Profitability and Technical Efficiency of Sugarcane in Some Selected Areas of *Goor* Zones in Bangladesh

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ABSTRACT

The present study was undertaken to estimate the profitability and technical efficiency of sugarcane farmers of *goor* zones in Bangladesh. The study employed 600 farm level cross sectional data from four sugarcane areas of *goor* zone during the period of November 2017 to April 2018. Technical efficiency of sugarcane farmers' was found to vary across the locations. Using simple accounting procedures and maximum likelihood estimation techniques, the stochastic production frontier was employed to estimate the profitability and farm specific technical efficiency of sugarcane in *goor* zone of Bangladesh. The study showed that the mean farm specific technical efficiency of sugarcane farmer's was 65 percent within the range from 60 t0 75 percent. Sugarcane experience, frequently visit by the field worker and training on sugarcane production technology were suggested to be important factors in reducing technical inefficiency and obtaining maximum achievable yield. The policy implication of the analysis suggested that investment in farmers' training and extension service would greatly improve technical efficiency and thereby contributes to income of the *goor* cane farmers.

Key words: Profitability, *goor* zones, sugarcane growers, educational level and extension contact.

INTRODUCTION

In Bangladesh, sugarcane is the important cash cum industrial crop just after jute and it covers 1.25 percent of the total cultivable land (Rahman, *et al.,* 2016). It is the principal raw material of sugar industry and the major source of white sugar and *goor* (jaggery) production and chewing purposes in Bangladesh. Currently, on an average, sugarcane is grown in 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 chewing purpose (Rahman, *et al.,* 2016). In 2018-19 on an average 3.92 million metric tons (MMT) of sugarcane is being produced in Bangladesh. Out of it 1.18 (30.11%) MMT are used by sugar mills to produce 0.068 MMT of sugar and 2.11(53.83%) MMT are used to produce 0.21 MMT of *goor* and remaining 0.63(16.06%) MMT are used for seed and chewing purposes (Anonymous 2019). Per capita consumption of sugar and *goor* in Bangladesh is less than 14.4 kg per annum (BBS, 2019). But in India, China, Thailand, Brazil, Pakistan and EU it is 19, 10, 36, 54, 23 and 34 kg respectively (World Sugar, 2019). According to Food and Agricultural Organization (FAO) per head annual necessity of sugar is 13 kg (Rahman *et al*., 2016; Alam *et al.,* 2008; Ali and Ali, 1990) and as such present requirement of sugar and *goor* for 168.95 million people is 2.19 million tons. However, our current (2018-19) domestic sugar and *goor* production was

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0.068 and 0.21 million tons respectively and imported sugar was 2.33 million tons (FAS, USDA, May, 2019). Total supply of sugar and *goor* was 2.60 million tons. 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.

Table 1. Demand and supply of sugar and *goor* in Bangladesh

Crushing Season	Population (million)	Demand of sugar & *goor* ('000 ton) (per capita 13 kg)	Sugar production ('000 ton)	Sugar import ('000 ton)	*Goor* Production ('000 ton)	Total supply of sugar & *goor* ('000 ton)	Scarcity/ Shortages ('000 ton)
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	300.00	2456.98	+863.56
2018-19	168.95	2196.50	68.95	2330	210.00	2608.95	+412.45

Source : BBS (2011-2018); DAE(2011-2020); BSFIC(2011-2020) and FAS, USDA, May-2019

Goor is more unrefined form than sugar and it is a brown raw of sucrose which gets it color because of other elements found in concentration such as wood ash and baggase. Sugarcane *goor* contains minerals (0.6-1.0%), iron (11 mg), calcium (0.40%), magnesium and phosphorous (0.045%). *Goor* also contains reducing sugars including glucose and fructose (10-15%), protein (0.25%) and fat (0.05%) (Rao *et al*., 2007). In Bangladesh, *goor* is mainly made from sugarcane. It is a substitute of sugar and is the alternative use of sugarcane. It meets up the shortage of sugar and a large number of rural populations use *goor* everyday. It is popular in urban and rural people to make different type of sweetnears and cakes.There are strong indications that the *goor* cottage industry would continue to play an important role in processing sugarcane at non mill zone in creating employment opportunities to the rural people (Khatun *et al*., 2015).

