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An Analysis of Economic Efficiency of Garlic Production in Selected Upazila of Dinajpur District in Bangladesh

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Abstract: This study aims at estimating technical, allocative, economic efficiency analysis of garlic producers in Khansama upazila of Dinajpur district by applying Stochastic Production Function (SPF). For accomplishing the objectives, data on 51 randomly selected garlic farmers were collected from two villages namely Kachinia and Kayempur of Khansama Upazila. Due to rapid break out of COVID19 pandemic over the world, data for this study were collected by using telephone interview method and then analyzed them with statistical software STATA 12.0 version. The mean technical, allocative and economic efficiency for all farmers are traced out as 0.69, 0.82 and 0.57 respectively which indicates a better management system of garlic cultivation is required for improvement of efficiency levels alongside optimum allocation of resources implemented. It is also observed that the farmers with large quantity of land allocated have lower efficiency levels and profitability also and vice versa. About 25.49%, 43.14% and31.36% of sampled farmers are technically, allocatively and economically efficient greater than 0.70 indicating scope for raising efficiency of the farmers. However the study has also several limitations including small sample size, avoid inclusion of farming system that can be considered for future study.

Keywords: *Efficiency; Garlic Production; Optimum Allocation; Profitability; Stochastic Production Function (SPF).*

Introduction: Garlic (*Allium sativum*) is one of the most important bulb crops grown and used as a spice or a condiment throughout Bangladesh. It is widely grown in winter season. Garlic is used as spice in various ways in all curries, fried, and for other purposes. It adds flavor of distinctive pungent and has also medicinal values. It is rich in proteins, phosphorus, potash, calcium, magnesium and carbohydrates. According to the Unani and Ayurvedic systems as practiced, garlic is carminative and is a gastric stimulant and thus helps in digestion and absorption of food. Allicin present in aqueous extract of garlic reduces cholesterol concentration in human blood. The inhalation of garlic oil or garlic juice has generally been recommended by doctors against cases of pulmonary tuberculosis, rheumatism, sterility, impotency, cough and red eyes diseases [1].Garlic stands third among the spice crops in the country in considering area (33.60 thousand ha) and second in production (1.45 lac m. tones) [2]. The yield (4.32 t/ha) of garlic [2] is very low in Bangladesh as compared to the other developed countries like; Netherlands (48 t/ha), Jordan (33.84 t/ha), Egypt (22.68 t/ha), Tajikistan (20.00 t/ha) and China (17.14 t/ha) [1, 3]. Bangladesh Agricultural Research Institute (BARI) introduced a developed variety of garlic. The yield of BARI Developed Modern varieties of garlic was 45 to 58% higher than those of the traditional variety. Society got net benefit Tk 1221.96 million from the investment of garlic research and extension. The internal rate of return (IRR), net present value (NPV) and benefit cost ratio (BCR) were estimated to be 50%, Tk 433.57 million and 2.81, respectively [3]. The row planting is famous for garlic cultivation in Bangladesh. Different spacing and row arrangement are used based on garlic farmer's perceptions. The spacing for garlic is 10 x10 cm, 15x10 cm, and 15 x 15 cm. On average, net return (Tk 74782/ha) was recorded from garlic at 15 x 15 cm spacing as double row arrangement [4].Today, garlic is one of the twenty most important vegetables in the world, with an annual production of about three million metric tons. Major growing areas are USA, China, Egypt, Korea, Russia and India. Garlic is used as both food and medicine in most of the countries. The world trade of this vegetable is dominating by the third world and Bangladesh has the emerging possibilities in this field. Unfortunately, Bangladesh contributes only 2% in world market share [5]. This share can be raised by providing proper facilities to the farmers and agricultural intensive can be accelerated the share and growth of garlic production.

