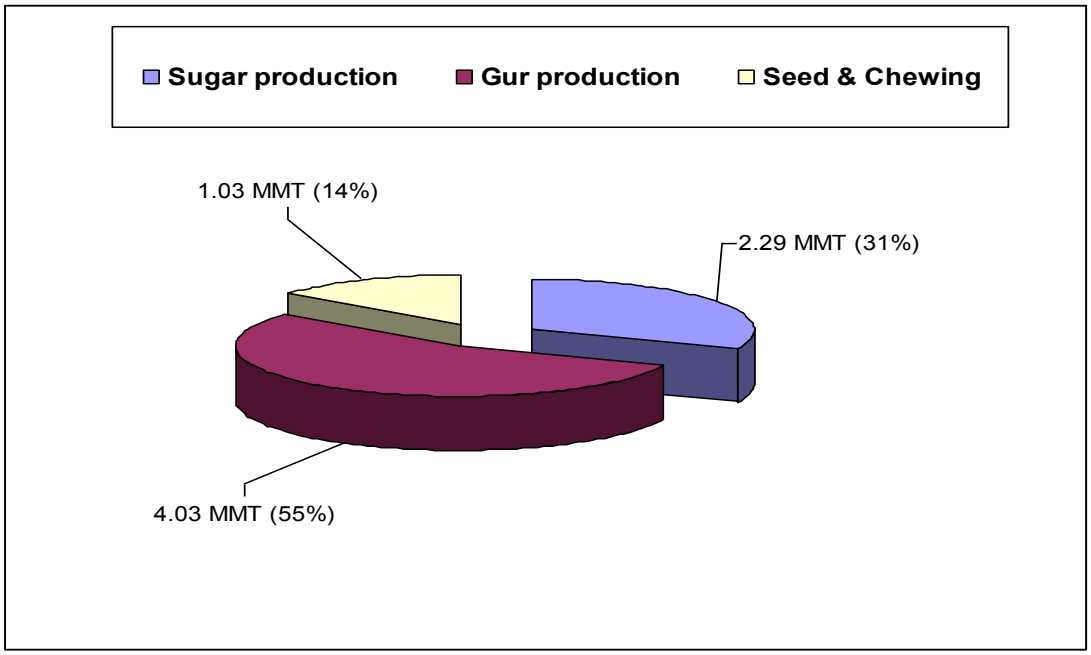

Figure 1.2: Utilization of sugarcane

Table 1.2 Demand and supply of sugar and *goor* in Bangladesh

Crushing Season	Populat-ion (million)	Demand of sugar & *goor* ('000 tone) (per capita 13 kg)	Sugar production ('000 tone)	Sugar import ('000 tone)	*Goor* Production ('000 tone)	Total supply of sugar & *goor* ('000 tone)	Scarcity /Shortages ('000 tone)
2008-09	145.91	1896.83	80.00	1300	446.00	1825.63	-71.20
2009-10	150.00	1950.00	62.00	1500	440.00	2002.00	+52.00
2010-11	150.00	1950.00	101.00	1400	460.00	1961.00	-34.00
2011-12	161.08	2094.00	69.35	1700	377.00	2146.35	+52.53
2012-13	163.00	2127.75	107.00	1547	355.00	2009.12	-118.63
2013-14	163.00	2127.75	128.27	1550	500.00	2178.27	+50.52
2014-15	163.00	2127.75	77.46	2075	500.00	2652.45	+524.52
2015-16	164.50	2138.50	58.20	2284	500.00	2842.20	+703.7
2016-17	164.50	2138.50	59.98	2097	500.00	2656.98	+518.4
2017-18	165.00	2145.00	68.56	2670	500.00	2656.98	+1063.56

Source : BBS, BSFIC (1999-17); FAS, USDA, May-2018

present requirement of sugar and *goor* for 165 million people, the annual demand is 2.14 million tons. However, our current (2017-18) domestic sugar and *goor* production was 0.068 and 0.50 million tons respectively and imported sugar was 2.67 million tons (FAS, USDA, May-2018). Total supply of sugar and *goor* was 2.65 million tons (Table 1.2). To meet that domestic demand, the

country's annual sugar and *goor* production should be increased, otherwise, people must consume less amounts of sugar and *goor* than their requirements. Therefore, there is an ample scope for increasing sugarcane production for sugar. Sugarcane is cultivated in almost all the districts of Bangladesh. It concentrates mainly the greater districts of Rajshahi, Chapai Nawabganj, Kustia, Jessore, Rangpur, Dinajpur, Bogra, Pabna, Sirajgonj, Faridpur, Barisal, Dhaka, Manikgonj, Chandpur and Mymensingh. But its area and production is decreasing day by day (Table: 1.4). The national average yield of sugarcane in Bangladesh is 42 tons per hectare (BBS, 2017) which is less than that of other countries of the world. Average cane yields in Pakistan, India, Thailand, China and Brazil were 53.20 t/ha, 66.93 t/ha, 63.71 t/ha, 80.82 t/ha and 74.42 t/ha respectively (FAO 2015).The Government of Bangladesh is emphasizing the attainment of self-sufficiency in sugar and *goor* production by stabilizing sugarcane area and increasing the yield. Bangladesh Sugarcane Research Institute (BSRI) has recommended a number of improved production technologies from planting to harvesting with a view to increase the per hectare yield of sugarcane through varietals improvement, better management of water resources, utilizing proper doses of fertilizers and other inputs and practicing improved cropping patterns. With the end in view Sugar Mills, Department of Agricultural Extension (DAE), Non government Organizations (NGOs) and other agencies have also been working for a long time to increase the production of sugarcane per unit area by adopting those practices.

Table 1.3 Millcapacity vs supply of sugarcane and sugar

Year	Total no. of mills	Total sugar production capacity (million m.ton)	Required quantity of raw cane for mill (million m.ton)	Yearly sugarcane production (million m.ton)	Yearly sugarcane supply to the mill (million m.ton)	Yearly shortage of cane in the mill (millionm.ton)	Total sugar production ((million m.ton
2014-15	15	0.21	4.50	2.65	1.21	3.29	0.077
2015-16	15	0.21	4.50	2.10	0.96	3.54	0.058
2016-17	15	0.21	4.50	2.03	0.99	3.51	0.060
2017-18	15	0.21	4.50	2.02	1.19	3.31	0.068
2018-19	15	0.21	4.50	2.12	1.18	3.32	0.069

Source: BSFIC, 2019

Table 1.4 Sugarcane area and production in mill zone and non mill zone in Bangladesh

Crushing year	Area (lakh ha)			Production (lakh m.ton)			Yield (ton/ha)		
	Mill zone	Non Mill zone	Total	Mill zone	Non Mill zone	Total	Mill zone	Non Mill zone	Total
2009-10	0.52	0.65	1.17	23.78	31.10	54.88	45.73	47.85	46.91
2010-11	0.65	0.75	1.40	30.40	36.00	66.40	46.77	48.00	47.43
2011-12	0.64	0.65	1.29	29.52	31.20	60.72	46.13	48.00	47.07
2012-13	0.65	0.43	1.08	30.63	20.56	51.19	47.12	47.81	47.40
2013-14	0.70	0.48	1.18	32.62	22.49	55.11	46.60	46.85	46.70
2014-15	0.63	0.42	1.05	26.56	23.00	49.56	42.16	54.76	47.20
2015-16	0.52	0.32	0.84	21.01	15.48	36.49	40.40	48.38	43.44
2016-17	0.48	0.66	1.14	20.31	31.82	53.13	42.31	48.21	46.61
2017-18	0.45	0.28	0.73	20.28	13.75	34.03	45.07	49.11	46.62
2018-19	0.48	0.29	0.77	22.18	17.05	39.23	46.21	57.99	50.68
Average	**0.57**	**0.49**	**1.07**	**25.73**	**24.25**	**50.07**	**44.85**	**49.70**	**47.01**

Source: BSFIC & DAE, 2019

7.3. Significance of the study

Sugarcane is one of the agro-based industrial crops of Bangladesh and sustains the economy of large number of rural people. It is the main source of sugar and *goor*. About 70% of total world's sugar is produced from sugarcane and 30% from sugar beet (Jamil and Gopang, 2004). Except diabetic patients, more than 99 percent of the people take sugar/*goor* and sugar products every day. It makes the food palatable and contributes on brain development of human being. It is an indispensable item for proper activities of brain. For each person, 77 mg glucose (simple form of sugar) is required every minute for perfect function of brain. Sugar falls under carbohydrate group of foods which is an important constituent of human diet. Sugar may provide 10-13% of the calories. It is used for manufacturing fruits and vegetable preservatives, sweets, fruit drops, confectionery, toffees, biscuits, sugar cubes, etc. The main by-products of sugar industries are molasses, bagasse, and press mud. The molasses can be utilized for producing spirit and alcohol. At present, Brazil and many other countries use bio-ethanol from sugarcane as an alternative of fossil fuel and it is being used in transport engine. Sugarcane is the world's largest source of fermented ethanol. It is one of the most photosynthetic efficient plants - about 2.5 % photosynthetic efficiency on an annual basis under optimum agricultural conditions. From sugarcane bagasses, high quality paper may be produced. Press mud is also an excellent source of organic matter. A further advantage is that bagasse can be used as a convenient on-site electricity source. The green leaves, cane tops and young suckers are used as high quality cattle feed. After harvesting sugarcane, the dry leaves and crop residues can be used as fuel. Considering the above aspects, there is a great impact of sugarcane in Bangladesh in respect of food, energy, employment, soil health improvement and in development of overall national economy. So it is an essential food item with great importance. The present production of sugarcane can meet neither the total sugar nor nutrient requirements of the country. Considering these circumstances, the

government of Bangladesh is determined to increase sugar and *goor* production by increasing the area of sugarcane and thereby sugarcane has been included in the national food security program.

The producers are profit-maximizes who take decisions based on expected profitability. Generally, while making production decisions, the farmers consider returns against expected cost. Sometimes it is mentioned that the yield they receive does not cover the cost of production. In this connection, better data base is necessary in order to appropriately understand the underlying processes that influence the output and productivity of this sector and how these are impacted by new policies and regulations. At the farm level, cost-return data of sugarcane production with intercrops can serve as means to better understand and assess a farm operation. Sugarcane cultivation with intercrops can be major element which can enhance sugarcane area as well as an effective way to earn more profit compare to other crops. Some short duration crops viz. vegetables, pulses, oilseeds and spices can be cultivated as intercrop with sugarcane which also offers an opportunity of increasing land utilization. Scarcity of resources has led to production economists to think about the reallocation of existing resources to have more output with given level of input combinations or to produce a prescribe level of output with the minimum cost without changing the production technology. But there is a lack of information about efficient use of inputs in sugarcane production. Similarly, the measurement of the productive efficiency of sugarcane production is an important issue because it gives pertinent information for making sound management decision in resources allocation. Except for few descriptive studies, econometric analysis has yet to be conducted to examine the production function of sugarcane cultivation and it is potential for future improvement. In order to formulate policy and planning for sustainable development of agricultural sector reliable and realistic data related to sugarcane production is needed. It is expected that the study would generate meaningful insights that policy makers and agricultural extension personnel can disseminate knowledge gap to the sugarcane producing farming community.

8. **Sub-project goal:** The goal of the proposed project is to create an update financial database of sugarcane production with intercrops in Bangladesh by 2018.

9. **Sub-project objectives:**

i) To determine the level of input use and estimate cost and return of sugarcane production with intercrops.

ii) To estimate the level and determinants of farm-level technical efficiency of sugarcane farmers and

iii) To identify constraints of sugarcane cultivation at farm level.

10. **Implementing locations**: Thakurgaon, Natore, Chuadanga, Faridpur, Sirajgonj, Chapainoabgonj, Bagerhat, Manikgonj, Barisal, Gazipur, Chandpur and Habigonj districts.

11.Methodology in brief

11.1. Selection of the study area

Selection of the study area is an important step in the farm management study. Sugarcane production is mainly divided into two vital zones in our country named millszone and non millszone. In millszone, sugarcane is used for sugarcane production. On the otherhand in non millszone area it is used for *goor* and juice purposes(chewing purposes). Based on the concentration of sugarcane area in millzone, non millzone and chewing zone, 12 districts namely Thakurgaon, Natore, Chuadanga, Faridpur, Sirajgonj, Chapainabganj, Bagerhat, Manikgonj, Barisal, Gazipur, Chandpur and Habigonj were selected.

Considering the uses of sugarcane the areas were classified as :

Sugarcane Zone	Districts	Upazilla
Mill zone	Thakurgaon	Thakurgaon sadar and Pirgonj
	Natore	Natore sadar and Boraigram
	Chuadanga	Chuadanga sadar and Jibanpur
	Faridpur	Faridpur Modhukhali
Goor zone	Sirajgonj	Sirajgonj sader and Kamarkhando
	Chapainawbganj	Shibgonj, Volahat
	Bagerhat	Mollarhat and Kochua
	Manikgonj	Manikgonj sader and Singair
Chewing zone	Barisal	Banaripara Ujipur
	Gazipur	Gazipur sader and Kapasia
	Chandpur	Motlob and Sahrasti
	Habigonj	Chunarughat and Madhapur

11.2 Sample design:

Twelve districts were selected as study area on the basis of the highest sugarcane growing areas considering intercrops in mill zone, *goor*zone and chewing zone. For the survey, 24 upazilas were selected taking 2 upazilas from each district. The specific survey location was selected based on information provided by BSFIC and DAE personnel. Before selecting each upazilla, zone base production areas were collected from the respective mill authority and upazilla agriculture offices and then highest two sugarcane growing upazilas were selected for the study.

11.3 Selection of samples and sample size:

The normal needed to select a sample of representative sugarcane farmers which would representing a reasonably true picture of the sugarcane growers. In this study, statistical tools were applied to select representative sample numbers. For determining the sample

size the variability of land holding of the farmers in the selected areas was considered. The series of data on size of land holding were plotted on a graph to observe the dispersion of the data. Distribution of data in a series happened to be distorted on the right side indicating a positive skewness. It was, however, ideal to choose samples from normal distribution. There was no safe general rule as to how large sample size must be used of the normal approximation in computing confidence limit (Cochran, 1999).