There are good number of studies have been done on production on sugarcane in mill zone (Kabir and Alam, 2001; Alam *et al.,* 2007; Khatun *et al*., 2011; Khatun *et al*., 2014). However, a few studies Alam *et al. (*2005) and Khatun *et al.* (2015) had done on *goor* production and marketing. Being a small scale sector, nevertheless, there is no detail update study on technical efficiency of sugarcane in *goor* zone in Bangladesh. In order to formulate policy and planning for sustainable development of agricultural sector, reliable and realistic data related to sugarcane production in *goor* zone is needed. Considering this situation the study was taken for the sugarcane production in *goo*r zone in some selected areas of non mill zone of Bangladesh. Moreover, it is expected that the study would generate meaningful insights for policy makers and agricultural extension workers to disseminate knowledge to sugarcane producing farming community.

MATERIALS AND METHODS

Selection of the study area

The study was conducted during the period of 2017-2018 cropping season. Sirajgonj, Chapainawbgonj, Bagerhat and Manikgonj districts were selected purposively as the study areas because these districts are leading *goor* producing areas of Bangladesh. From each district, two upazilas namely Sirajgonj sader and Kamarkhandoc from Sirajgonj district, Shibgonj, Volahat from Chapainawbganj district, Mollarhat and Kochua from Bagerhat district and Manikgonj sader and Singair from Manikgonj district were purposively selected on the basis of intensive sugarcane cultivation for *goor* producing respectively.

Selection of samples and sample size

In order to normalize the data 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,1990) were chosen for this study. By applying these techniques the number of samples for different locations were estimated and presented below:

Table 2. Distribution of selected *goor* farms in the study areas, Bangladesh

Sugarcane zone	Districts	No. of Farms
Goor zone	Sirajganj	130
	Chapainawabganj	182
	Bagerhat	122
	Manikgonj	166
Total		600

Methods of data collection

For conducting the field survey, data enumerators were used to collect data from 600 sugarcane *goor* farmers. The information was collected for the crop that was already planted in 2017. Data were collected from the farmers who produced sugarcane in non-mill zone through pretested questionnaire. Additionally, data were collected through Focus Group Discussion (FGD) and Key Informant Interview (KII) using semi structured checklist.

Analytical techniques

Profitability analysis of sugarcane *goor* farmers

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

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

$$GR= X_1P_1 + X_2P_2 + X_3P_3 + X_4P_4 + X_5P_5 + X_6P_6 + X_7P_7 + X_8P_8 + X_9P_9 + X_{10}P_{10} + X_{11}P_{11} + X_{12}P_{12} + X_{13}P_{13} + X_{14}P_{14} + X_{15}P_{15}$$

Where,

GR = Gross return from sugarcane (Tk/ha), X_1= Quantity of the sugarcane seed (sett) (ton/ha), P_i = Price of sugarcane (Tk/ton), X_2 = No.of tillage operation, P_4 = Price of tillage operation (Tk/ha), X_3 = Human labour (mandays./ha), P_3 = Price of human labour (Tk./mandays), X_4 = Cowdung (ton/ha), P_4 = Price of Cowdung (Tk./ton), X_5 = Urea (kg/ha), P_5 = Price of urea (Tk/kg), X_6 = TSP (kg/ha), P_6 = Price of TSP (Tk/kg), X_7 = MoP (kg/ha), P_7 = Price of MoP (Tk/kg), X_8 = Gypsum (kg/ha), P_8 = Price of Gypsum (Tk/kg), X_9 =Zink sulphate (kg/ha), P_9 = Price of zink sulphet (Tk/kg), X_{10} = Boron (kg/ha), P_{10} = Price of Boron (Tk/kg), X_{11}= Bavistin/knowin (kg/ha), P_{11} = Price of Bavistin/knowin (Tk/kg), X_{12} = Regent(kg/ha), P_{12} = Price of Regent (Tk/kg), X_{13} = Carbofuran (kg/ha), P_{13} = Price of carbofuran (Tk/kg), X_{14} = Irrigation (no./ha), P_{14}= Price of irrigation cost (Tk./ha).