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Literature Review: Samavatean *et. al.,*[6] conducted a study on the balance of the input and the output per unit area for garlic in Hamedan province of Iran. The result revealed that garlic production required total energy input of 40307.89MJ/ha 1. Cost analysis showed that 6969.11 dollars were required for 1 ha garlic production. Hussain *et. al.,*[7] estimated technical efficiency of the garlic farming of the farmers living in Khyber Pakhtunkhwa province, Pakistan. The result showed that the estimated mean technical efficiency was 0.77 or 77 percent implying that returns of the farmers from the garlic production can be increased by optimum allocation of the resources. Sabzevari *et. al.,* [8] applied Data Evolvement Analysis (DEA) for analyzing energy efficiency and its optimization for garlic producers of Guilan province, Iran. The study estimated 18 units as technically efficient and 43 units as pure technical efficient. Study of Miraj and Ali [9] estimated that mean technical efficiency of garlic farms in district Peshawar, Pakistan was 84.60 per cent ranging from 57.62 to 96.07 per cent using multistage random sampling procedure on 110 farms. The study of Rahmawati [10] identified factors that reduce technical inefficiency were age, farmer experience, and training in Karanganyar Regency and also suggested that production of garlic can be increased by increasing land area, increasing the quantity of seeds, and reduce the quantity of liquid pesticides. Technical efficiency can be improved through providing training for farmers [11]. Mina *et. al.,*[12] identified that group membership, farm size, and distance to the farm-to-market road (FMR) were statistically significant for garlic output having 81 percent of farmers were technically efficient in garlic production. Using Ordinary Least Square Method (OLS) Ahmed et. al., [13] studied resource uses in the production of garlic on randomly selected 120 farmers from two local areas of Kano state, Nigeria. The result showed that quality of seed, organic manure and labor inputs have significant positive effect on the output of garlic. Patidar [14] did economic analysis of garlic production in the Ratlam district of Madhya Pradesh, India. They collected data of 60 garlic farmers from three villages and analyzed with OLS and Production function. They found average productivity and gross return of garlic production were 136.04 q/ha and 306550 respectively. Gross income for small scale farmers was recorded as 315414, whereas 321950 for medium farmers and 282285 for large scale farmers. The sum of elasticity was estimated at 0.72. Human labor, fertilizer and irrigation were notified as significant positive influencer for all types of farms.

Present Status of Garlic Production in Home and Aboard: Bangladesh has tremendous achievement in production of Garlic due to its favorable climate as well as the farmers' management policy. Table 01 shows that production of Garlic steadily increased from 2006 to 2017 but it had been reduced in 2008 by -18.05% compared to 2007 accounts of output in 2008 as of 144817.00 tons and the process of raising production continues from 2009 to 2012 and at 2013 it reduced from 233609.00 tons in 2012 to 223685.00 tons 2013 as account for -4.25% and after that it remains its increase and in 2016, it was 381851.00 tons [5].

Table 1: Garlic production in Bangladesh.

Year	Output in tons	Change in %
2017	425,401.00	11.40%
2016	381,851.00	10.45%
2015	345,725.00	10.81%
2014	312,000.00	39.48%
2013	223,685.00	-4.25%
2012	233,609.00	11.69%
2011	209,153.00	27.23%
2010	164,392.00	6.18%
2009	154,831.00	6.91%
2008	144,817.00	-18.05%
2007	176,710.00	72.43%
2006	102,485.00	

Source: FAO, 2019

Table 2: Agricultural indicators of garlic in the World.

Indicators	Value
Area	1577779 Hectare in 2017
Seed	12001 tons in 2016
Yield	178501 Hg/Ha in 2017

Source: FAO,2019

In case of words' Garlic production, the total areas of Garlic production in the world is around 1577,779 hectare in 2017 as in table 02 by using seeds of 12001 tons in 2016 and output yield as 178504 Hg/Ha in 2017 according to FAO.

Table 3: Top countries in contributing worlds' Garlic production

Country	Output in Tons	Share of worlds' production (%)
China	22216965	86
India	1693000	6
Bangladesh	425401	2
South Korea	293686	1
Spain	274712	1
Egypt	274668	1
Russia	258455	1
USA	232000	1
Uzbekistan	214263	1

Source: FAO,2019

China is in top one countries of the worlds' producing Garlic in 2017; it is seen from above table 03 that China produced around 22.2 million tons that can be counted as 78.73% of total share in the worlds' garlic production. The others contributed to 88.25% of it. The total garlic production in 2017 around the world was 28.2 million. However, Bangladesh is recognized as 3rd largest contributor of Garlic in the worlds' total share of Garlic production in 2017, estimating 425401 tons output of Garlic according to FAO and is shown by 2% in worlds' Garlic production in table 3. Table 3 clearly shows that Chaina has about 86% contribution in worlds' garlic cultivation where as India has 6%, Bangladesh has 2% and the rest of the contributors have 1% for each of them.