In order to normalize the data the following Fisher's measure of skewness (Fisher. 1958; Karim, 1996) formula was used and by applying this technique an optimum number of samples (Moser and Kalton, 1980; Cochran, 19990) were chosen for this study. For population in which the principal deviation from normality consists of positive skewness, a crude rule that occasionally found useful is:

Sample size, $n \geq 25\ G_1^2$ (which says 95% confidence probability)

Where,

Fisher's measure skewness G1 $= \frac{E(yi-\bar{Y}^3)\,E(y_i-\bar{Y})^3}{\sigma^3} = \frac{1}{N\sigma^3}\sum_{i=3}^{N}(y_i-\bar{Y})^3$

N = Population size

yi = I th member of the population

$\bar{Y}$= Population mean

σ == Standard deviation

As the strata differ not only in size but also in variability and it was considered reasonable to take large samples from the more variable strata and smaller from the less variable strata, we can then account for both (differences I stratum size and differences in stratum variability) by using disproportionate sampling design by requiring:

$\frac{n_1}{N_1}\sigma_1 = \frac{n_2}{N_2}\sigma_2 = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots = \frac{n_k}{N_k}\sigma_k$

Where,

$\sigma_1, \sigma_2, \ldots\ldots\ldots\ldots\ldots\ldots\sigma_k$ denote the standard deviation of the k strata

$N_1, N_2, \ldots\ldots\ldots\ldots\ldots\ldots N_k$ $\quad denote\ the\ population\ size\ of\ the\ k\ stata$

$n_2, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots n_{k=}$ $denote\ the\ sample\ sizes\ of\ the\ k\ stata$

This is called optimum allocation in the context of disproportionate sampling. The allocation in such a situation results in the following formula for determining the sample sizes. T Neyman Allocation Method (Neyman, 1934) was used to determining the samples from different strata (Parel, *et.al*., 1973; Kothari, 2001).

Sample size ni = $\frac{N_i\ \sigma_i}{N_1\sigma_1 + N_2\sigma_2 + \ldots\ldots\ldots\ldots + N_k\sigma_k} \times n$ for i= 1,2,…….k

Where,

$\sigma_1, \sigma_2, \ldots\ldots\ldots\ldots\ldots\ldots\sigma_k$ denote the standard deviation of the k strata

$N_1, N_2, \ldots\ldots\ldots\ldots\ldots\ldots N_k$ *denote the population size of the k stata*

$n_2, \ldots\ldots\ldots\ldots\ldots\ldots\ldots n_{k=}$ *denote the sample sizes of the k stata*

n= Sample size

By applying these techniques the number of samples for different locations were estimated and presented bellow:

Table 11.1Distribution of selected farms in the study areas, Bangladesh

Sugarcane Zone	Districts	No. of Farms
Mill zone	Thakurgaon	160
	Natore	146
	Chuadanga	174
	Faridpur	120
Goor zone	Sirajgonj	130
	Chapainawbganj	182
	Bagerhat	122
	Manikgonj	166
Chewing zone	Barisal	132
	Gazipur	124
	Chandpur	182
	Habigonj	162
All		1800

11.4 Methods of data collection:

For conducting the field survey data enumerator were required to collect data from 1800 sugarcane and sugarcane with intercropping farmers. The survey period was fixed at 7 months and started from August 2017 to February 2018. The information was collected for the crop that was already planted in 2017 and was harvested February 2018. The questionnaire was printed after pretest.

The questionnaire includes farm size, family size, education of the farmers, land owned, sugarcane land owned, sugarcane varieties cultivated, cost and returns sugarcane and intercropping and other information to fulfill the objectives of the study. Data was collected in three categories: (1) Farmers who supplied sugarcane to the mill authority and cultivate intercrops with their sugarcane; (2) Farmers who produced *goor* in non-mill zone areas as well as cultivate intercrops with their sugarcane and (3) Farmers who produced chewing cane and cultivate intercrops with their chewing cane in non-mill zone areas. For getting more accurate

and representative results, at least 600 samples from each category were selected from the study area. For household survey a total of 1800 (12 districts) sugarcane cultivating farmers were interviewed for collecting field level data for the study. Additionally, data were collected through Focus Group Discussion (FGD) and Key Informant Interview (KII) using semi structured checklist.Principle Investigator and Co-principle Investigator were alsoinvolved in data collection.

11.5 Analytical techniques:

Farm level collected data was edited, summarized, tabulated and analyzed to fulfill the objectives of the study. In most cases, tabular method of analysis supported with appropriate statistical parameters was used to present the results of the study.

Various types of analytical technique were applied to find out various issues of the broad objectives. As per requirements of data analysis and different statistical and econometrical method was applied in this study. The various possible applications of the analytical methods are discussed below.

The first objective of the study is to estimate the cost and return of sugarcane production. An attempt was made to estimate the detailed cost and return, profitability of sugarcane and sugarcane with intercrops cultivation in Bangladesh. The profitability of sugarcane and sugarcane with intercrops production was calculated using simple accounting procedures. Hence, data relating to input use for the production of selected sugarcane in mill zone and non mill zone area, their market prices was collected. On the other hand, data on outputs and their prices were also be gathered for the study.

Gross return (GR) was calculated by multiplying the total volume of sugarcane produced by per unit price of sugarcane plus average amount of seed sell. The following equation was used to estimate GR:

$$GRi = \sum_{i=1}^{n} (\mathbf{QiPi} + \mathbf{Si}) \quad \text{.....(1)}$$

Where,

GR_i = Gross return from i^{th} product (Tk/ha)
Q_i = Quantity of the i^{th} product (ton)
P_i = Per unit price of the i^{th} product (Tk)
S_i = Average amount of seed sell (Tk)
i =1, 2, 3, ……., n

Net return analysis considered fixed cost, cost of land rent, interest on operating capital etc. Net return was calculated by deducting all costs (variable and fixed costs) from gross return. To determine the net return following equation was used in the study:

$$\pi = PyY - \sum_{i=1}^{n} PxiXi - TFC \quad \text{.....(2)}$$

Where,

π = Net return (Tk/ha)

P_y= Per unit price of the product (Tk/ton)

Y = Quantity of the production per hectare (ton)

P_{xi} = Per unit price of i^{th} inputs (Tk)

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

TFC = Total fixed cost (Tk)

i = 1, 2, 3,..... n (number of inputs)

The efficiency of inputs used in sugarcane production will be measured by the following equation-1.

$$\frac{MVP_x}{MFC_x} = 1 \quad \text{..... (3)}$$

Where, MVP is the marginal value product of 'x' input and MFC is the marginal factor cost of 'x' input. When the ratio of MVP and MFC is equal to unity indicates that the resource is efficiently used in the process of sugarcane production. On the other hand, the technical efficiency of sugarcane farmers will be estimated through using the stochastic Cobb-Douglas production frontier model. The model can be written as multivariate double logged transformed multiple regression equation.

A stochastic frontier production model was used to determine the technical efficiency of sugarcane farmers. The modeling and estimation of stochastic frontier production function originally proposed by Aigner *et. al.* (1977) and Meeusen and Van Den Broeck (1977) which has been an important area of economic study in the last two decades. The stochastic production frontier model is specified with error terms, the model is as follows:

$$Y = f(X_i,B) + (v_i - u_i) \quad \text{..... (4)}$$

Where, Y_i is output for observation i (i.e., yield/ha), X_i denotes the actual input vector (i.e., input use/ha), β is the vector of production function parameters, v is distributed randomly and symmetrical two-sided error term that cannot be influenced by producers, it was identically and independently distributed as N (0, σ^2_v) and may be considered as the 'normal' error term. The u was a non-negative one-sided error term and distributed half-normal as N(0, σ^2_u) which captures deviations from the frontier due to inequality.

Empirical model

The Cobb-Douglas form was used in many empirical studies, particularly those relating to developing countries in agriculture. In this study, it is assumed that the Cobb- Douglas is the appropriate form of the frontier production function. The stochastic production which is used for the sugarcane producers was specified as:

$$\text{Ln } Y_i = \beta_0 + \beta_1 \text{Ln}X_{1i} + \beta_2 \text{Ln}X_{2i} + \beta_3 \text{Ln}X_{3i} + \beta_4 \text{Ln}X_{4i} + \beta_5 \text{Ln}X_{5i} + \beta_6 \text{Ln}X_{6i} + \beta_7 \text{Ln}X_{7i} + \beta_8 \text{Ln}X_{8i} + \beta_9 \text{Ln}X_{9i} + v_i - u_i \quad (5)$$

Where, Ln = Natural logarithm, Y_i = Yield of sugarcane (ton/ha), X_{1i} = Human labour (man-days/ha), X_{2i} = Animal labour (pair-days/ha), X_{3i} = Seed (kg/ha), X_{4i}= Organic manure (kg/ha), X_{5i} = Urea (kg/ha), X_{6i} = TSP (kg/ha), X_{7i} = MP (kg/ha), X_{8i} =Furadan (kg/ha), X_{9i} = Irrigation cost (Tk/ha), $v_i - u_i$ = error term

The empirical model of farm specific technical inefficiency model is:

$$u_i = \delta_0 + \delta_1 z_{1i} + \delta_2 z_{2i} + \delta_3 z_{3i} + \delta_4 z_{4i} + \delta_5 z_{5i} + \delta_6 z_{6i} + \delta_7 z_{7i} + W_i \quad (6)$$

Where, z_{1i} = Experience in sugarcane farming (years), z_{2i} = Age of the operator (years), z_{3i} = Education level of the operator (year of schooling), z_{4i} = Visited by the field worker, z_{5i} = Farm size of the operator (ha), z_{6i} = Dummy for sugarcane training of the operator (1 = yes, 0 = otherwise), W_i are unobservable random variable, which are assumed to be independently distributed, obtained by truncation of the normal distribution with mean zero and unknown variance σ^2, such that u, is non-negative.

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

$$\sigma^2 = \sigma^2_u + \sigma^2_v \quad (7)$$

$$\gamma = \sigma^2_u / \sigma^2 \quad (8)$$

The maximum likelihood estimates (MLE) methods of the parameters of the stochastic production frontier were obtained by using the program, computer software, FRONTIER 4.1 (Coelli, 1996).

12. Results and Discussion

12.1 Socio- Economic Characteristics of the Sample Farmers:

Socio-economic characteristics of the sample farmers affect their production. It will therefore, be worthwhile to know the background information of the farmers who grow sugarcane and its intercrops. The socio-economic characteristics considered in the study were: age, educational status, family size, occupation, farm size etc.

A. Age: Age is an important factor for adoption of improved technologies. In the study areas, the highest percent of the farmers in the age group of 46-60 (38%) years followed by 30-45 (35%) years. The lowest percent of farmers were under the age of above 60 (3%) years (Table 12.1).

Table 12.1 socio-economic profile of the sugarcane farmers in the study areas

Items		Per of farmers
a. Age	Up to 30 years	24
	31-45 years	35
	46-60 years	38
	Above 60	3
b. Literacy	Illiteracy	14
	Primary	40
	Secondary	25
	SSC	14
	Above SSC	7
c. Occupation	Agriculture	80
	Agriculture+ Business	14
	Agriculture+Service	3
	Others*	3
d. Experience of cultivation (year)	Up to 5 years	5
	6-10 years	15
	11-20 years	35
	21-30 years	25
	Above 30 years	20
Family size	Small (1-4)	32
	Medium (5-7)	58
	Large(8 and above)	10

* Others mean rickshaw puller, van puller, labour etc.

B. Literacy level: The sample farmers were classified into five categories based on their educational level. Among the educated farmers 40 % were belonged to primary level, 25% secondary level, 14% SSC level and 7 % were above SSC level. Overall literacy rate was 86% and it was 1.21 times higher than national average of 71%.

C. Occupation: A good number of respondent farmers have various occupation such as agriculture; agriculture and business; agriculture and service and others for the livelihood. About 80% farmers were engaged solely on agriculture.

D. Experience (years): Most of the farmers (45%) were found to cultivate sugarcane for 16-30 years. About 30% farmers had experienced to cultivate sugarcane for 11-20 years.

E. Family Size: Family size included the member of respondent household and it was categorized are small, medium and large. About 58 of the respondent households were medium family size in the study areas. Only 10 percent respondent households were large family size.

12.2. Cost and Returns Analysis of sugarcane production

This section presents a detailed cost structure of sugarcane production and returns from sugarcane of all sample farmers are from mills zone, *goor* zone and chewing zone (juice and chewing) of Bangladesh. Use of different inputs namely human labour, power tiller and material inputs, carrying cost, interest on operating capital, land use cost were determined. In section 12.2.1 describes the cost of production and returns of sugarcane in mill zone. In section 12.2.2 presents cost and returns of sugarcane in *goor* zone. Section 12.2.3 interpreted the cost and returns of sugarcane in chewing zone. Moreover, in section 12.2.4 describes sugarcane with intercrops.

12.2.1. Cost and returns of sugarcane in mills zone

Among the 15 sugar mills, 4 zones (namely Thakurgaon, Natore, Faridpur and Chuadanga) were selected for this study considering the sugarcane cultivation intensity. Sugarcane seed is called sett, because vegetative parts of sugarcane are used as seed. Sett is the number of one factor in any production process. In mills zone average sets were used 6.31 ton /ha by spending Tk. 19,687 which constitutes 9.12 percent of the total cost (Table 12.2). In mills zone, 42.50% farmers used sets from own sources, 37.50% from mills and 20% from others (Table 12.5). Farmers used power tiller for land preparation to make the soil suitable for sugarcane plantation. On an average, Tk.7500 was used for land preparation. In sugarcane cultivation human labour is intensively used. Human labour is the most important and largely used in the production process for sugarcane, it is used in land preparation, planting, input use (fertilizer, manure and insecticides application),

Table 12.2 Per hectare average production cost of sugarcane in mills zone

Particulars	Quantity	Unit price(Tk.)	Total cost (Tk.)	% of Total cost
Sett (ton)	6.31	3120	19687.20	9.12
Tractor/power tiller cost (Tk.)			7500.00	3.47
Total labour (man days)	252	300	75600.00	35.02
Cowdung (ton)	0.50	3000	1500.00	0.69
Fertilizers & insecticides cost:			21762.00	10.08
Urea (kg)	270	16	4320.00	2.00
TSP (kg)	236	22	5192.00	2.41
MoP (kg)	190	15	2850.00	1.32
Zypsum (kg)	60	10	600.00	0.28
Zincsulphet (kg)	7	150	1050.00	0.49
Boron (kg)	7	200	1400.00	0.65
Bavistin (kg)	0.5	2200	1100.00	0.51
Furadan (kg)	20	150	3000.00	1.39
Regent (kg)	15	150	2250.00	1.04
Irrigation cost (Tk.)	0.5	-	8500.00	3.94
Carrying/Transport	20	-	13960.00	6.47
Total variable cost			**148509.20**	68.80
Land use cost			52500.00	24.32
Interest on operating capital			14850.92	6.88
Total cost			**215860.12**	100
Yield (ton)	70			
Gross Return		2950	**218400.00**	
Net Return (Cash cost basis)			69890.80	
Net Return (Full cost basis)			2539.88	
BCR (Cash cost basis)			1.47	
BCR (Full cost basis)			1.01	

Source: Field Survey: 2017-18

irrigation, mulching, earth up, weeding, cane tying, harvesting and transport/carrying *etc*.. In mills zone per hectare average labour was used 252 man-days and cost was Tk.75,600 which constitute 35.02 percent of the total cost (Table 12.2).. In sugarcane production, different types of fertilizers namely- Urea, TSP, MoP, Zypsum, Zinc Sulphate, Boron and different types of fungicides were used. Per hectare average used of Urea, TSP, MoP, Zypsum, Zinc Sulphate, Boron, Furadan were 270kg, 236 kg, 190 kg, 60 kg,7 kg, 7 kg and 20 kg. Total fertilizers and insecticides cost was Tk. 21,762/ha and shares 10.08 percent of the total cost. Irrigation cost and carrying costs were Tk.8500/ha and Tk.13960/ha. Land use cost and interest on operating cost were Tk.52,500/ha and Tk.14,850.92/ha which shares 24.32 and 6.88 percent of the total cost.