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)

Efficiency analysis

A stochastic frontier production model was used to determine the technical efficiency of sugarcane farmers. 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. 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 stochastic production frontier model is specified with error terms, the models is as follows:

$$Y = f(X_i, B) + (v_i - u_i) \quad \text{..... (3)}$$

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 $(0, \sigma^2_v)$ 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$(0, \sigma^2_u)$ which captures deviations from the frontier due to inequality.

Empirical model

The stochastic production which is used for the sugarcane producers was specified as:

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

Where, Ln = Natural logarithm, Y_i = Yield of sugarcane (ton/ha), X_{1i} = Human labour (man-days/ha), X_{2i} = Tillage implements cost (Tk./ha), X_{3i} = Sugarcane settss (kg/ha), X_{4i}= Cowdung (kg/ha), X_{5i} = Urea (kg/ha), X_{6i} = TSP (kg/ha), X_{7i} = MP (kg/ha), X_{8i} = Carbofuran (kg/ha), X_{9i} = Irrigation cost (Tk/ha), $v_i - u_i$ = error term

The empirical model of farm specific technical inefficiency model is:

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

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

$$\sigma^2 = \sigma^2_u + \sigma^2_v \text{.....(6)}$$

$$\gamma = \sigma^2_u / \sigma^2 \text{.....(7)}$$

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

RESULTS AND DISCUSSION

Input use pattern of sugarcane for *goor* production

Use of different inputs namely human labour, tillage implements cost (Tractor/power tiller etc.), material inputs were determined. On an average, 7.25 t ha^{-1} sugarcane setts (seeds) were used in sugarcane for *goor* zone, whereas, the highest (9.20 t) was used in Chapainawabgonj and lowest (6.30 t) in Bagerhat district (Table 3). Usually, average seed /sett rate of sugarcane is 6.0-7.5 t ha^{-1}. Sugarcane seed is not true seed. It is vegetative part of sugarcane and it calls sett. As vegetative propagated, so, weight of setts depends on cane weight and the cane weight depend on girth, number of internodes, internodes distance, fiber density, sugar content etc. Moreover, because of various plant spacing, type settlings (single budded/double budded), time of plantation (late plantation requires dense spacing compare to early/medium plantation). Because of above reason the sett rate of sugarcane widely varies.

Table 3. Per hectare input used level in sugarcane for *goor* zone in the study areas

Particulars	Sirajgonj	Chapai nawabgonj	Bagerhat	Manikganj	Average	Stadard error
Sugarcane setts (ton)	6.36	9.20	6.30	7.18	7.25	1.35
Tillage implements cost (Tk)	7875	7875	7875	9525	8287.50	825.00
Human labour (man days)	300	350	284	330	316	29.62
Cowdung (ton)	3.80	3.84	3.00	4.00	3.66	0.45
Urea (kg)	290	311	310	320	308	12.66
TSP(kg)	243	222	198	212	219	18.93
MoP(kg)	200	175	170	180	181	13.15
Gypsum(kg)	110	59	80	80	82	20.98
Zink sulphet(kg)	7.5	7.5	6.5	6.5	6.75	0.58
Boron (kg)	7.0	7.5	7.0	7.5	7.5	0.29
Bavistin (kg)	1.0	1.25	0.75	1.0	1.0	0.20
Regent 3 GR (kg)	22	18	15	15	17.50	3.32
Carbofuran 5 G (kg)	30	20	22	37	27.25	7.80
Irrigation cost(Tk.)	10000	14000	10000	14000	12000	2309.40