Materials and Methods:

Study Area and Data Collection: Due to Corona Virus (COVID19) pandemic, data were collected from May, 2020 to June 2020 by using mobile phone interview method. First one of our research associate visited the study area and then collects the desired farmer's phone number. After that we contact them through mobile phone and those who are willing to give information, we collect from them. Data were collected from both primary and secondary sources. The sample consists of 51 randomly selected farmers from two villages namely Kachinia and Kayempur of Khansama Upazila of Dinajpur. The questionnaire was prepared in English but the data collectors ask the respondents in local language and then put the collected information in questionnaire using English language. The study was conducted during growing season of 2020. The responses of the respondents that were recorded in the interview schedule were transferred into a master sheet for entering the data in the computer. Data entry was then done by using computer software packages like Microsoft Excel, STATA (Version12.0) and various descriptive statistical measures (i.e., sum, average, percentages, ratios, standard deviation etc.) were employed to examine the objectives that are estimating technical, allocative and economic efficiencies of the garlic farmers, explaining the present condition of garlic's production in Bangladesh as well as suggesting the possible policy implication in regarding efficiency level obtained. Tabular analysis included socioeconomic characteristics of sample farmers, production practices and their costs and return, input use, problems faced by the respondents and their probable suggestions.

Specification of Production Model: The Cobb-Douglas form of production is widely used to analyze productivity and resource use efficiency of Garlic [15, 16 and 17]. The functional form of multiple regression equation is as follows

$$Y = aX_1^{b_1} X_2^{b_2} \ldots X_n^{b_n} e^{u_i} \quad \ldots\ldots (1)$$

Where, Y= Output; X_1...........X_n = Inputs; a = Constant;
b_1, b_2............b_n = Coefficient of relevant variables; u_i= Stochastic disturbance term,
e = Base of natural logarithm; The function is linearized in the farm-forming into the following logarithmic (double-log form) :

$$\ln Y_i = \ln\beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \beta_7 \ln X_{7i} + \beta_8 \ln X_{8i} + \beta_9 \ln X_{9i} + \beta_{10} \ln X_{10i} + \beta_{11} \ln X_{11i} + \beta_{12} \ln X_{12i} + \beta_{13} \ln X_{13i} + v_i - u_i \quad \ldots\ldots (2)$$

Where, ln = Natural logarithm; Y_i= Yield of Garlic for the i-th farm (kg/ha); X_{1i}= Land area (Hectare); X_{2i} = Human labor used by the i-th farm (man-days/ha); X_{3i} = Seed used by the i-th farm (kg/ha); X_{4i} = Urea used by the i-th farm (kg/ha); X_{5i} = TSP used by the i-th farm (kg/ha); X_{6i} = MoP used by the i-th farm (kg/ha); X_{7i} = Magnesium used by the i-th farm (kg/ha); X_{8i} = Cost of tractors used (Tk./ha); X_9 = Di-Ammonium Phosphate (DAP) used by the i-th farm (kg/ha); X_{10i} = Irrigation cost of the i-th farm (Tk./ha); X_{11} = Pesticide used by the i-th farm (ml/ha); X_{12i} = Vitamin used by the i-th farm (ml/ha); X_{13i} = Rent of land used (Tk./ha) ; β's are unknown parameters to be estimated; v_i - u_i = Stochastic error term from a composed error model ε_i and v_i is assumed to be independently and identically distributed random errors and independent of u_i.