Per hectare average production cost in mills zone was Tk.2,15,860 and Tk.1,48,509 on the basis of full cost and cash cost. Average yield of sugarcane production was 70 ton/ha and gross return in mills zone was Tk. 2,18,400/ha. Net return in mills zone was Tk.69,890.80/ha and Tk.2540/ha on cash cost and full cost basis respectively. Average benefit cost ratio (BCR) was 1.47 and 1.01 on cash cost and full cost basis respectively (Table 12.2).

12.2.2. Cost and returns of sugarcane in *goor* zone

Four districts were selected namely Sirajgonj, Chapainawabganj, Bagerhat, Manikgonj for goor zone. Sugarcane is used for *goor* production in this zone.In *goor* zone per hectare average production cost of sugarcane was Tk.2,68,452.00on full cost basis where it was Tk. 1,96,320.00on cash cost basis. Human labour cost was the most important and the largest item of input costs. The average per hectare human labour was used 316 man-days and cost was Tk.94,650.00 which shares 35.26 percent of the total cost followed by land use cost Tk. 52,500 (19.56% of total cost) and sett cost was Tk. 29,000.00 (10.80 % of the total cost). Farmers normally used home supplied sets but sometimes they purchased it from others. In this zone, 52% farmers used sets from own

Table 12.3Per hectare average production cost of sugarcane in *goor* zone

Particulars	Quantity	Unit price(Tk.)	Total cost (Tk.)	% of Total cost
Sett (ton)	7.25	4000	29000.00	10.80
Tractor/power tiller cost (Tk.)	-		8287.50	3.09
Total labour (man days)	316	300	94650.00	35.26
Cowdung (ton)	3.66	5000	18300.00	6.82
Fertilizers & insecticides cost:			**22,713.50**	8.45
Urea (kg)	307.75	16	4924.00	1.83
TSP (kg)	218.75	22	4812.50	1.79
MoP (kg)	181	15	2715.00	1.01
Zypsum (kg)	82.25	10	822.50	0.31
Zincsulphet (kg)	8.75	140	1225.00	0.46
Boron (kg)	8.50	200	1700.00	0.63
Bavistin (kg)	1	2200	2200.00	0.82
Furadan (kg)	27.25	150	4087.50	1.52
Regent (kg)	17.5	130	2275.00	0.08
Irrigation cost (Tk.)	4	3000	12000.00	4.47
Carrying/Transport	-	-	9321.25	3.47
Total variable cost	-	-	**196320.25**	73.13
Land use cost	-	-	52500.00	19.56
Interest on operating capital	-	-	19632.02	7.31
Total cost			**268452.27**	100.00
Yield (ton)	85			
Gross Return		4000	**340000.00**	
Net Return (Cash cost basis)			143679.75	
Net Return (Full cost basis)			71547.72	
BCR (Cash cost basis)			1.73	
BCR (Full cost basis)			1.27	

Source: Field Survey: 2017-18

Sources and 48% purchased from others (Table 12.5). Cost of home supplied sets was determined by the opportunity cost principle. Sett cost was found to be different across the locations mainly due to variation in amounts of sett and planting systems. In *goor* zone average price of sett was observed Tk 4,000/ton. Per hectare average sett was used 7.25 ton and the cost was

Tk.29,000which shares 10.80 percent of the total cost (Table 12.3). Farmers usually used cowdung as manure. Average market price of cowdung was estimated Tk 5000 per ton. On an average, per hectare cowdung cost was Tk 18,300 which shares 6.82 percent of the total cost. Farmers used Urea, TSP, MoP, Zypsum, Zinc shulphate, Boron as fertilizers. On average, farmers spent per hectare Tk 22,713.50 for fertilizer and insecticides in sugarcane production (Table 12.3). Per hectare irrigation cost was Tk. 12,000 which shares 4.47 percent of the total cost.

On an average, per hectare yield of sugar cane in *goor* zone was 85 ton and gross return was Tk.3,40,000. Net return was determined by deducting all costs from gross return. The average net return was Tk.1,43,679/ha on cash cost and Tk. 71,547/ha on full cost basis. Undiscounted Benefit Cost Ratio (BCR) was found 1.73 and 1.27 in cash cost and full cost basis respectively (Table 12.3).

12.2.3. Cost and returns of sugarcane in chewing zone

In non mill zone Sugarcane are used for *goor* production and chewing purposes. Chewing cane is used for chewing and drinking purposes. BSRI Akh 41,BSRI Akh 42, Co 208, Q 69, Bombai etc., were used for chewing and drinking purposes because, these cane are soft and juicy.In this section cost and return analysis was donefor chewing cane. Four districts were selected namely Barisal, Gazipur, Chandpur and Habigonj districts under chewing cane zone considering chewing cane intensity. In chewing zone, average price of sett was considered Tk. 5,000/ton. Per hectare sett was used 8 ton and the sett cost was Tk.40,000 which shares 11.45 percent of the total cost. In this zone, 60% farmers used sets from their own sources and 40% from others (Table 12.5). Per hectare average human labour was used 386 man-days and cost was Tk.1,54,400 in chewing zone, which shares 44.22 percent of the total cost. The highest human labour was used in chewing zone compare to millzone and *goor* zone. Average uses of urea, TSP, MoP, Gypsum, Zinc sulphat, Boron, Furadan were 364kg, 350kg, 210kg, 106 kg, 10 kg, 8 kg, 40kg and 20kg respectively. Average fertilizers and insecticides cost was Tk.33,434 which is also higher than other zones. Irrigation cost and carrying/transport costs were Tk. 6,000/ha and Tk.12,190 which shares 1.72 and 3.49 percent of the total cost respectively (Table 12.4).Per hectare average production cost of chewing sugarcane were Tk.2,69,724 and Tk.3,49,196 on the basis of cash cost and full cost respectively. Average yield of sugarcane in chewing zone was 132 ton/ha and gross return was Tk. 6,60,000/ha. Net return was Tk. 3,90,276/ha and Tk.3,10,803/ha on the basis of cash cost and full cost basis respectively. Average benefit cost ratio (BCR) was 2.45 and 1.89 on cash cost and full cost basis respectively (Table 12.4).

Usually farmers of chewing zone invest higher amount of material cost and used higher amount of human labour for management practices compared to other zones. As a result they received higher amount of yield (Table 12.6 & Table 12.7).

Table 12.4Per hectare average production cost of sugarcane in chewing zone

Particulars	**Quantity**	**Unit price(Tk.)**	**Total cost (Tk.)**	**% of Total cost**
Sett (ton)	8	5000	40000.00	11.45
Tractor/power tiller cost (Tk.)			13700.00	3.92
Human labour (man days)	386	400	154400.00	44.22
Cowdung (ton)	5	2000	10000.00	2.86
Fertilizers & insecticides cost:			**33434 .00**	**9.59**
Urea (kg)	364	16	5824.00	1.67
TSP (kg)	350	22	7700.00	2.21
MoP (kg)	210	15	3150.00	0.90
Zypsum (kg)	106	10	1060.00	0.30
Zincsulphet (kg)	10	180	1800.00	0.52
Boron (kg)	8	200	1600.00	0.46
Bavistin (kg)	1.5	2200	3300.00	0.95
Furadan (kg)	40	150	6000.00	1.72
Regent (kg)	20	150	3000.00	0.86
Irrigation cost (Tk.)	3	2000	6000.00	1.72
Carrying/Transport			12190.00	3.49
Total variable cost			**269724.00**	77.24
Land use cost			52500.00	15.03
Interest on operating capital			26972.40	7.72
Total cost			**349196.40**	100.00
Yield (ton)	132			
Gross Return		5000	**660000.00**	
Net Return (Cash cost basis)			390276.00	
Net Return (Full cost basis)			310803.60	
BCR (Cash cost basis)			2.45	
BCR (Full cost basis)			1.89	

Source: Field Survey: 2017-18

Table12.5 Sources of sugarcane sets in different zones

Zones	Quantity (ton)	Sources of sets
Mills	6.31	37.5 % farmers purchased sets from mills. 42.5 % farmers used sets from own source. 20%farmers purchased setts from neighbor/relatives
Goor	7.25	52 % farmers used sets from own source 48%farmers purchased sets from neighbor/relatives
Chewing	8	60% farmers used sets from own source 40%farmers purchased sets from neighbor/relatives

Source: Field Survey: 2017-18

Table12.6Comparison of fertilizers use in different zones for sugarcane cultivation

Fertilizers and insecticides	Recommended doses of fertilizers	Fertilizers used by the farmers		
		Mill zone	*Goor* zone	Chewing zoone
		Qty (kg)	Qty(kg)	Qty(kg)
Urea	390	270	307.75	364
TSP	300	236	218.75	350
MoP	180	190	181.00	210
Zypsum	167	60	82.25	106
Zinc sulphate	11	7	8.75	10
Boron	7.50	7	8.50	8
Furadan	40	20	27.25	40
Regent	16.66	15	17.5	20

Table12.7 Per hectare cost and return analysis of sugarcane in different zones

Parameters	Mill zone	*Goor* zone	Chewing zone	Average
Total cost (Tk.) (Cash cost basis)	148509	196320	269724	204851
Total cost (Tk.) (Full cost basis)	215860	268452	349196	277836
Yield (ton/ha)	70	85	132	95.67
Price (Tk/ton)	3120	4000	5000	4040
Gross return (Tk.)	218400	340000	660000	406133
Net Return (Tk.) (Cash cost basis)	69890	143680	390276	201282
Net Return (Tk.) (Full cost basis)	2540	71548	310804	128297
BCR (Cash cost basis)	1.47	1.73	2.45	1.88
BCR (Full cost basis)	1.01	1.27	1.89	1.45

Source: Field Survey: 2017-18

12.2.4. Cost and returns of sugarcane with intercrops

Intercropping is a type of multiple cropping. It implies cultivation of more than one crop in a particular area during a specific period of time (Miah 1992). When two crops are interspaced with one another, the system is known as intercropping. In this system one crop is known as principal crop and the other is intercrop. The life period of principal crop is longer than the intercrop. Intercrop is sown or planted after the sowing or plantation of the main or principal crop. But intercrop is harvested before the harvesting of main crop. In this case sugarcane is main/principal crop and intercrops may be potato, tomato, onion, garlic, carrot, lentil, coriander etc. This system is the judicious utilization of time and space to increase total crop output per unit area. Intercropping is profitable practices. It increases total crop yield balancing the nutritional requirements, higher monetary return, and greater resource utilization and fulfils the diversified needs of the farmers (Sing, *et. al*., 1986).

Table 12.8 Per hectare average production cost of sugarcane with intercrops (potato) at Thakurgaon

Particulars	Sugarcane		Potato		Total Cost (Tk.)	% of Total cost
	Qty.	Total Cost (Tk.)	Qty.	Total Cost (Tk.)		
Sets/seeds(ton))	5.53	16313	0.66	11220	27533	13.60
Animal Labour (Pair days)	2	1400	-	-	1400	0.69
Tractor	3	11250	-	-	11250	5.56
Human Labour (Mandays)	236	82600	72	21600	104200	51.47
Cowdung (ton)	2	8400	63	3150	11550	5.71
Fertilizers:		**14224**		**6230**	**20454**	**10.10**
Urea (kg)	271	4336	82	1311	5647	2.79
TSP (kg)	237	5214	72	1584	6798	3.36
MOP (kg)	236	3540	89	1335	4875	2.41
Others Fertilizers (Tk.)		1134		2000	3134	1.55
Regent(kg)	13.5	2025		-	2025	1.00
Furadan (kg)	44	6600		-	6600	3.26
Irrigation cost (Tk.)	3	4800		3000	7800	3.85
Total variable cost		147612		45200	192812	95.25
Interest on operating cost		7380		2260	9640	4.75
Total cost:		**154992**		**47460**	**202452**	**100.00**
Yield (ton)	82.73	-	9.5	-		
Gross Return		**258125**		**95000**	**353125**	
Net Returns (Cash cost basis)		110513		49800	160313	
Net Returns (Full cost basis)		103133		47540	150673	
BCR (Cash cost basis)		1.75		2.10	1.83	
BCR: (Full cost basis)		1.67		2.0	1.74	

Source: Field Survey: 2017-18

Table 12.8revealed per hectare cost and return of sugarcane + potato cropping system. Per hectare total cost of production of sugarcane + potato wasTk.1,92,812 and Tk.202452 on cash cost and full cost basis. Costs of production of sugarcane and potato was Tk.1,47,612 and Tk.45,200 on cash cost and Tk.1,54,992 and Tk.47,460 on full cost basis respectively. Total man days requirement was 236 for sugarcane and 72 man-days for potato intercrop with sugarcane. Total human labour cost was Tk.1,04,200 per hectare which covers 51.47 percent of the total cost. Per hectare sets/seeds, fertilizers, and irrigation costs were Tk. 27,533, Tk. 20,454, Tk.7,800 respectively which correspondingly constitute 13.60,10.10 and 3.85 percent of the total cost. Per hectare gross return of sugarcane + potato was Tk. 3,53,125. Per hectare net returns and BCR observedTk.1,60,313 and 1.83 on cash cost basis and Tk. 1,50,672 and 1.74 on full cost basis respectively.