Source: Field survey: 2017-18

Average tillage implements (Tractor/power tiller *etc.*), cost was Tk. 8,287.50/ha. The average human labour was used 316 man days/ha in four districts, while, it was the highest in Chapainawabganj (350 man days/ha) and the lowest in Bagerhat district (284 man days/ha). The farmers used 3.66 t ha^{-1} cowdung as manure including application of urea, TSP, MoP, Gypsum, Zink sulphet and Boron at the rate of 308, 219, 181, 82, 6.75 and 7.50 kg/ha respectively in sugarcane of *goor* zone . For insects and pest control farmer used 1, 17.50 and 27.25 kg/ha Bavistin, Regent 3 GR

and Carbofuran 5 G respectively and the average irrigation cost was Tk.12,000/ha (Table 3).The variation of applying other inputs among the farmers depends on many factors like financial condition, awareness regarding technical knowledge on sugarcane cultivation, soil fertility intercultural operation, farm size, family size, experience etc. In fact sugarcane is a highly management responsive crop. Therefore, good management practice provides not only higher yield but also more sure sugar/goor content.

Cost and returns of sugarcane in *goor* zone

In *goor* zone, average sugarcane setts was used 7.25 t ha^{-1} and the sugarcane setts cost was considered Tk.29,000/ha which shares 10.82 percent of the total cost. Farmers normally used home supplied setts but sometimes they purchased it from others. Average tillage implements cost was Tk. 8,287/ha which shares 3.09 percent of the total cost. Human labour cost was the most important and the largest item of input costs. Per hectare average human labour was used 316 man-days and cost was Tk.94,800 which shares 35.36 percent of the total cost.

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 6.83 percent of the total cost (Table 4). Farmers used urea, TSP, MoP , gypsum, zinc shulphate, boron as fertilizers. Per hectare average costs of urea, TSP, MoP , gypsum, zink sulphat, boron, bavistin, carbofuran and regent were Tk.4,928, Tk.4,818, Tk.2,715, Tk.820, Tk.945, Tk.1,500, Tk.2,200, Tk.4,087 and Tk.2,275 respectively. On average, farmers spent per hectare Tk 24,288.50 for fertilizer and insecticides in sugarcane production (Table 4). Per hectare irrigation cost was Tk. 12,000 which shares 4.48 percent of the total cost. Land use cost was Tk.52,500 /ha and interest on operating cost was Tk. 19, 599/ha (Table 4). Per hectare average variable cost of sugarcane was Tk.1,95997 and total cost was Tk.2,68,096. 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.1,44,002/ha on cash cost and Tk. 71,903/ha on full cost basis respectively. Benefit Cost Ratio (BCR) was found 1.73 and 1.27 in cash cost and full cost basis respectively (Table 4).

Maximum likelihood estimates stochastic frontier production function and inefficiency model of sugarcane for *goor* zone

The empirical results indicated that at *goor* zone, the coefficients of human labour, sugarcane setts, cowdung, urea, TSP,MP, Carbofuran and irrigation costs were positive and significant, while that of tillage implements cost was positive but not significant. It indicated that human labour, seets, cowdung, urea, TSP, MP, Carbofuran and irrigation costs had significant and positive impacts on *goor* cane zone (Table 5). At 1% level of significance human labour had the largest positive coefficient compared to other inputs. Holding other things constant, the yield of sugarcane would increase by 0.299% as farmers used 1% additional human labour in different types of management practices like, weeding, mulching, fertilizer application,

Table 4. Per 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	10.82
Tillage implements cost (Tk.)	-		8287.50	3.09
Total labour (man days)	316	300	94800.00	35.36
Cowdung (ton)	3.66	5000	18300.00	6.83
Fertilizers & insecticides cost:			24288.50	9.06
Urea (kg)	308	16	4928.00	1.84
TSP (kg)	219	22	4818.00	1.80
MoP (kg)	181	15	2715.00	1.01
Gypsum (kg)	82	10	820.00	0.31
Zinc sulphet (kg)	6.75	140	945.00	0.35
Boron (kg)	7.50	200	1500.00	0.56
Bavistin (kg)	1.0	2200	2200.00	0.82
Carbofuran 5 G (kg)	27.25	150	4087.50	1.52
Regent 3 GR (kg)	17.5	130	2275.00	0.85
Irrigation cost (Tk.)	4	3000	12000.00	4.48
Carrying/Transport Cost(Tk.)	-	-	9321.25	3.48
Total variable cost	-	-	**195997.25**	73.11
Land use cost (Tk.)	-	-	52500.00	19.58
Interest on operating capital (Tk.)	-	-	19599.72	7.31
Total cost			**268096.98**	100.00
Yield (ton)	85			
Gross Return(Tk.)		4000	**340000.00**	
Net Return (Cash cost basis)(Tk.)			144002.75	
Net Return (Full cost basis) (Tk.)			71903.03	
BCR (Cash cost basis)			1.73	
BCR (Full cost basis)			1.27	