Efficiency Analysis: The level of technical efficiency of garlic farmers can be estimated with the following formula:

$$Y_i = f(X_i; \beta) + \varepsilon_{ii} = 1,2,\ldots\ldots n \quad \ldots\ldots (3)$$

Where, Y_i = Output of the ith farmer, X_i = a vector of farm inputs; β = a vector of parameters to be estimated; f = a production function relationship; ε_i = the error term consisting of two elements as $\varepsilon_i = v_i - u_i$, here v_i is a random error having zero mean, $N(0;\sigma^2_v)$and it is assumed to be symmetric independently distributed as $N(0;\sigma^2_v)$ random variables and independent of u_i. u_i is a non-negative truncated half normal, $N(0;\sigma^2_v)$ random variable associated with factors of production and also associated with technical inefficiency of the farm having a range of value between zero and one. Technical efficiency is computed as a ratio of observed output to the maximum potential output of a farm [16, 17, 18, and19]**.** Therefore Technical efficiency can be written as

$$TE_i \text{ (Technical Efficiency)} = \frac{Y_i}{Y^*} = \frac{Y_i}{f(Xi;\beta)}$$

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{f(X_i;\beta).exp(V_i - U_i)}{f(X_i;\beta).exp(V_i)} = exp\,(-U_i) \quad \ldots\ldots (4)$$

Where, Y_i is the maximum possible output that a farm can produce by using its inputs (X_i); β is the parameter of technology to be estimated. Equation (4) defines technical efficiencies as the ratio of observed output to maximum possible output with an environment indicated by $exp\,(v_i)$ if it satisfies the condition of $TE = 1$.
Cost efficiency is measured by the ratio of minimum cost of production to actual cost of production [18, 21, 22, 23 and 24]. The value from it ranges between 0 and 1. If it is closer to 0, then the firm is less cost efficient and vice

versa. So the cost or economic efficiency is measured by the following formula with using error term $\varepsilon_i = v_i + u_i$ instead of using $\varepsilon_i = v_i - u_i$.

$C_i = f(Y_i P_i; \beta) + \varepsilon_i i = 1,2,\ldots\ldots n$ ……………………………………..…….(5)

Here, C_i = Total cost of production incurred by inputs of the ith farm, Y_i *and* P_i = Vector of input and output cost of ith farm; β = a vector of parameters to be estimated; Similarly equation (4), ε_i = the error term consisting of two elements as $\varepsilon_i = v_i + u_i$. List of the input prices are shown as below table.

Table 4. Average unit price of inputs used per hectare production of Garlic.

Items	Unit	Taka (Average)
Human Labor	Man/days	358
Tractor Charge	Hectare	2500
Seed	Per Kilogram	450
Cow dung	Per Hectare	4250
Urea	Per Kilogram	26
TSP	Per Kilogram	29
MoP	Per Kilogram	22
Gypsum	Per Kilogram	11
Lime	Per Kilogram	40
Irrigation Charge	Per hectare	3480
DAP	Per Kilogram	31
Pesticide	570 ml./Per hectare	640
Vitamin	512 ml./Per hectare	721
Land Rent	Per hectare/year	12000

Source: Authors own calculation from field survey, 2020

Table 4 shows the average unit price of the inputs used in the production process of garlic. The table reveals that price of the seed is 450 taka per kg, similarly, labor cost is tk. 358 man/days, tractor Charge is tk. 2500 per hectare, tk. 4250 per hectare for cow dung, tk. 26 per kg for urea tk. 29/kg for TSP, tk. 22/kg for MoP, tk. 11/kg. for gypsum, tk.40/kg for lime, tk.3480/per hectare for irrigation cost, tk. 31/kg for DAP were estimated. Alongside tk. 640 for 570 ml. pesticides used in per hectare and tk. 721 for 521 ml. vitamin used in per hector were also seen in the table 4.

Then economic efficiency:

$$EE_i(\text{Economic Efficiency}) = \frac{C_i}{C_i{}^*} = \frac{f(Y_i P_i \beta).exp(V_i + U_i)}{f(Y_i P_i; \beta).exp(V_i)} = exp\ (U_i) \quad \ldots\ldots\ldots\ldots\ldots(6)$$

Where, C_i = Expected cost of production that should be and C_i = actual cost of production incurred by the ith farm. The farm farm is economically efficient if and only if U_i is equal to 0 as well as the ideal cost is equal to observed cost. Since Allocative Efficiency is the ratio of Technical and economic efficiency [15, 25, and 26], Allocative Efficiency (AE) is measured as

$$\text{Allocative Efficiency } (AE_i) = \frac{Economic\ Efficiency(EE_i)}{Technical\ Efficiency\ (TE_i)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The concept of technical efficiency, allocative efficiency and the economic efficiency are shown in below figure. In figure 1, a firm is said to be technically efficient while producing at point M. The reason is that it is producing at iso-quant curve IQ-IQ'. In any point rather than M, it is inefficient point because that point is not on the iso-quant curve, suppose the firm is producing at point L instead of previous point M. This new production condition would be inefficient because this operation point is outlying from M where iso-quant curve belongs to.