Table 12.9 Per hectare average production cost of sugarcane with intercrops (lentil) at Natore

Particulars	Sugarcane		Lentil		Total Cost (Tk.)	% of Total cost
	Qty.	Total Cost (Tk.)	Qty.	Total Cost (Tk.)		
Setts/seeds (ton)	5.25	15487	0.014	1400	16887	9.86
Animal Labour(Pair days)	2	2000	-	-	2000	1.17
Tractor	4	8000	-	-	8000	4.67
Human Labour (Man days)	260	78000	37	11100	89100	52.01
Manure/cowdung (ton)	1	4000	-	-	4000	2.33
Fertilizer:					17,208	10.05
Urea (Kg)	298	4768	20	320	5088	2.97
TSP (Kg)	240	5280	20	440	5720	3.34
MOP (Kg)	160	2400	20	300	2700	1.58
Other fertilizers (Tk.)		1700	-	2000	3700	2.16
Regent (Kg)	11	1760	-	-	1760	1.03
Furadan (Kg)	22	3300	-	-	3300	1.93
Irrigation cost	-	6000	-	2000	8000	4.67
Transport/carrying cost(Tk.)	-	12500	-	1000	13500	7.88
Total variable cost	**-**	**145195**	**-**	**18560**	**163755**	**95.6**
Interest on operating cost	-	7260	-	300	7560	4.41
Total cost:	**-**	**152455**	**-**	**18860**	**171315**	**100**
Yield(ton)	66.19		0.60		0	
Gross Return	**-**	**206500**	**-**	**40500**	**247000**	
Net Return(Cash cost basis)	-	61305	0	21940	83245	
Net Return(Full cost basis)	-	54045	-	21640	75685	
BCR(Cash cost basis)	-	1.42	-	2.18	1.80	
BCR(Full cost basis)	-	1.35	-	2.15	1.76	

Source: Field Survey: 2017-18

Table 12.9 displayed per hectare cost and return of lentil cropping systems. Total cost of production of sugarcane and lentil was Tk.1,52,455 and Tk.18,860 respectively on full cost basis. Per hectare total cost of production of sugarcane + lentil was Tk.1,63,755 and Tk.1,71,315 on cash cost and full cost basis respectively. In sugarcane + lentil intercropping per hectare human labour was used 297 man days and cost was Tk. 89,100 that constitutes 52.01 percent of the total cost. Material input costs of sets/seeds (Tk. 16,887), fertilizers (Tk. 17,208) and irrigation cost(Tk. 8,000) which share 9.86%, 10.05% and 4.67% of the total cost respectively (Table 12.9).

Gross returns were Tk.2,06,500/ha and Tk. 40,500/ha from sugarcane and lentil respectively and in total it was Tk. 2,47,000/ha. Net return and BCR of sugarcane+ lentil were Tk.83,245 and 1.80 respectively on cash cost basis. On the other hand, it was Tk.75985 and 1.76 on full cost basis respectively. However, sugarcane + lentil cropping system is an efficient and economically better cropping system in the mill zone area.

Table 12.10Per hectare average production cost of sugarcane with intercrops (coriander) at Natore

Items	Sugarcane		Coriander		Total Cost (Tk.)	% of Total cost
	Qty.	Total Cost (Tk.)	Qty.	Total Cost (Tk.)		
Sets/seeds (ton)	4.90	14455	0.006	480	14935	7.06
Tractor		8600			8600	4.06
Human Labour (man days)	230	69000	40	12000	81000	38.28
Manure/cowdung	120	6000			6000	2.84
Fertilizer:					16710	7.90
Urea (kg)	300	4800	40	640	5440	2.57
TSP(kg)	224	4928	36	792	5720	2.70
MOP(kg)	160	2400	30	450	2850	1.35
Other Fertilizers		1200		1500	2700	1.28
Regent/Insecticide (kg)	15	2400		1000	3400	1.61
Furadan (kg)	20	3000			3000	1.42
Irrigation cost		9000			9000	4.25
Carrying/Transport		2000			2000	0.95
Total variable cost:		127783		16862	144645	68.35
Interest on operating capital		12778.3	0	1686.2	14464.5	6.84
Land use cost		52500		0	52500	24.81
Total cost		193061.3	0	18548.2	211609.5	100.00
Yield (ton)	65.24		0.64		0	
Total Return		**203550**		**32000**	**235550**	
Net Return (Cash cost basis)		75767		15138	90905	
Net Return (Full cost basis)		10488.7		13451.8	23940.5	
BCR (Cash cost basis)		1.59		1.90	1.63	
BCR (Full cost basis)		1.05		1.73	1.11	

Source: Field Survey: 2017-18

Table 12.10 revealed cost and returns of sugarcane + coriander cropping system in Natore (mill zone). Total cost of production of sugarcane + coriander was Tk.2,11,609.50 on full cost and Tk.1,44,645/ha on cash cost basis. Per hectare human labour was used230 man-days in sugarcane and it was 40 man-days in coriander cultivation as intercrop. Per hectare human labour cost of sugarcane + coriander was Tk.81,000 which shares 38.28 percent of the total cost. Per hectare sets/seeds, fertilizers and irrigation costs were Tk.14,935, Tk.16,710 and Tk.9,000and correspondingly it contributed 7.07, 7.90 and 4.25 percent of the total cost respectively. Land use cost, transport cost, interest on operating capital were Tk.52,500, Tk.2,000 and Tk.14,464.50 respectively (Table 12.10).

Gross return from sugarcane was Tk.2,03,550/ha and from coriander it was Tk. 32,000/ha and total Tk.2,35,550/ha from sugarcane+ coriander cropping system. Net returns was Tk.90,905/ha on cash cost basis and Tk.23940.50/ha on full cost basis. Benefit –cost ratio of sugarcane+ coriander was 1.63 and 1.11 on cash and full cost basis respectively, which indicates that the cropping system sugarcane+ coriander was promising and profitable.

Table 12.11Per hectare average production cost of sugarcane with intercrops (Mungbean) at Bagerhat

	Sugarcane			Intercrop (Mungbean)			Total cost/ Return (Taka)	
Particulars	**Quantity**	**Unit price (Taka)**	**Cost/ Return (Taka)**	**Quantity**	**Unit price (Taka)**	**Cost/ Return (Taka)**		% of Total cost
Sett (ton)/seed (kg)	7.7	5000	38500	9.8	100	980	39480	14.15
Tractor/power tiller	-	-	8650				8650	3.10
Total labour (man days)	410	250	102500	49	250	12250	114750	41.12
Fertilizers& insecticides:							17249	6.18
Urea (kg)	378	16	6048				6048	2.17
TSP (kg)	238	22	5236				5236	1.88
MoP (kg)	127	15	1905				1905	0.68
Zypsum (kg)	130	10	1300				1300	0.47
Zincsulphet (kg)	7	180	1260				1260	0.45
Boron (kg)	7.5	200	1500				1500	0.54
Bavistin (kg)	0.5	2200	1100				1100	0.39
Furadan (kg)	23	150	3450				3450	1.24
Regent (kg)	20	200	4000				4000	1.43
Irrigation	5	1000	5000				5000	1.79
Carrying			10275			2000	12275	4.40
Total variable cost			190724			15230	190724	68.35
Land use cost			52500				52500	18.81
Interest on operating capital			19072			1523	20595	7.38
Total cost			262296			16753	279049	100.00
Yield (ton)	65	5000		0.64		43520		
Gross return			325000		6800		368520	
Net Return (Cash cost basis)			134276			28290	162566	
Net Return (Full cost basis)			62703.60			26767	89470.60	
BCR (Cash cost basis)			1.70			2.86	1.79	
BCR (Full cost basis)			1.24			2.60	1.32	

Source: Field Survey: 2017-18

Table 12.11 revealed cost and returns of sugarcane + mungbean cropping system in Bagerhat district (*goor* zone). Per hectare cost of sugarcane was estimated Tk.2,62,296 on full cost and Tk.1,90,724 on cash cost basis. Per hectare cost of mungbean was computed at Tk.16,753 on full cost and Tk.15,230 on cash cost basis. Per hectare cost of sugarcane + mungbean production accounted for Tk.2,79,049 on full cost basis and Tk.1,90,724 on cash cost basis. In total per hectare 459 man-days human labour was used in sugarcane+ mungbean cultivation and cost was Tk. 12,250, which shares 41.12 percent of the total cost. Per hectare material input costs sets/seeds, fertilizers and irrigation costs were Tk.39,480, Tk.17,249 and Tk.5,000 respectively

and correspondingly it contributed 14.15, 6.18 and 1.79 percent of the total cost of production. Land use cost, transport cost, interest on operating capital were Tk.52,500, Tk.12,275 and Tk.20,595 respectively (Table 12.11).

Table 12.12Per hectare average production cost of sugarcane with intercrops (carrot) at Manikgonj

Particulars	Sugarcane			Intercrop (Carrot)			Total cost/ Return (Taka)	% of Total cost
	Quantity	Unit price (Taka)	Cost/ Return (Taka)	Quantity	Unit price (Taka)	Cost/ Return (Taka)		
Sett (ton)/seed (kg)	7.65	4000	30600	4.4	1200	5280	35880	11.93
Tractor/power tiller	-	-	8500				8500	2.83
H. labour (man days)	330	320.	105600	25	400	10000	115600	38.45
Cowdung (ton)	2	5000	10000				10000	3.33
Fertilizers & insecticides:							**25199**	**8.38**
Urea (kg)	343	16	5488				5488	1.83
TSP(kg)	260	22	5720				5720	1.90
MoP(kg)	231	15	3465				3465	1.15
Zypsum (kg)	55	10	550				550	0.18
Zincsulphet (kg)	10	150	1500				1500	0.50
Boron (kg)	7	200	1400				1400	0.47
Bavistin (kg)	0.58	2200	1276				1276	0.42
Furadan (kg)	20	150	3000				3000	1.00
Regent	14	200	2800			5000	7800	2.59
Irrigation	4	3000	12000				12000	3.99
Carrying			8500			4900	13400	4.46
Total variable cost			200399			25180	**225579**	75.03
Land use cost			52500				52500	17.46
Ints. on ope.capital			20039.9			2518	22557.9	7.50
Total cost			272938.9			27698	**300636.9**	100
Yield (ton)	112			4.7				
Gross Return		4000	448000		10000	47000	**495000**	
Net return (Cash cost basis)			247601			21820	269421	
Net return (Full cost basis)			175061			19302	194363	
BCR (Cash cost basis)			2.24			1.87	2.19	
BCR (Full cost basis)			1.64			1.70	1.65	

Source: Field Survey: 2017-18

Gross return was Tk.3,25,000/ha from sugarcane, Tk. 43,520/ha from mungbean and Tk. 3,68,520/ha from sugarcane+ coriander cropping system. Net returns was Tk.1,62,566/ha on

cash cost and Tk.89,470/ha on full cost basis. Benefit –cost ratio of sugarcane + coriander was 1.79 and 1.32 on cash and full cost basis respectively (Table 12.11), which indicates that the cropping system sugarcane+ mungbean was promising and profitable.

Table 12.12 revealed cost and returns of sugarcane + carrot cropping system in Manikgonj district (*goor* zone). Per hectare cost of sugarcane was estimated at Tk.2,72,938.9 on full cost and Tk.2,00,399 on cash basis. Per hectare cost of carrot was Tk.27,698 and Tk.25,180/ha on full cost and cash cost basis respectively. Total cost of production of sugarcane + carrot was Tk.3,00,636.90 on full cost and Tk. 2,25,579/ha on cash cost basis. Per hectare human labour was used 330 man-days in sugarcane and 25 man-days in carrot cultivation as intercrop. Total human labour cost of sugarcane + carrot was Tk.1,15,600 per hectare which shares 38.45 percent of the total cost. Per hectare material input costs sets/seeds, fertilizers& insecticides and irrigation costs were Tk.35,880, Tk.25,199and Tk.12,000 and correspondingly itcontributed11.93, 8.38 and 3.99 percent of the total cost respectively. Land use cost, transport cost, interest on operating capital were Tk.52,500, Tk.8500 and Tk.22,557.90 per hectare which shared 1.46%, 4.46% and 7.50% of the total cost respectively (Table 12.12).

Gross return was Tk.4,48,000 /ha from sugarcane, Tk. 47,000/ha from carrot and Tk.,4,95,000/ha from sugarcane + carrot cropping system. Net returns was Tk.2,69,421/ha on cash cost and Tk.1,94,363.10/ha on full cost basis. Benefit –cost ratio of sugarcane+ carrot was 2.19 and 1.65 on cash and full cost basis respectively, which indicates that the cropping system sugarcane+ carrot was promising and profitable at Manikgonj district.

Table 12.13 displayed cost and returns of sugarcane + garlic cropping system in Chapai Nawabganj district (*goor* zone). Per hectare cost of sugarcane was estimated Tk.1,91,243on cash cost and Tk.2,62,867 on full cost basis. Cost of garlic was Tk.1,06,370 on cash cost and Tk.96,700 per hectare on full cost basis respectively. Total cost of production of sugarcane + garlic was Tk.2,87,943/ha on cash cost and Tk.3,69,237 on full cost basis. Per hectare 250 man-days human labour was used in sugarcane and 100 man-days in garlic cultivation as intercrop. Per hectare total human labour cost of sugarcane + garlic was Tk.1,18,750 which shared 32.16 percent of the total cost. Per hectare material input costs setts/seeds, fertilizers & insecticides and irrigation costs were Tk.83,700, Tk.21,093and Tk.20,000 and correspondingly it contributed 22.67, 5.71 and 5.42 percentof the total cost respectively.Per hectare land use cost, transport cost, interest on operating capital was Tk.52,500, Tk.18,500 and Tk.28,784 respectively (Table 12.13).

Table 12.13Per hectare average production cost of sugarcane with intercrops (garlic) at Chapai Nawabgonj

Particulars	Sugarcane			Intercrop (Garlic)			Total cost/ Return (Taka)	% of Total cost
	Quantity	Unit price (Taka)	Cost/ Return (Taka)	Quantity	Unit price (Taka)	Cost/ Return (Taka)		
Sett (ton)/seed (kg)	7.8	4000	31200	350	150	52500	83700	22.67
Tractor/power tiller	-	-	8000				8000	2.17
H. labour (man days)	375	250	93750	100	250	25000	118750	32.16
Cowdung (ton)	2	5000	10000				10000	2.71
Fertilizers & insecticides:							**21093**	**5.71**
Urea (kg)	302	16	4832				4832	1.31
TSP (kg)	235	22	5170				5170	1.40
MoP (kg)	150	15	2250				2250	0.61
Zypsum (kg)	54	10	540				540	0.15
Zincsulphet (kg)	16	150	2400				2400	0.65
Boron (kg)	10	200	2000				2000	0.54
Bavistin (kg)	0.58	2200	1276				1276	0.35
Furadan (kg)	17.5	150	2625				2625	0.71
Regent			2700			5200	7900	2.14
Irrigation	4	3000	12000			8000	20000	5.42
Carrying/transport cost			12500			6000	18500	5.01
Total variable cost			191243			96700	287943	
Land use cost			52500				52500	14.22
Ints. on ope.capital			19124.3			9670	28794.3	7.79
Total cost			262867			106370	369237.3	100
Yield (ton)	72			5.86				
Gross Return		**4000**	**288000**		**42500**	**249050**	**537050**	
Net Return (Cash cost basis)			96757			152350	249107	
Net Return (Full cost basis)			25132.7			142680	167812.7	
BCR (Cash cost basis)			1.51			2.58	1.87	
BCR (Full cost basis)			1.10			2.34	1.45	

Source: Field Survey: 2017-18

Per hectare gross return was Tk.2,88,000 from sugarcane, Tk.2,49,050/ha from garlic and total Tk.5,37,050 from sugarcane + garlic cropping system. Per hectare net returns was Tk.2,49,107 on cash cost and Tk.1,67,812 on full cost basis. Benefit –cost ratio of sugarcane+ garlic was 1.87and 1.45 on cash and full cost basis respectively, which indicates that the cropping system sugarcane+ garlic was promising and profitable.