Source : Field Survey ; 2017-18

insect and pest control sugarcane setts (0.148), cowdung (0.082), TSP (0.126), MP (0.103), Carbofuran (0.066) and irrigation cost (0.025) were positive implying that holding other things constant, the yield of sugarcane would increase by 0.148, 0.082, 0.126, 0.103, 0.066 and 0.025 percent as farmers increase 1% additional sugarcane setts, cowdung, urea, TSP, MP, Carbofuran and irrigation cost respectively. The coefficient of urea (0.156) was significant at 5% level, implying that holding other things constant, the yield of (mechanical control by hand), tying, etc. At 1% level of significance, the coefficients of sugarcane would increase by 0.16 percent as farmers would apply 1% additional urea (Table 5).

In the technical inefficiency model the coefficients for the experience (0.015), age (0.004), and education (0.022) were negative and significant at 1% level. This indicated that the experience of sugarcane farmers tends to decrease the sugarcane production inefficiencies or increase efficiencies. The farmers who had greater (2008), Coelli (1996) and Bettese *et al.* (1993). The coefficient of farm size (0.035) had negative effect at 5% level of significant.

Table 5. Maximum likelihood estimates of the stochastic Cobb-Douglas frontier production and technical inefficiency model of sugarcane for *goor* zone

Independent variables	Parameters	Coefficients	Standard Error
Constant	β_0	4.872	0.979
Ln Human labour	β_1	0.299*	0.053
Ln Tillage implements	β_2	0.029	0.045
Ln Se tts	β_3	0.148*	0.038
Ln Cowdung	β_4	0.082*	0.024
Ln Urea	β_5	0.156**	0.082
Ln TSP	β_6	0.126*	0.043
Ln MP	β_7	0.103*	0.023
Ln Carbofuran 5G	β_8	0.066*	0.026
Ln Irrgation	β_9	0.025*	0.004
Technical inefficiency model:			
Constant	δ_0	0.065	0.162
Experience	δ_1	-0.015*	0.006
Age	δ_2	-0.004	0.002
Education (year)	δ_3	-0.022*	0.007
Visit by field worker	δ_4	-0.102**	0.052
Farm size	δ_5	-0.027**	0.014
Dummy for sugarcane training (1=Yes, 0= otherwise) Dt	δ_6	-0.072**	0.037
Variance parameters :			
Sigma - squared	σ^2	0.009*	0.003)
Gamma	γ	0.331	0.259
Log likelihood function		104.00	

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

This indicated that the farm size decreases the inefficiencies of sugarcane production and increases the efficiencies. The large farmers were technically more efficient than the small farmers. The field workers visited the farmers' plot and advised them properly; as a result technical efficiency of that farmer would be increased. The coefficient of the field visit by the field worker was negative (0.102) and significant at 5% level (Table 5) 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 chewing cane production. This is similar to that of Rahman *et al*. (2000), Chaudhry (2001), and Islam (2003). Training tends to decrease inefficiency or increase efficiency. When a farmer got more training on sugarcane production, then his knowledge increased and he can follow the appropriate measure on sugarcane production and ultimately his technical efficiency will be increased. The coefficient of dummy variable training was negative (0.07) and significant at 5% level, which indicated that the training on sugarcane production increased the technical efficiency of the sugarcane farmers. This is similar to that of Rahman *et al.* (2000); Chaudhry (2001) and Islam (2003). Thereby, there are the important factors for obtaining maximum achievable yield. Therefore, policies leading to the increase of training and contact with the extension would be favorable for increasing technical efficiency. 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 (Table 5).