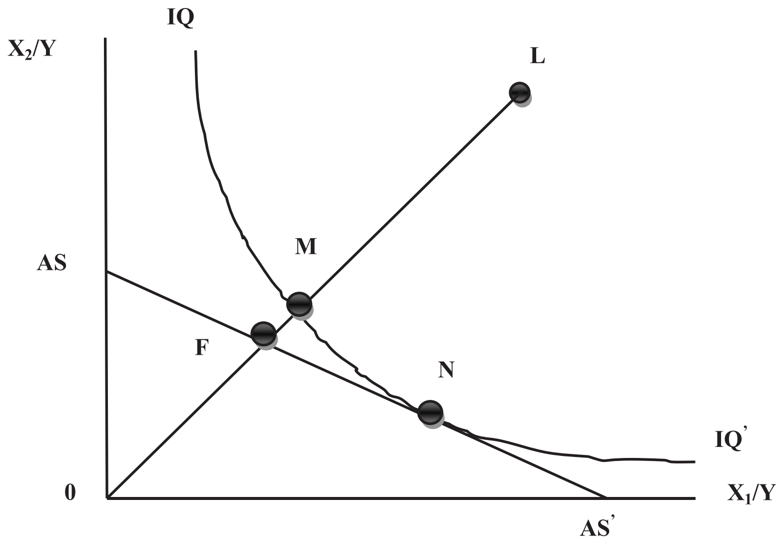

Fig 1. Technical, Allocative and Economic Efficiency.

And the technical inefficiency for producing at point L can be shown by the distance of LM. This implies quantity of inputs that farmers can decline inputs which would not lead to decline in the output level relatively. Here technical efficiency is the ration indicated as OM/OL. This ratio is equal to 1- OM/OL. Technical efficiency contains value ranges between zero and one. Zero means firm has no technical efficiency and value of one means firm is fully technically efficient. The slope of line AS-AS' indicates the input price ration which is also known as the iso-cost line. Allocative efficiency at point L is the ratio indicated in figure by OF/OM. The reduction in the cost of production can be done by the distance FM, if the firm produces at point N which represents the technically and allocatively efficient situation for the firm. But the point M implies technically efficient but allocatively inefficient production for the firm. Whereas the total economic efficiency is ratio of OF/OL, again the distance of LM representing decrease in the cost if the firm operates its production at point F which is both technically and allocatively efficient in lieu of at point L which is inefficient in both cases technically and allocatively. Since economic efficiency refers to the combination of the technical and allocative efficiency, then we have

Economic Efficiency = Technical Efficiency X Allocative Efficiency

= (OM/OL) X (OF/OM) = (OF/OL)

Cost function: The empirical Cobb-Douglas frontier cost function with double log form can be written by normalizing with price of labor as:

$$lnC_i = ln\delta_0 + \delta_1\, lnH_{1i} + \delta_2\, lnH_{2i} + \delta_3\, lnH_{3i} + \delta_4\, lnH_{4i} + \delta_5\, lnH_{5i} + \delta 6\, lnH_{6i} + \delta_7\, lnH_{7i} + \delta_8\, lnH_{8i} + \delta_9\, lnH_{9i} + \delta_{10}\, lnH_{10i} + \delta_{11} lnH_{11i} + \delta_{12}\, lnH_{12i} + \delta_{13}\, lnH_{13i} + \delta_{14}\, lnH_{14i} + W_i \quad \text{....................(9)}$$