Table 12.14Per hectare average production cost of sugarcane with intercrops of potato at Habiganj district (Chewing zone)

Particulars	Sugarcane		Potato		Total Cost (Tk.)	% of Total cost
	Qty.	Total Cost (Tk.)	Qty.	Total Cost (Tk.)		
Sets/ seeds(ton))	8	40000	0.68	27200	67200	20.17
Animal Labour (Pair days)	3	2100	-		2100	0.63
Tractor	3	12000			12000	3.60
Human Labour (Man days)	250	87500	60	21000	108500	32.57
Cowdung (ton)	3	15000	1	5000	20000	6.00
Fertilizers & insecticides:					**31305**	9.40
Urea(kg)	320	5120	70	1120	6240	1.87
TSP(kg)	320	7040	50	1100	8140	2.44
MOP(kg)	225	3375	70	1050	4425	1.33
Others Fertilizers (Tk.)		2000		1500	3500	1.05
Regent(kg)	20	3000			3000	0.90
Furadan (kg)	40	6000			6000	1.80
Irrigation cost (Tk.)	3	9000		3000	12000	3.60
Caring / Transport				2000	2000	0.60
Total variable cost		192135		62970	255105	76.58
Interest on operating cost		19213.5		6297	25510.5	7.66
Land use cost		52500			52500	15.76
Total cost:		**263848.5**		**69267**	**333115.5**	100.00
Yield (ton)	125		10		0	
Gross Return		**625000**		**200000**	**825000**	
Net Returns (Cash cost basis)		432865		137030	569895	
Net Returns (Full cost basis)		361151.5		130733	491884.5	
BCR (Cash cost basis)		3.25		3.18	3.23	
BCR: (Full cost basis)		2.37		2.89	2.48	

Source: Field Survey: 2017-18

Table 12.14 revealed cost and returns of sugarcane + potato cropping system in Habiganj district (chewing zone). Per hectare cost of sugarcane was estimated at Tk.1,92,135on cash cost and Tk.2,63,848 on full cost basis. Cost of potato was Tk.62,970/ha and Tk.69,267/ha on cash cost and full cost basis respectively. Total cost of production of sugarcane + potato was Tk.2,55,105/ha on cash cost and Tk.3,33,115/ha on full cost basis. Per hectare 250 man-days human labour was used in sugarcane and 60 man-days in potato cultivation as intercrop. Per hectare total human labour cost of sugarcane + potato was Tk.1,08,500 which shared 32.57 percent of the total cost. Per hectare material input costs sets/seeds, fertilizers & insecticides and irrigation costs were Tk.67,200, Tk.31,305and Tk.12,000 and correspondingly it contributed 20.17, 9.40 and 3.60 percent of the total cost respectively. Per hectare land use cost, transport

Table 12.15Per hectare average production cost of sugarcane with intercrops of tomato at Chandpur district (Chewing zone)

Particulars	Sugarcane		Tomato		Total Cost (Tk.)	% of Total cost
	Qty.	Total Cost (Tk.)	Qty.	Total Cost (Tk.)		
Sets/ seeds(ton))	8	40000	150.00	6000	46000	12.03
Animal Labour (Pair days)	3	2100	-		2100	0.55
Tractor	3	12000			12000	3.14
Human Labour (Man days)	320	112000	120	42000	154000	40.27
Cowdung (ton)	3	15000	2	10000	25000	6.54
Fertilizers & insecticides:					**40840**	10.68
Urea(kg)	350	5600	250	4000	9600	2.51
TSP(kg)	320	7040	225	4950	11990	3.14
MOP(kg)	225	3375	125	1875	5250	1.37
Others Fertilizers & insecticides		2000		3000	5000	1.31
Regent (kg)	20	3000			3000	0.78
Furadan (kg)	40	6000			6000	1.57
Irrigation cost (Tk.)	3	12000		4000	16000	4.18
Harvesting/Carrying/Transport				4000	4000	1.05
Total variable cost		220115		79825	299940	78.43
Interest on operating cost		22011.5		7982.5	29994	7.84
Land use cost		52500			52500	13.73
Total cost:		**294626.5**		**87807.5**	**382434**	100.00
Yield (ton)	122		12		0	
Gross Return		**610000**		**360000**	**970000**	
Net Returns (Cash cost basis)		389885		280175	670060	
Net Returns (Full cost basis)		315373.5		272192.5	587566	
BCR (Cash cost basis)		2.77		4.51	3.23	
BCR: (Full cost basis)		2.07		4.10	2.54	

Source: Field Survey: 2017-18

cost, interest on operating capital were Tk.52,500, Tk.2,000 and Tk.25,510 respectively (Table 12.14). Per hectare gross return was Tk.6,25,000 from sugarcane, Tk.2,00,000 from potato and total gross return was Tk. 8,25,000 from sugarcane + potato cropping system. Per hectare net returns was Tk.5,69,895 on cash cost and Tk.4,91,884 on full cost basis. Benefit –cost ratio of sugarcane+ potato was 3.23 and 2.48 on cash and full cost basis respectively (Table 12.14), which indicates that the cropping system sugarcane+ potato was promising and profitable.

Table 12.15 revealed cost and returns of sugarcane + tomato cropping system in Chandpur district. Per hectare cost of sugarcane was estimated at Tk.2,20,115on cash cost and Tk.2,94,626 on full cost basis. Cost of tomato was Tk.79,825/ha and Tk. **87,807**/ha on cash cost and full cost

basis respectively. Total cost of production of sugarcane + tomato was Tk.2,99,940/ha on cash cost and Tk.3,82,434**/ha** on full cost basis. Per hectare 320 man-days human labour was used in sugarcane and 120 man-days was used in tomato cultivation as intercrop. Per hectare total human labour cost of sugarcane + tomato was Tk.1,54,000 which shared 40.27 percent of the total cost. Per hectare material input costs sets/seeds, fertilizers & insecticides and irrigation costs were Tk.46,000, Tk.40,804and Tk.16,000 and correspondingly it contributed 12.03, 10.68 and 4.18 percent of the total cost respectively. Per hectare land use cost, transport cost, interest on operating capital was Tk.52,500, Tk.4,000 and Tk.29,994 respectively (Table 12.15).

Per hectare gross return was Tk.6,00,000 from sugarcane, Tk.3,60,000 from tomato and total gross return was Tk.9,70,000 from sugarcane + tomato cropping system. Per hectare net return was Tk.6,70,060 on cash cost and Tk.5,87,566 on full cost basis. Benefit –cost ratio of sugarcane+ tomato was 3.23 and 2.54 on cash and full cost basis respectively (Table 12.15), which indicates that the cropping system sugarcane+ tomato was promising and profitable.

Table 12.16 Comparative performance analysis of sole sugarcane and with intercrops in different zones

Parameters	Mills zone				*Goor* zone				Chewing zone		
	Sole Sugarcane	Sugarcane +potato	Sugarcane +lentil	Sugarcane +coriander	Sole Sugarcane	Sugarcane +M. bean	Sugarcane +carrot	Sugarcane +garlic	Sole Sugarcane	Sugarcane +Potato	Sugarcane +Tomato
Yield(t/ha):											
Sugarcane	70	82.73	66.19	65.24	85	65	112	72	132	125	122
Intercrop	-	9.50	0.60	0.64	-	0.64	4.7	5.86	-	10	12
Price (Tk./ton):											
Sugarcane	3120	3120	3120	3120	4000	5000	4000	4000	5000	5000	5000
Intercrop	-	10000	67500	50000	-	68000	10000	42500	-	20000	30000
Value of product (Tk):											
Sugarcane	218400	258125	206500	203550	340000	325000	448000	288000	660000	625000	610000
Intercrop	-	95000	40500	32000	-	43520	47000	249050	-	200000	360000
Gross Return	218400	353125	247000	235550	340000	368520	495000	537050	660000	825000	970000
Total cost:											
Cash cost basis	148509	192812	163755	144645	196320	190724	225579	287943	269724	255105	299940
Full cost basis	215860	202452	171315	211609	268452	279049	300636	369237	349196	333115	382434
Net Return:											
Cash cost basis	69890	160313	247000	90905	143679	162566	495000	249107	390276	569895	670060
Full cost basis	2539	150673	83245	23941	71547	89470	269421	167812	310803	491885	587566
BCR (undiscounted):											
Cash cost basis	1.47	1.83	1.80	1.63	1.73	1.79	2.19	1.87	2.45	3.23	3.23
Full cost basis	1.01	1.74	1.76	1.11	1.27	1.32	1.65	1.45	1.89	2.48	2.54

Source: Field Survey: 2017-18

12.3. Determinants of Farm Level Technical Efficiency of Sugarcane Farmers

The concept of efficiency is at the core of economic theory. The theory of production economics is concerned with optimization and optimization implies efficiency. Efficiency is an important issue of productivity growth in the agriculture based economy of developing countries. Definition of a technical efficiency reflects the ability of a farm to obtain the maximum possible output from a given level of inputs and production technology. It is a relative concept, since each farm's production performance is compared to a best- practice input-output relationship or production frontier. A farm is technically inefficient in the sense that if it fails to produce maximum output from a given level of input. Technical inefficiency is then measured as the deviation of an individual farm from the best-practice frontier.

The technical efficiency in production was estimated by using the stochastic frontier production. The primary advantage of a stochastic frontier production function is that it enables one to estimate U_i (non-negative random variable which is under the control of the farm) and therefore also to estimate farm specific technical efficiencies. The measure of technical efficiency is equivalent to the ratio of the production of the ith farm to the corresponding production value if the farm effect Ui were zero.

12.3.1 Maximum Likelihood Estimates of Farm-specific Stochastic Frontier Production Function and Inefficiency Model

The maximum likelihood estimates (MLE) methods of the parameters of the stochastic production frontier were obtained using the program, computer software, FRONTIER 4.1 (Coelli, 1996). Asides from estimates of coefficients in the model, the output also provides other variance parameters such as sigma squared (σ^2), gama (γ) and log likelihood function. To estimate the farm specific technical efficiency for sugarcane production in the study area, per hectare yield as dependent variable and other independent variables were standardized on the basis of per hectare of land. The maximum likelihood estimates for the parameters of the Cobb-Douglas stochastic frontier production function for the sugarcane farmers are presented Table 12.17.

In this study to estimate farm specific technical efficiency for sugarcane production, the stochastic frontier production function was used. The empirical results indicated that the coefficients of human labour, power tiller, seed, cowdung, Urea,TSP,Furadan 5G and irrigation cost were positive and significant, while that of MP was positive but not significant.

At 1% level of significance, the coefficients of human labour, seed, cowdung, Urea,TSP, Furadan 5G and irrigation cost were positive. In other words the elasticity of human labour, seed, cowdung, urea, TSP, Furadan 5G and irrigation cost were 0.364, 0.105, 0.005, 0.168, 0.110, 0.023 and 0.013 respectively. It implied that human labour, seed, cowdung, Urea, TSP,Furadan 5G and irrigation cost had significant and positive impact on sugarcane production. The yield of

sugarcane would increase by 0.364, 0.105, 0.005, 0.168, 0.110, 0.023 and 0.013 percent if the farmers apply 1percent additional human labour, seed, ocowdung, urea, Furadan 5G and irrigation cost respectively. Moreover, the coefficient of dummy variables D_2 (Chewing zone =1 and others =0) was found positive and significant at 1 % level. This implied that sugarcane production is higher in Chewing zone that of other locations. This is because the farmers of Chewing zone location are more efficient and advanced in sugarcane production than farmers of other locations and got highest BCR (Table 12.4). On the other hand the dummy variable $D_1$of mills zone was negative and significant.

Table 12.17 Maximum likelihood estimates of the stochastic Cobb-Douglas frontier production and technical inefficiency model for sugarcane

Independent variables	Parameters	Coefficients	Standard error	t-ratio
Constant	β_0	4.672	0.569	10.18
Ln Human labour	β_1	0.364*	0.028	12.98
Ln Power tiller	β_2	0.075**	0.031	2.380
Ln Seed	β_3	0.105*	0.031	3.371
Ln Organic manure	β_4	0.005*	0.002	2.527
Ln Urea	β_5	0.168*	0.065	2.576
Ln TSP	β_6	0.110*	0.032	3.133
Ln MP	β_7	0.0531	0.030	1.794
Ln Furadan 5G	β_8	0.023*	0.007	3.109
Ln Irrgation	β_9	0.013*	0.002	5.499
Dummy for location (Millzone=1, others=0)D_1	β_{10}	-0.059**	0.024	-2.460
Dummy for location (Chewing zone=1, others=0) D_2	β_{11}	0.081*	0.024	3.358
Technical inefficiency model:				
Constant	δ_0	0.329	0.267	1.232
Experience	δ_1	-0.0013**	0.0008	-1.606
Age	δ_2	-0.002*	0.0007	-2.837
Education (year)	δ_3	-0.0008	0.0017	-0.487
Visit by field worker	δ_4	-0.030*	0.0071	-4.233
Farm size	δ_5	-0.0256*	0.0100	-2.549
Dummy for sugarcane training (1=Yes, 0= otherwise)	δ_6	-0.026**	0.013	-1.925
Variance parameters :				
Sigma- squared	σ^2	0.097*	0.008	12.12
Gamma	γ	0.233	0.649	0.359
Log likelihood function		269.85		

* and ** indicatesignificant at 1% and 5% probability; Source: Field survey 2017-18)

This implied that the farmers of mills zone was not efficient than farmers of other locations. At 5% level of significance the coefficients of power tiller was positive and significant. This indicates that the elasticity of power tiller was 0.075, which was playing a significant positive role on sugarcane production. It further implied that holding other things remaining same, the yield of sugarcane would increase by 0.075 percent as farmers would apply 1 percent additional power tiller cost.