Technical efficiency and its distribution

This is similar to the findings of Kadiri *et al.*(2014) who found that there is great variation in the levels of efficiency; the range is from 38.4 percent to 90.10 percent with a mean of 62.60 percent. The mean level of technical efficiency indicates that on average output falls 47.40 percent short of the maximum possible level. Therefore in the short run it is possible to increase production in the study area by an average of 47.40 percent by adopting the technology used by the best performances. The result showed the estimated farm size specific technical efficiencies in Table 6. It is observed that the mean value of technical efficiency was 0.65 with a range from 0.40 to 0.86. This implied that, on average, the sugarcane production in the study areas were producing sugarcane about 65 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 35 percent. This implies that the output of each farmer can be increased on an average 35 percent without incurring any additional production cost.

The mean technical efficiency of large, medium and small farmers was 75%, 60% and 60% respectively. The variation of technical efficiency was 40-86% at sugarcane in goor zone (Table 6). The higher variation in technical efficiency implied that technical efficiency was fluctuating to some extent for large farmers in sugarcane for goor production. The technical efficiency was not same for different categories.

Table 6. Farm specific technical efficiency of sugarcane production in *goor* zone

Farm category	No. of farms	Technical efficiency			
		Mean	Maximum	Minimum	Standard deviation
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**

Source: Field survey 2017-18

The variation in technical efficiency was observed higher with the small farmers ranged from (40 to 68) than medium ranged from (50 to 72) and large ranged from (65 to 86) farmers. The higher variation in technical efficiency implied that technical efficiency was somewhat fluctuating for the small farmers (Table 6).

On an average, 46 percent of the farmers at *goor* zone achieved technical efficiency level of more than 60 percent and 54 percent farmers' technical efficiency level was less than 60 percent (Table 7). When considering the farm categories, it was observed that 100 percent large farmers obtained more than 60 percent technical efficiency level. On the other hand, 48 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, 52 percent of the medium and there is no large farmers who achieve less than 60 percent technical efficiency level. Technical efficiency level of different farm categories indicated that there was no farmer less than the level of 40 percent denoting that technical efficiency was some what satisfactory in sugarcane in *goor* zone (Table 7).

Table 7. Frequency distribution of technical efficiency of sugarcane production in *goor* zone

Farm category	Number of farmer under different efficiency level (%)					
	< 40	41-60	61-80	81-90	91-100	All
Large	-	-	45 (56)	35 (44)	-	80 (100)
Medium	-	113 (52)	105 (48)	-	-	218 (100)
Small	102 (34)	110 (36)	90 (33)	-	-	302 (100)
All	102 (17)	**223 (37)**	**240 (40)**	**35 (6)**	**-**	**600 (100)**

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

Frequency of extension contact and technical efficiency

Table 8 indi cated that the farmers who contacted frequently with extension workers were technically more efficient than the farmers with less contacted with extension workers. In large farmers, the highest technical efficiency (86%) was achieved by those farmers who contacted 4 to 5 times with extension workers during the production period. Less technical efficiency (46%) was achieved by the small farmers who did not contact with extension workers during the production period.

Table 8. Relationship between farming experience and technical efficiency of sugarcane producers of *goor* zones according to farm category in the study area

Frequency of contact	Farm category					
	Large		Medium		Small	
	Mean	SD	Mean	SD	Mean	SD
No contact	65.30	3.41	54.50	2.23	46.00	2.65
1-3	70.45	2.36	68.80	2.50	52.23	3.23
4-6	86.00	1.30	72.00	3.40	65.00	4.65
All	72.00	2.78	64.00	2.45	54.00	3.25

Source: Field survey 2017-18. SD = Standard deviation

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REFERENCES

Ahmad, M. 2001. Agricultural productivity growth differential in Punjab, Pakistan: A district level data. The Pakistan Development Rev., 40: 1-25.

Anonymous. 2011-2020. Unpublished report of Bangladesh Sugar and Food Industries Corporation (BSFIC), and Department of Agricultural Extension (DAE) , Dhaka .