The coefficients of the explanatory variable in the model for the inefficiency effects are presented in the Table 12.17. The coefficient for the experience and age were negative and significant, which implied that the inefficiency effects decrease with the increase of the experiences and age of farm operators of sugarcane. In other words, technical efficiency increased with the increase of experiences and age of the farmers. The farmers, who had greater experience about sugarcane production and older were technically more efficient than less experienced and younger farmers in managing and allocating productive resources. This result conforms to result of similar studies (Sumi*et al.* 2004). It can be said, however, that with the increase of age of farmers the efficiency of farmers tends to increases. This result is in line with those of Rao *et al*. (2003), Hussain (1999) and Coelli (1996). According to them the negative coefficients suggest that as the age, education increases, the inefficiency decreases. The coefficient for the education variable was negative, which indicates that the farmers with greater years of formal schooling tend to be more technically efficient. This indicates that the farmers with more education respond more readily in using the new technology and produce output closer to the frontier. This result is similar to that of Seyoum *et al.* 1998; Dey, *et al*. 2000; Pagan, 2001. The coefficient for the visit by the field worker was 0.03 and negative at one percent level of significance. This implied that the regular visit by field workers to the farmers' sugarcane plot tends to decrease inefficiency or increase efficiency. This is similar to that of Rahman *et al*. (2000), Chaudhry (2001), and Islam (2003). The estimated coefficient of the farm size variable is 0 .026 and negative at five percent level of significance, which indicated that the increase of sugarcane farm size tends to decrease inefficiency or increase efficiency. This is similar to that of Rahman *et al.* (2000), Ahmed *et al*. (2002). Training improves skills and the result supports that professional training reduces inefficiency. The coefficient of sugarcane training (D_t) was negative and significant at 5% level. It indicated that the training on sugarcane production reduced the production inefficiency and increased the technical efficiencies of sugarcane production. If a farmer gets more training programs, his level of inefficiencies would decrease. The estimated values of the variance parameters (σ andγ)were large and significantly different from zero, which indicated a good fit and correctness of the specified distributional assumption.

12.3.2 Maximum Likelihood Estimates of Location-specific Stochastic Frontier Production Function and Inefficiency Model

Estimation of location specific technical efficiency for sugarcane is essential for drawing appropriate policy for the location. If we find out the significance of efficiency differences between locations then we will be able to identify the factors which are responsible for those differences. The maximum likelihood estimates of the coefficients of location specific stochastic Cobb- Douglas production frontier and technical inefficiency model is shown in Table 12.18

The empirical result indicated that at chewing zone, the coefficients of human labour, seed, cowdung, urea, TSP,MP, Furadan 5G and irrigation costs were positive and significant, while that of power tiller cost was positive but not significant. It indicated that human labour, seed, cowdung, urea, TSP,MP, Furadan 5G and irrigation costs had significant and positive impacts on sugarcane production at chewing zone.

At 1% level of significance human labour had the largest positive coefficient compared to other inputs. In other words, the elasticity of human labour (0.42) was the biggest amount than all other inputs at chewing zone. Holding other things constant, the yield of sugarcane would increase by 0.415% as farmers used 1% additional human labour in different types of management practices like, weeding, mulching, properly fertilizer application, insect and pest control (mechanical control by hand), tying, etc. At 1% level of significance, the coefficients of seed (0.245), cowdung (0.012), TSP (0.114), MP (0.102), Furadan 5G (0.022) and irrigation cost (0.011) were positive implying that holding other things constant, the yield of sugarcane at chewing zone would increase by 0.245, 0.0120, 0.114, 0.102,0.022 and 0.01 percent as farmers increase 1% additional seed, cowdung, TSP, MP, Furadan 5G and irrigation cost respectively. The coefficient of urea (0.167) was significant at 5% level, implying that holding other things constant, the yield of sugarcane would increase by 0.17 percent as farmers would apply 1% additional urea. In technical inefficiency effect the coefficient for the experience (0.017), age (0.029) were negative and significant. This indicated that the farmers, who had greater experience about sugarcane production, older farmers were technically more efficient than the less experienced, younger less. The coefficient of farm size (0.035) had negative effect at 5% lel significant. This indicated that large farmers were technically more efficient than the small farmers.

The coefficient of the field visit by the field worker was negative (0.049) and significant at 1% level which indicated that the field visit could increase the technical efficiency. The farmers who are in touch with the extension workers in order to seek advice are more efficient in sugarcane production. The coefficient of dummy training was negative (0.04) and significant at 1% level significant, which indicated that the training on sugarcane production increased the technical efficiency of the sugarcane farmers.

At mills zone, the coefficients of human labour, seed urea, MP and irrigation cost were positive and significant, while that of power tiller, cowdung and TSP were positive but not significant. It indicated that human labour, seed urea, MP and irrigation costs had positive and significant impact on sugarcane production at mills zone. On the other hand the coefficient of Furadan 5G was negative but not significant. At 1% level of significance the coefficients of human labour (0.22), seed (0.17), urea (0.14) and MP (0.15) were positive implying that holding other things constant, the yield of sugarcane at mills zone would increase by 0.22, 0.17, 0.14 and 0.15 percent as farmers increased 1% additional human labour, seed urea and MP.

Table 12.18 Maximum likelihood estimates for parameters of location-specific Cobb-Douglas stochastic frontier production and technical inefficiency model for sugarcane

Independent variables	Parameters	Locations		
		Chewing zone	Mills zone	Goor zone
Constant	β_0	6.845 (0.762)	6.709 (0.741)	4.872(0.979)
Ln Human labour	β_1	0.415* (0.040)	0.222* (0.041)	0.299*(0.053)
Ln Power tiller	β_2	0.002 (0.069)	0.087 (0.053)	0.029(0.045)
Ln Seed	β_3	0.245* (0.095)	0.172* (0.062)	0.148*(0.038)
Ln Cowdung	β_4	0.012* (0.002)	0.005 (0.004)	0.082*(0.024)
Ln Urea	β_5	0.167** (0.082)	0.139* (0.052)	0.026(0.167)
Ln TSP	β_6	0.114* (0.042)	0.008 (0.054)	0.126*(0.043)
Ln MP	β_7	0.102* (0.023)	0.145* (0.053)	0.059(0.044)
Ln Furadan 5G	β_8	0.022* (0.007)	- 0.005 (0.025)	0.066*(0.026)
Ln Irrgation	β_9	0.011* (0.002)	0.017** (0.008)	0.025*(0.004)
Technical inefficiency model:				
Constant	δ_0	0.512 (0.301)	0.178 (0.108)	0.065(0.162)
Experience	δ_1	-0.017 ** (0.007)	- 0.002 (0.002)	-0.015* (0.006)
Age	δ_2	-0.029* (0.011)	0.0.001 (0.001)	-0.004(0.002)
Education (year)	δ_3	- 0.020 (0.019)	0.0001 (0.003)	-0.022*(0.007)
Visit by field worker	δ_4	-0.049* (0.015)	- 0.030 ** (0.015)	-0.102**(0.052)
Farm size	δ_5	-0.035** (0.016)	0.012 (0.017)	-0.027**(0.014)
Dummy for sugarcane training (1=Yes, 0= otherwise) Dt	δ_6	-0.037 (0.013)*	- 0.066*(0.023)	-0.072**(0.037)
Variance parameters :				
Sigma- squared	σ^2	0.009* (0.003)	0.009* (0.002)	0.009*(0.0030)
Gamma	γ	0.366 (0.274)	0.002 (1.284)	0.331(0.259)
Log likelihood function		114.199	89.86	104.00

Source: Field survey (2017-18)

* & ** indicate significant at 1% and 5% level of proba.. Figures in the parentheses indicate standard error

The coefficient of sugarcane irrigation cost at mills zone was (0.027) positive and significant at 5% level, which indicated that other things remaining the same; the yield of sugarcane would increase by 0.02 percent as farmers would increase 1% irrigation cost in sugarcane plot. In the technical inefficiency effect the coefficient of dummy D_t was (0.06) negative and significant at 1% level, which indicated that the trained farmers could increase technical efficiency. At goor zone in sugarcane production, the coefficients of human labour, seed, cowdung, TSP, Furadan and irrigation cost were positive and significant, while that of power tiller, urea, and MP were positive but not significant. It indicated that human labour, seed, cowdung, TSP, Furadan and irrigation cost had positive and significant impacts on sugarcane production at goor zone. At 1% level of significance human labour had the largest positive coefficient compared to other inputs. In other words, the elasticity of human labour (0.29) was the biggest amount than all other inputs at *goor* zone. Holding other things constant, the yield of sugarcane would increase by 0.29% as farmers used 1% additional human labour in different types of management practices like, weeding, mulching, properly fertilizer application, insect and pest control (mechanical control by hand), tying, etc. At 1% level of significance the coefficients of seed (0.15), cowdung (0.08),TSP (0.126), Furadan(.066) and irrigation cost (0.03) were positive indicating that holding other things constant, the yield of sugarcane would increase by 0.154, 0.08, 0.126, 0.066 and 0.025 percent as farmers would apply 1% additional seed, cowdung, TSP, Furadan and irrigation cost respectively (Table 12.18).

In technical inefficiency model the coefficients of experience of *goor* zone and chewing were negative and significant, at mills zone it was negative also which implied that the experience of sugarcane farmers tends decrease the sugarcane production inefficiencies or increase efficiencies. The coefficients of education and farm size at chewing zone was negative and goor zone it was negative and significant which indicates that an increase of education decreases the inefficiencies of sugarcane production. The coefficients of farm size of *goor* zone and chewing zone was negative and significant which indicated that farm size decreases the inefficiencies of sugarcane production and increases the efficiencies. The coefficients of field visit and dummy for sugarcane training of three locations was negative and significant which indicated that the regular visit by field workers to the farmers' sugarcane plot and sugarcane training tends to decrease inefficiency or increase efficiency. When a farmer got training on sugarcane production, then his knowledge increased and he can follow the appropriate measure on sugarcane production and ultimate his technical efficiency increased. At the same way, the field worker visited the farmers plot and advised them properly, as a result technical efficiency of that farmer increased. This is similar to that of Rahman *et al*. (2000), Chaudhry (2001), and Islam (2003). The variance parameters sigma-squared was positive and significant at 1% level of significance which indicated a good fit and correctness of the specified distributional assumption.

12.3.3 Maximum likelihood estimates of farm size-specific stochastic frontier production function and inefficiency model

The maximum likelihood estimates o f the coefficients of farm-size specific stochastic Cobb-Douglas production frontier and technical inefficiency model are presented in Table 12.19. At 1% level of significance, the coefficient of human labour (0.12) was positive and significance for large sugarcane farmers. It indicated that other things remaining constant, the yield of large farmers would increase by 0.12 percent as farmers used 1% additional human labour. At 1% level of significance, the coefficients of power tiller (0.19), seed (0.08), cowdung (0.03), MP (0.17) and irrigation cost (0.04) were positive (Table 12.13) implying that holding other things constant, the yield of sugarcane would increase by 0.19, 0.08, 0.03, 0.179 and 0.045 percent as large farmers would apply 1 percent additional power tiller, seed, organic manure, MP and irrigation cost respectively.

In medium farm categories, the coefficients of human labour, power tiller, seed, cowdung and irrigation cost were positive and significant, while that of urea, TSP, MP and Furadan 5G were positive but not significant. At 1% level of significance, human labour had the largest positive coefficient compared to other inputs. In other words, the elasticity of human labour (0.24) was the biggest among all inputs, implying that human labour had positively the greatest impacts on sugarcane production for medium farmers. Holding other things constant, the yield of sugarcane would increase by 0.24 percent as farmers would apply 1% additional human labour. At 1% level of significance, the coefficients of power tiller (0.073), seed (0.14), cowdung (0.006) and irrigation cost (0.01) were positive implying that holding other things constant, the yield of sugarcane would increase by 0.07, 0.14, 0.006 and 0.01 percent as farmers would apply 1% additional power tiller, seed, cowdung and irrigation cost respectively.

The empirical results of the small farmers indicated that the coefficients of human labour, power tiller, cowdung, MP, Furadan 5G and irrigation cost were positive and significant, while that of urea and TSP were positive but not significant. It indicated that human labour, power tiller, cowdung, MP, Furadan 5G and irrigation cost had significant and positive impacts on sugarcane production for small farmers. At 1% level of significance human labour had the largest and positive coefficient compared to other inputs.

In other words, the elasticity of human labour (0.45) for small farmers was the biggest of all other groups. Other things being constant the yield of sugarcane would increase by 0.45% as farmers used 1% additional human labour in different types of management practices like, seed cutting, land preparation, planting, weeding, mulching, application of fertilizers, tying, earthling up, harvesting and carrying. At 1% level of significance, the coefficients of power tiller, cowdung, MP, Furadan 5G and irrigation cost were positive (Table 12.19) implying that holding other things constant, the yield of sugarcane would increase by 0.139, 0.008, 0.10, 0.01 and 0.007

percent for small farmers would apply 1 percent additional human labour, power tiller, cowdung, MP, Furadan 5G and irrigation cost respectively.

Table 12.19 Maximum likelihood estimates for parameters of farm size-specific Cobb-Douglas stochastic frontier production and technical inefficiency model for sugarcane

Independent variables	Parameters	Farm Size Group		
		Large	Medium	Small
Constant	β_0	7.628(0.455)	6.991(0.495)	9.11(0.826)
Ln Human labour	β_1	0.118*(0.033)	0.235*(0.039)	0.452*(0.049)
Ln Power tiller	β_2	0.196*(0.055)	0.073**(0.039)	0.129*(0.049)
Ln Seed	β_3	0.081*(0.024)	0.143*(0.040)	-0.124(0.121)
Ln Cowdung	β_4	0.034*(0.006)	0.006*(0.002)	0.008*(0.003)
Ln Urea	β_5	0.065(0.118)	0.113(0.089)	0.128(0.116)
Ln TSP	β_6	0.021(0.037)	0.064(0.044)	0.0017(0.069
Ln MP	β_7	0.169*(0.045)	0.037(0.027)	0.102*(0.048)
Ln Furadan 5G	β_8	-0.027(0.037)	0.011(0.010)	0.014*(0.010)
Ln Irrgation	β_9	0.035*(0.007)	0.014*(0.004)	0.007*(0.0037)
Technical inefficiency model:				
Constant	δ_0	0.302(0.269)	0.471*(0.094)	0.469(0.379)
Experience	δ_1	-0.006**(0.003)	-0.003*(0.001)	-0.012*(0.002)
Age	δ_2	-0.006**(0.003)	0.0004(0.001)	-0.001(0.002)
Education (year)	δ_3	0.010(0.010)	-0.003(0.002)	-0.016*(0.005)
Visit by field the worker	δ_4	-0.075**(0.035)	-0.053*(0.009)	-0.053*(0.026)
Farm size	δ_5	-0.130**(0.067)	-0.110*(0.033)	0.046(045)
Dummy for sugarcane training (1=Yes, 0= otherwise) Dt	δ_6	-0.092*(0.031)	-0.035*(0.011)	-0.067**(0.038)
Variance parameters :				
Sigma- squared	σ^2	0.021*(0.005)	0.011*(0.001)	0.0067*(0.001)
Gamma	γ	0.999*(0.0001)	0.999*(0.030)	0.999*(0.256)
Log likelihood function		66.415	151.756	82.878

Source: Field Survey: 2017-18* and ** indicate significant at 1% and 5% level of probability.