Anonymous. 2011-2020. Unpublished report of Department of Agricultural Extension (DAE) , Dhaka.

Alam, M.M. and Huquee, M.I. M. 2005. Market effects on the production profitability of sugarcane, sugar and gur in Bangladeh. Bangladesh J. Sugarcane, 24-27: 47-56.

Alam,G.M.M. ; Alam, M.M.; Alam, M.J. ; Zahan, W.A. and Alam, M.S. 2007. Profitability of intercropping with sugarcane in some selected mills zones. Bangladesh J. Sugarcane, 29 : 64-67.

Alam,G.M.M.; Alam,M.M. and Miah,M.A.S. 2008. Socio - economic Economic studies on Date Palm Plantation in Bangladesh. Bangladesh J. Sugarcane, 30:71-78.

Battese, G. E. ; Malik, S. J. and Broca , S. 1993. Production function for wheat farmers in selected districts of Pakistan: An application of a Stochastic Frontier Production Function with time-varying inefficiency effects. Pakistan Development Rev., 32: 233-68.

BBS, 2011 -2018. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics (BBS). Ministry of Planning.

Chaudhry, G. M. 2001.Technical efficiency analysis of Pakistan agriculture with special reference to chemical fertilizer use. Asia-Pacific J. of Rural Development, 11 (1): 15-25.

Coelli, T.J. 1996. Specification and estimation of stochastic frontier function. An unpublished Ph. D. thesis. School of Economic Studies, University of New Eng land, Armidale, Australia.

Cochran W.G. 1999, Sampling techniques (3 rd edn), John Willey & Sons, New York, USA, pp. 39-44.

FAS, USDA. 2019. Sugar: World Markets and Trade. Foreign Agricultural Service. United States Department of Agriculture. apps.fas.usda.gov/psdonline/circulars /sugar.pdf

Fisher, R. A. 1958, Statistical methods for research workers (thirteen edition). Section 21. Oliver and Boyd, Edinburg, U.K. p. 356.

Kabir, M.H. and Alam, M.M. 2001. Technical and allocative efficiency of irrigated sugarcane farmers in Northwest and Southwest regions of Bangladesh. Bangladesh J. Sugarcane, 23 : 74:81.

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.

Khatun,S. and Rahman M.H. 2011. Economic efficiency of sugarcane production in northern region of Banglad esh. *Bangladesh J. Sugarcane* , **32:** 98-107.

Khatun,S.; Kamruzzaman,M.; Islam, M.S. ; Rahman,M.S. and Rahman M.H. 2015. Production and marketing of sugarcane *goor* in selected areas of Bangladesh. *Bangladesh J. Sugarcane* , **36:** 119-125.

Khatun,S. ; Kamruzzaman,M. ; Islam, M.S. ; Rahman,M.S. and Rahman M.H. 2014. An empirical study on technical efficiency of sugarcane production in Rajshahi district of Bangladesh. *Bangladesh J. Sugarcane* , **35:** 131-137.

Kamruzzaman, M. and Islam , H. 2008. Technical efficiency of wheat growers in some selected sites of Dinajpur district of Bangladesh. *Bangladesh J. Agril. Research* , **33**(3): 363 -373 .

Moser, S. C. and Kalton, G. 1980 . Survey methods in social investigation (2 nd edn.), Heineman Educational Books Ltd., London WC1B 3HH, p.146 .

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

Rahman, K.M.M. ; Schmitz , P.M. and Wronka , T.C . 2000. A Translog stochastic production frontier analysis of technical efficiency of rice production in Bangladesh. *Journal of Business Administration,* **26** (3&4): 15-46.

Rahman, M.S. ; Khat un, S. and Rahman , M.K. 2016. Sugarcane and sugar industry in Bangladesh: An overview. *Sugar Tech,* **18**(6): 627-635.

Rao, P.V.K.J.; Das, M. and Das S.K. 2007. Jaggary- a traditional Indian sweetener. *Indian J. of Traditional Knowledge,* **6** (1): 95-102.