Figures in the parentheses indicate standard error

In the technical inefficiency model the coefficients of experience of large, medium and small farmers were negative and significant. The negative and significant coefficient of experience measured in years indicated that the farmers with more experience tend to be less inefficient or more efficient. So, farming experience (the farmers who cultivate sugarcane for longer period

can increase the technical efficiency. This result is in line with those of Ahmad (2002), Kamruzzaman *et al.* (2008), Coelli (1996), Bettese *et a*l. (1992) and Hassan *et al.* (2005). At 5% level of significance the negative coefficient of age of large farmers indicated that the older farmers are more efficient than the younger ones. The negative and significant coefficient of education of small farmers indicated that the farmers with greater years of formal schooling tend to decrease inefficiency or increase technical efficiency. This indicates that the farmers with more education respond more readily in using the new technology and produce output closer to the frontier. This result is similar to that of Seyoum *et al.* (1998); Dey, *et al*. 2000; Pagan, (2001). The positive but non- significant coefficient of education of large farmers indicated that the educated large farmers were less efficient than the less educated large farmers. Usually, the high educated large farmers do not operated by themselves. They are engaged on other services and business and they depend on others for sugarcane cultivation. On the other hands, the less educated large farmers efficiently operate their lands by themselves. The estimated coefficient of the farm size variable was negative and significant of large and medium farmers, which indicated that the increase of sugarcane farm size tends to decrease inefficiency or increase efficiency. This is similar to that of Rahman *et al.* (2000), Ahmed *et al.* (2002). The coefficient of visit by the field workers and sugarcane training were negative and significant of three categories of farmers. This implied that the regular visit by field workers to the farmers' sugarcane plot tends to decrease inefficiency or increase efficiency. This is similar to that of Rahman *et al*. (2000), Chaudhury (2001), and Islam (2003). Training improves skills and the result supports that professional training reduces inefficiency. The coefficient of sugarcane training (D_t) was negative and significant. It indicated that the training on sugarcane production reduced the production inefficiency and increased the technical efficiencies of sugarcane production. If a farmer gets more training programmes, his level of inefficiencies would decrease. The estimated values of variance parameters were large and significantly different from zero which indicated a good fit and correctness of the specified distributional assumption. The significant value of γ also indicated that there were significant technical inefficiency effects in the production of sugarcane.

12.3.4 Technical Efficiency and its Distribution

The estimated location specific and farm size specific technical efficiencies are presented in the Table 12.4It was observed that the mean value of technical efficiency was 0.66 with a range from 0.40 to 0.88. This implied that, on average, the sugarcane production in the study areas were producing sugarcane to about 66 percent of the potential (stochastic) frontier production level, given the levels of their inputs and the technology currently being used. This also indicated that there existed an average level of technical inefficiency of 34 percent. The technical efficiency of large, medium and small farmers was 73%, 65% and 62% respectively. The variation in technical efficiency was observed higher with large farmers (ranged 52-88%) than medium (ranged 50-74%) and small (ranged 40-72%) farmers. On the other hand, the mean technical

efficiency was higher at chewing zone (73%) as compared to mill zone (63%) and *goor* zone goor zone (65%). The variation of technical efficiency was higher at *goor* zone ranged 40-86% whereas, it was 50-80% at mill zone and 60-88% at chewing. The higher variation in technical efficiency implied that technical efficiency was fluctuating to some extent for small farmers as well as for the farmers at *goor* zone in sugarcane production.

Table 12.20 Farm specific technical efficiency of sugarcane production

Location	Farm category	No. of farms	Technical efficiency			
			Mean	Maximum	Minimum	Standard deviation
Chewing zone	Large	60	0.80	0.88	0.66	0.04
	Medium	208	0.72	0.74	0.62	0.02
	Small	332	0.66	0.72	0.60	0.02
	All	**600**	**0.73**	**0.88**	**0.60**	**0.03**
Mill zone	Large	110	0.65	0.80	0.52	0.04
	Medium	198	0.64	0.72	0.50	0.04
	Small	292	0.62	0.65	0.50	0.03
	All	**600**	**0.63**	**0.80**	**0.50**	**0.04**
Goor zone	Large	80	0.75	0.86	0.65	0.02
	Medium	218	0.60	0.72	0.50	0.03
	Small	302	0.60	0.68	0.40	0.04
	All	**600**	**0.65**	**0.86**	**0.40**	**0.04**
All	Large	250	0.73	0.88	0.52	0.03
	Medium	624	0.65	0.74	0.50	0.04
	Small	926	0.62	0.72	0.40	0.03
	All	**1800**	**0.66**	**0.88**	**0.40**	**0.03**

Source: Field survey (2017-18)

Considering different locations, the farmers at chewing zone were found to be more technically efficient in sugarcane production compared to the farmers of other locations. Forty three percent of the farmers at chewing zone achieved technical efficiency level of more than 60 percent (Table 12.21).On the other hand, 34 percent farmers at mill zone and 46 percent of the farmers at *goor* zone achieved technical efficiency level more than 60 percent. On the contrary, more number of farmers at mill zone (66%) achieved technical efficiency level of less than 60% followed by chewing (60%) and *goor* zone (54%). When considering the farm categories, it was observed that 68 percent large farmers obtained more than 60 percent technical efficiency level. On the other hand, 47 percent of the medium and 30 percent of the small farmers achieved more than 60 percent technical efficiency level. On the contrary, 70 percent of the small, 53 percent of the medium and 32 percent of the large farmers achieved less than 60 percent technical efficiency level. Technical efficiency level of different farm categories indicated

that there was no farmer above the level of 90 percent denoting that technical efficiency was somewhat satisfactory in sugarcane production (Table 12.21).

Table 12.21 Frequency distribution of technical efficiency of sugarcane production

Region/ Location	Farm category	Number of farmer under different efficiency level (%)					
		< 40	41-60	61-80	81-90	91-100	All
Chewing zone	Large	-	-	15(25)	45(75)	-	60(100)
	Medium	-	110(52)	98(48)	-	-	208(100)
	Small	-	230 (69)	102(31)	-	-	332(100)
	All	**-**	**340(57)**	**215(36)**	**45(7)**	**-**	**600(100)**
Mill zone	Large	-	80(72)	30(28)	-	-	110(100)
	Medium	-	106(53)	92(47)	-	-	198(100)
	Small	50(17)	160(55)	82(28)		-	292(100)
	All	**50(8)**	**346(58)**	**204 (34)**	**-**	**-**	**600(100)**
Goor zone	Large	-	-	45(56)	35(44)	-	80(100)
	Medium	-	113(52)	105(48)	-	-	218(100)
	Small	102(34)	110(36)	90(30)	-		302(100)
	All	**102(17)**	**223(37)**	**240(40)**	**35(6)**		**100(100)**
All	Large	-	80(32)	90(36)	80(32)		250(100)
	Medium	-	329(53)	295(47)	-		624(100)
	Small	152(16)	500(54)	274(30)	-		926(100)
	All	**152(8)**	**909(51)**	**659(37)**	**80(4)**		**1800(100)**

Figures in the parentheses indicate percent of total
Source: Field survey (2017-18)

It is concluded that in technical efficiency model, human labour, seed, cow dung, urea, TSP, MoP and Furadan had the positive and significant impact on sugarcane production in chewing zone. In inefficiency model experience, age, visited by the field worker, farm size had the negative impact, which indicated that, an increase of experience, age, visited by the field worker, farm size the technical inefficiency would be decreased as a result, technical efficiency would be increased. Mean technical efficiency of sugarcane production was 66 percent with a range from 40-88% (Table 12.20). This implied, that on average, the sugarcane production in the study area were about 66 percent of the potential level, given the levels of their inputs. It also indicated that there existed an average level of technical inefficiency of 34 percent. Considering different locations, the farmers at chewing zone were found to be more technically efficient in sugarcane production compared to the farmers of the other locations. Technical efficiency of different

farm categories indicated that there was no farmer above the level of 90 percent (Table12.21) denoting that technical efficiency was satisfactory in sugarcane production.

12.4. Constraints of Sugarcane Cultivation at Farm level of Bangladesh

Yield gap is a great problem in agricultural sector. There are many constraints which pervert to attain the potential level of yield of sugarcane in farm level of Bangladesh. Many of the farmers still follow the traditional practice and they do not follow the modern technology. According to the opinions given by the sugarcane growers the constraints of sugarcane farmers are divided into two groups – technical and socio- economic constraints.

12.4.1 Technical Constraints:

Technical constraints are related to production techniques and technologies. The farmers in the study areas mentioned a number of technical constraints which affected sugarcane production. The summary of the sugarcane production constraints (Table 12.22) are discussed below:

Lack of clean/ certified seed: Seed/sett is a main factor of any production system. Although all the farmers were found to produce high yielding varieties of sugarcane, 97 percent of them mentioned that they had lacking of clean sett/*good* quality of sett and this constraint ranked 1st position among the constraints. Farmers are usually used sugarcane sets from their own plots or from neighbors/relatives, which were not diseases free and not good quality. In mill zone, a few numbers of farmers used certified seed from sugar mills, these are not sufficient. Irrespective of locations 99, 99 and 94 percent of the sugarcane farmers of chewing, *goo*r and mill zone mentioned that lack of clean sets/ disease free sets is a problem.

Pest and diseases: Pest and diseases is one of the important constraints of sugarcane production. Pest and diseases can damage the whole plot of sugarcane. It is essential to control it. In the study area 96.67 percent farmers mentioned that they faced pest and diseases as a problem and it ranks 2nd among the constraints. Considering the locations 100, 90 and 100 percent farmers of chewing, mill zone and *goor* zone respectively mentioned that infestation of pest and disease is a problem.

Irregular supply of fertilizers and insecticides: Sugarcane is a long duration crop and it needs large amount of inputs. In the mill zone farmers get some fertilizers and insecticides from sugar mills on loan. In the study area on average 67.67 percent farmers (Table 12.22) responded that supply of fertilizers and insecticides from the mills were irregular and inadequate.

Non - availability of tractors: For a good production, deep plough is of immense need and the use of tractor and power tiller is needed for this purpose. It is found that 64.67 percent of the farmers responded that the availability of tractors is a constraint (Table 12.22).

Table 12.22 Constraints and problems of sugarcane production as mentioned by the farmers

Constraints of sugarcane production	Farmers responded (%)				Rank
	Chewing	Mill zone	*Goo rz*one	All	
Technical :					
Lack of clean seed	99	94	99	97.00	1
Pest and diseases	100	90	100	96.67	2
Irregular supply of fertilizers and insecticides	75	68	60	67.67	10
Non–availability of tractors	60	62	72	64.67	11
Lack of irrigation facilities	65	72	72	69.67	7
Long duration	90	98	88	92.00	3
Socio- economic:					
Lack of proper knowledge	65	55	48	56.00	12
Lack of adequate operating capital	82	78	88	82.67	6
High price of input	35	45	52	44.00	14
Low product price	56	85	67	69.33	9
Labour scarcity in the peak period	42	52	40	44.67	13
Scarcity of *purzi*	-	98	-	98.00	4
Corruption of *purzi* distribution	-	85	-	85.0	5
Delay payment of Taka	-	70	-	70.00	8
Theft of sugarcane	45	30	42	39.00	15
Top cutting	40	25	28	31.00	16

Note : Same farmers mentioned more than one constraint as they faced at different time period of sugarcane production. As a result adding of all responses exceeded hundred.

Lack of irrigation facilities: Irrigation is an important factor of sugarcane production. Table showed that69.67 percent farmers responded that lack of irrigation facilities was a problem. These constraints arise mainly due to ownership of irrigation equipment, excessive irrigation charge during peak periods and mechanical trouble of irrigation equipment. This constraint was severe for the farmers at Mill zone (72%), *goor* zone (72%) and chewing also(65%) because they had very limited access to irrigation equipment for the irrigation during the early stage of sugarcane production.

Long duration: Sugarcane is a long duration crop. Most of the farmers can earn their livelihood by growing food crops on their small piece of land. But when their lands were engaged for sugarcane cultivation, they faced many problems like, want of food and money within the period of planting to harvesting. About 92 percent of the farmers mentioned that long duration is a problem.

12.4.2 Socio-economic Constraints:

Farmers in the study areas mentioned a number of socio- economic constraints which affected sugarcane production. In order to get a gross picture of socio-economic constraints the responses are presented below:

Lack of proper knowledge: The sugarcane growing farmers in the study areas mentioned that they have lack of proper knowledge regarding modern technology of sugarcane production. The knowledge gap prevails in every stage of sugarcane production especially for the adoption of modern sugarcane production technology. Most of the farmers had knowledge gap about new variety, seed treatment, time of planting, spacing, recommended fertilizer management, time of irrigation, measurement of pest and diseases control which were essential for yield increase. About 56 percent of the total farmers mentioned that they have lack of proper knowledge about sugarcane production and it ranked 12th position among the constraints. Considering the locations 65,55, and 48 percent sugarcane farmers (Table 12.22)of chewing, mill and *goor* zone respectively mentioned that they had lack of proper knowledge about modern sugarcane cultivation.

Lack of adequate operating capital*:* Sugarcane is a high cost involved crop. Capital is a common problem of the subsistence farming in Bangladesh. Especially for the small farmers, it is very difficult to bear the investment cost of sugarcane production. On the other hand, agricultural credit from formal sources is very limited and farmers often cannot afford it for various reasons. It is found from the Table 12.22 that on average 82.67 percent farmers in the study area mentioned that adequate capital was a problem and it ranks 6th among the constraints.

High price of input*:* High price of inputs was a socio-economic constraint of sugarcane production. Forty four percent of sugarcane farmers in the study area mentioned that high input price was a problem of sugarcane production and it ranks 14th position among the constraints. Considering the locations 52, 45 and 35 percent farmers of *goor* zone, mill zone and chewing zone, respectively faced constraints of high price of inputs.

Low product price*:* The problem of low price of sugarcane was mentioned by 69.33 percent of the respondents in the study areas. The more number of farmers at mill zone (85%) mentioned that the price of sugarcane was low. The farmers of chewing (56%) and *goor* (67%) reported about low price of sugarcane. Specially the farmers of chewing zone mentioned that they did

not get actual price due to middleman. The farmers of mills zone said that the price of sugarcane was not sufficient and it should be increased.

Labour scarcity in the peak period: Shortage of human labour is a seasonal problem and generally occurs in the peak period of sugarcane cultivation. Shortage of human labour hampered different intercultural management and delayed harvesting which ultimately reduced the yield. On average, about 44.67 percent of the farmers faced the problems of labour scarcity in the peak period. A larger number of farmers at mills zone (52%) faced this problems followed by those at chewing (42%) and *goor* zoner (40%).

Scarcity of *purzi :* *Purzi* is the supply order of sugarcane to the sugar mills. Farmers claimed that they did not get *purzi* in time and in the sufficient numbers even when the sugarcane was fully matured and was about to become dry. Sugar mills have a limited capacity to crush cane within a period. They have no capacity to crush all sugarcane at a time. Therefore, there was a scarcity about *purzi*. . On average, 91.33 percent of the farmers of mill zones reported that scarcity of *purzi* is a constraint and it ranked 4th position among the constraints.

Corruption of *purzi* distributio*n:* The respondents of mill zone claimed that the *purzi* was available to the prominent and influential farmers. Fictitious cane growers collect *purzi* from office and receive the value of sugarcane with the help of cashier. About 85 percent of the farmers claimed that there was a corruption in *purzi* distribution.

Delay payment*:* Taka payment from sugar mills is a problem. After delivery of cane to the sugar mills, the farmers did not get money in time. On an average 70 percent of the farmers reported that delay in payment of Taka after delivery of sugarcane to the sugar mills is a constraint.

Theft of sugarcane: Fifteen percent of the farmers reported that theft of sugarcane is a social problem.

Top cutting*:* Top cutting is also a social problem. People cut the top cane for cattle feed. Thirty one percent of them reported that sugarcane top cutting is another social problem.

13. Research highlight/findings (Bullet point – max 10 nos.):

- Per hectare production cost of sugarcane wasTk.1,48,509, Tk.1,96,320, Tk.2,69,724 on cash cost and Tk.2,15,860, Tk.2,68,452, Tk.3,49,196 on full cost basis in mills zone, *goor* zone and chewing zone respectively.
- Per hectare Gross Return of sugarcane was Tk.2,18,400, Tk.3,40,000 and Tk.6,60,000 in mill zone, *goor* zone and chewing zone respectively.
- Per hectare Net Return of sugarcane was Tk.69,890, Tk.1,43,679, Tk. 3,90,276 on cash cost and Tk.2540, Tk.71,547, Tk. 3,10,803 on full cost basisin mill zone, *goor* zone and chewing zone respectively.

- The highest Benefit Cost Ratio (BCR) was found in chewing zone(2.45) followed by *goor* zone (1.73) and mills zone(1.47) and indicates sugarcane cultivation in chewing zones observed worth paying.
- Benefit Cost Ratio of sugarcane + potato, sugarcane + lentil, sugarcane + coriander, sugarcane + mungbean, sugarcane + carrot, sugarcane + garlic, sugarcane + potato(chewing zone) and sugarcane + tomato were 1.83, 1.80, 1.63, 1.79, 2.19, 1.87, 3.23, 3.23 on cash cost basis and 1.74, 1.76, 1.11,1.32, 1.65, 1.45, 2.48, 2.54 on full cost basis respectively. Among the intercrops higher benefit observed in sugarcane +tomato followed by sugarcane + potato in chewing zone.
- The average technical efficiency of all zones was 66 percent ranged from 88-40 percent.
- The mean technical efficiency of chewing zone, *goor* zone and mill zone was 73, 65 and 63 percent respectively.
- In inefficiency model, the coefficient of experience of the farmer, age, field visit by the field worker and farm size were negative and significant, which implied that the inefficiency effects decrease with the increase of experiences, age, farm visit and farm size of the farmer.
- Long duration crop, lack of clean/ certified seed, pest and diseases, irregular supply of fertilizers and insecticides, lack of proper knowledge, lack of adequate operating capital, high price of input, low product price, labour scarcity in the peak period, scarcity of *purzi* were the main constraints/problems of sugarcane farmers.

13. References

Ahmed, M., G. M. Chaudhry and M. Iqbal. 2002. Wheat Productivity, Efficiency and Sustainability: A Stochastic Production Frontier Analysis. *The Pakistan Development Review.* Part II (Winter 2002): 643-663.

Aigner, D. J. C., Lovell, A. K. and Schimidt, P. J. 1977. Formulation and Estimation of Stochastic

Alam, M.M, M.I Haque, and S.M. Bokhiar. 2005. Contribution of Sugarcane Crop to the National Economy of Bangladesh, *Bangladesh J. Sugarcane*. Vol. 24-27 : 27-32.

Ali, M. Y. and M. K. Ali. 1990. *BangladesherAkh Chaser Projukti goto Sambhabana*. A Bengali Manual on Technological Potentiality of Sugarcane Production. Bangladesh Sugarcane Research Institute. Ishurdi, Pabna.

Battese, G. E. 1992. Frontier Production and Technical Efficiency: A Survey of Empirical Application in Agricultural Economics. *Agricultural Economics*.7:185-208.

Battese, G. E., and T. J. Coelli. 1992. Frontier Production Functions, Technical Efficiency and Panel Data: With Application to Paddy Farms in India. *The Journal of Productivity Analysis.*3:153-169.

Frontier Production Function Models. *Journal of Econometrics*. 6: 21-37.

BBS 2017. Bangladesh Statistical Year Book. Bangladesh Bureau of Statistics. Ministry of Planning, Government of the People's Republic of Bangladesh. Dhaka, Bangladesh.

Cochran W.G. (1999), Sampling Techniques (3rdEdn), John Willey & Sons, New York, USA, Pp 39-44

Chaudhry, G. M. 2001.Technical Efficiency Analysis of Pakistan Agriculture with Special Reference to Chemical Fertilizer Use. *Asia-Pacific Journal of Rural Development.* Vol.XI (1):15-25.

Dey, M. M. 2000. Technical Efficiency of Tilapia Growth Pond Operations in the Philippines. *Aquaculture Economics and Managemen*t. 4(1/2):73-112.

FAO 2015. FAO Statistics. faostat.fao.org.

Fisher, R. A. (1958), Statistical Methods for Research Workers (Thirteen edition). Section 21. Oliver and Boyd, Edinburg, U.K. Pp 356

Hussain, M. S. 1999. An Analysis of the Efficiency of Cottonne Farmers in the Punjab Province in Pakistan. An Unpublished Ph.D. Thesis Graduate School of Agriculture and Resource Economics, University of New England, Armidale Australia

Islam, M. H. 2003. Profitability and Technical Efficiency of Wheat Production in some selected Areas of Dinajpur District. M.S. Thesis. Department of Agricultural Economics. Bangladesh Sheikh Mujibur Rahman Agricultural University. Gazipur. Bangladesh.

Jamil, M. and Dr. A. D. Gopang. 2004. Sugarcane Scenario, Constraints and Strategies to Improve its Production in Pakistan. *Pakistan Sugar Journal*. Vol. XIX(6):55-65.

Karim, M. R. (1996), Optimal crop –livestock farming in dry land (High Barind) area of Bangladesh. Ph.D. dissertation, Dept. of Agricultural Economics, BAU, Mymensingh-2202, Bangladesh.

Kamruzzaman, M., M. A. Ahmed, and M. A Basher. 2001. Effect of Credit on Yield Gap and Technical Efficiency of Boro paddy Production in Selected Area of Comilla District. *Bangladesh Journal of Agricultural Economics. XXIV*(1 & 2): 113-126.

Kamruzzaman, M. and . H. Islam, 2008. Technical Efficiency of Wheat Growers in Some Selected Sites of Dinajpur District of Bangladesh. *Bangladesh Journal of Agril. Research.* 33(3): 363-373

Kothari, C. R. (2001), Research Methodology: Methods and techniques (2nd edition). WishwaPrakashan, 4835/24 Ansari Road, Daryaganj, New Delhi 110002. Pp468

Meeusen, W. and J. V. D. Broeck. 1977. Efficiency Estimation from Cobb-Douglas Production Function with Composed Error. *International Economic Review*. 18:435-444.

Miah, M.A.H. (1992). An Economic Study on Sugarcane Cultivation with several Intercrops in Jaipurhat Sugar mills Area. An unpublished masters degree thesis. Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh.

Moser, S. C. and G. kalton (1980) Survey methods in Social Investigation (2nd edn.), Heineman Educational Books Ltd., London WC1B 3HH, P146

Neyman, J. (1934), On the two different aspects of the representative method: The method of Stratified sampling and the method of purposive selection. Journal of the Royal Statistical Society, 97: 558-606.

Pagan, J. A. 2001. Explaining Technical Inefficiency in Mexico's Micro-enterprises. University of Texas-Pan American , Edinburg: 78.

Parel, C. P.; G. C. Caldito; P.L. Ferrer; G.G. De Guzman; C.S. Sinsioco and R.H.Tan(1973), Sampling design and procedures. The Agricultural Development Council. 630 fifth avenue, NY 10020, USA.

Rahman, K. M. M., P.M. Schmitz, and T. C. Wronka. 2000. A Translog Stochastic Production Frontier Analysis on the Estimation of Technical Efficiency of Rice Production in Bangladesh. *Journal of Business Administration.* Vol. 26(3 & 4):15-46.

Rao, C. A. R., K. R. Chowdry, Y. V. R. Reddy and G. V. K. Rao. 2003. Measuring and Explaining Technical Efficiency in Crop Production in Andhra Pradesh. *Indian Journal of Agricultural Economics*. Vol. 58(4):768-780. October - December.

Rahman, K. M. M., P.M. Schmitz, and T. C. Wronka. 2000. A Translog Stochastic Production Frontier Analysis on the Estimation of Technical Efficiency of Rice Production in Bangladesh. *Journal of Business Administration.* Vol. 26(3 & 4):15-46.

Sing, V.; Kothari, S.K.; and tripathi, H.N. (1986). Studies on Intercropping in Sugarcane in Central Uttar Pradesh, *Indian Sugarcane Journal*, 35: 559-562

Seyoum, E. T.; G.E. Battese and E. M. Fleming (1998), Technical efficiency and productivity of maize producers in eastern Ethiopia: a study of farmers within and outside the Sasakawa-Global 2000 project. Agricultural Economics, 19 (3): 341-348.

Sugar: World Markets and Trade, United States Department of Agriculture, Foreign Agricultural Service; May 2018

World Sugar. 2017. Annual Report. Illovo Sugar Limited. : 54-55.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment					
i) Laptop computer	01	60,000	01	60,000	
ii)Desktop computer	01	60,000	01	59,990	
iii) Laser printer	01	20,000	01	19,990	
iv) Digital camera	01	25,000	01	24,990	
v)UPS	01	10,000	01	9,980	
vi) Scanner	01	10,000	01	9,950	
(b) Lab &field equipment					
(c) Other capital items					
i)Executive Table	01	20,000	01	20,000	
ii) Executive Chair	01	10,000	01	9,950	
iii) Visitor Chair	06	24,000	06	23,970	
iv) File cabinet	02	40,000	02	39,990	
v) Steel Almirah	01	24,000	01	23,990	
vi) Computer	01	5,000	01	4,990	
Table	01	30,000	01	30,000	
vii) Book selves					

2. Establishment/renovation facilities: N/A

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized: N/A

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	2,18,310	2,03,310	2,03,310	0	100	
B. Field research/lab expenses and supplies	10,80,000	10,80,000	10,80,000	0	100	
C. Operating expenses	3,55,848	2,97,754	2,95,888	1866	100	Bank charge
D. Vehicle hire and fuel, oil & maintenance	2,53,432	2,31,867	2,31,867	0	100	
E. Training/workshop/seminar etc.	-	-	-	-	-	-
F. Publications and printing	1,48,000	1,23,255	0	1,23,255	0	Refund to PIU, NATP-2
G. Miscellaneous	27,430	25,467	25,467	0	100	
H. Capital expenses	3,37,790	3,23,400	3,23,400	0	100	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
i)To determine the level of input use and estimate cost and return of sugarcane production at farm level	Cost and return analysis have been done using simple accounting procedure.	i) Per hectare production cost of sugarcane in mill zone, *goor* zone and chewing zone were Tk.1,48,509, Tk.1,96,320 and Tk.2,69,724 respectively on cash cost basis. ii) Per hectare Gross Return of sugarcane in mill zone, *goor* zone and chewing zone were Tk.2,18,400, Tk.3,40,000 and Tk.6,60,000 respectively. iii) Per hectare Net Return of sugarcane were Tk.69,890, Tk.1,43,679, Tk. 3,90,276 on cash cost basis and Tk.2540, Tk.71,547, Tk. 3,10,803 on full cost basis respectively iv) Cost & return of sugarcane+ potato was Tk.2,02,452/ha& Tk.3,53,125/ha ; sugarcane+ lentil was Tk.1,71,315/ha& Tk.2,47,000/ha; sugarcane+ coriander Tk.2,11,609/ha & Tk.2,35,550/ha in mills zone respectively. v) BCR of sugarcane + potato, sugarcane + lentil and sugarcane+ coriander was 1.74, 1.76 and 1.11 respectively. vi) Cost, return and BCR of sugarcane+ carrot were Tk 3,00,636/ha, Tk.4,95,000/ha, 1.65 and in sugarcane+ garlicwere Tk.3,69,237/ha& Tk. 5,37,050/ha, 1.45 respectively in *goo*r zone. vii) Cost, return and BCR of sugarcane + potato were Tk 3,33,115 /ha , Tk.8,25,000/ha, 2.48 and in sugarcane+ tomato were Tk.3,82,434/ha & Tk. 9,70,000/ha, 2.54 respectively in chewing zone	The generated data base will be helpful for policy maker, researchers, BSFIC and extension personnel in order to appropriately understand the underlying process that influence the output and productivity of this sector and how these are impacted by new policies and regulations.
ii) To estimate the level and determinants of farm-level technical efficiency of sugarcane farmers; and	A stochastic frontier model was used.	i) In technical efficiency model Seed, Human labour, Urea, TSP, MoP, Furadan, irrigation cost have the positive impact on sugarcane yield. ii) The mean technical efficiency of chewing zone, *goor* zone and mill zone was 0.73, 0.65 and 0.63 respectively.	Data base will be helpful for the farmers, researchers and policy maker to take an appropriate program.

		iii)In inefficiency model the coefficient of experience of the farmer, age, field visit by the field worker and farm size negative and significant, which implied that the inefficiency effects decrease with the increase of experiences, age, farm visit and farm size of the farmer.	
iii)To identify constraints of sugarcane cultivation at farm level	Descriptive analysis was used	i)There were many constrains of sugarcane farmers such as – long duration crop, lack of clean seed, lack of proper knowledge, lack of adequate operating capital, high price of input, low product price, labour scarcity in the peak period, scarcity of *purzi* etc.	Data base will be helpful for the farmers, researchers and policy maker to take an appropriate program

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication			
Information development			
Other publications, if any			

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

ii. **Generation of new knowledge that help in developing more technology in future**

iii. Technology transferred that help increased agricultural productivity and farmers' income

iv. Policy Support

G. Information regarding Desk and Field Monitoring

i) **Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):**
   a) By AERS, BARC on 18/02/18- satisfactory.
   b) By PIU, NATP-2, BARC- satisfactory.

ii) **Field Monitoring (time& No. of visit, Team visit and output):**
Two times field monitoring was done by internal committee on 17/12/17 and 04/02/18. They were satisfied in data collection procedure.

I. Lesson Learned/Challenges (if any)

i)
ii)
iii)

J. Challenges (if any)

Signature of the Principal Investigator
Date …….
Seal

Counter signature of the Head of the organization/authorized representative
Date …….
Seal