Where, ln = Natural logarithm; C_i = Cost of production of the i-th farm (Tk./ha); H_{1i} = Labour wage rate of the i-th farm (Tk./man-days); H_{2i} = Charges of Tractor used of the i-th farm (Tk./ha); H_{3i} = Price of seed used by the i-th farm (Tk./kg); H_{4i} = Price of Cow dung of the i-th farm (Tk./kg); H_{5i} = Price of urea of the i-th farm (Tk./kg); H_{6i} = Price of TSP of the i-th farm (Tk./kg); H_{7i} = Price of MoP of the i-th farm (Tk./kg); H_{8i} = Price of gypsum of the i-th farm (Tk./kg); H_{9i} = Price of Lime of the i-th farm (Tk./kg); H_{10i} = Price of DAP of the i-th farm (Tk./kg); H_{11i} = Price of irrigation charge of the i-th farm (Tk./ha); H_{12i} = Price of pesticide of the i-th farm (Tk./ha); H_{13i} = Price of vitamin of the i-th farm (Tk./ha); H_{14i} = Price of land rent of the i-th farm (Tk./ha); W = Random error term.

Results and Discussion:

Estimation of Production Function: The estimation of technical efficiencies can be obtained from combining both Cobb-Douglas production function and the inefficiency model. The value of sigma square varies from 0 to 1. If the value of estimated parameter is equal to zero that means non-existence of technical inefficiencies in our study while a value of 1 or closer to 1 Implies more appropriate model fitted as well as the value also shows the goodness of fit [27]. In table 05 (below), the estimated value of sigma square is 0.153 at 1% level of significance indicating a 15.3% residual mutation.

Table 5. Estimated results of the production function of Garlic farmers.

Variables description	Coefficients	Standard Error	Z-Statistics
Constant	-73.271**	33.946	-2.16
Land area (Hectare)	0.575***	0.138	4.15
Human labor (Man-days)	0.710***	0.183	3.87
Seed (kg/ha)	0.268**	2.038	2.10
Urea (kg/ha)	-10.456*	6.414	-1.63
TSP (kg/ha)	5.033**	2.562	1.96
MoP (kg/ha)	40.711**	21.230	1.92
Magnesium	-36.014*	19.655	-1.83
Tractor Charge (Tk./ha)	-0.0531	.050	-1.05
DAP (kg/ha)	0.045*	0.026	1.72
Irrigation cost(Tk./ha)	0.017	0.038	0.45
Pesticide (ml/ha)	-0.860	0.721	-1.19
Vitamin (ml/ha)	-0.419**	0.206	-2.03
Rent of Land	6.914**	3.130	2.21
Wald chi-square	186.19***		
Sigma ($\boldsymbol{\sigma}_v$)_v	0.294	0.021	
Sigma($\boldsymbol{\sigma}_u$)_u	0.258	0.488	
Sigma-squared ($\boldsymbol{\sigma}_s^2 = \boldsymbol{\sigma}_v^2 + \boldsymbol{\sigma}_u^2$)	0.153	0.007	
Gamma (γ) [$\boldsymbol{\sigma}_u^2$ /($\boldsymbol{\sigma}_u^2$+ $\boldsymbol{\sigma}_v^2$)]	0.593		
Lambda	0.168	0.490	
Log likelihood	10.746		
Number of observation	------------------------------- 51 ---------------------------		

Source: Survey results, 2020 (Computed by Author)
Note: *, ** and *** refers to 10%, 5% and 1% level of significance, respectively.

Having Wald Chi-square at 1% level of significance, we can reject the null hypothesis about the penurity of inefficiency. Positively correlated coefficients are found for Land area (0.575), Human labor (0.710), Seed (0.268), TSP (5.033), MoP (40.711), DAP (0 .045), Irrigation cost (0.017), Rent of Land (6.914). All of them are significantly correlated with the garlic output except irrigation cost. On the contrary, the negatively related parameters are found for Urea (-10.456), Magnesium (-36.014), Tractor Charge (-.0531), Pesticide (-0.860), Vitamin (-0.419) where Vitamin is significantly correlated at 5% level of significance, Magnesium and Urea are at 10% level of significance.

Estimation of Cost Function: The parameters of stochastic cost frontier that were estimated shown in below Table 06. If we look at Wald Chi-square estimated as 310.20 which is significant at 1% level indicating the acceptance of the model. The model exhibits that the reason behind the mutation of garlic producing costs are due to the mutation in their cost efficiencies of farmers.

Table 6. Estimated results of cost function of Garlic farmers.

Variables description	Coefficients	Standard Error	Z-Statistics
Constant	2.357***	8.738	2.88
Land Rent(Hectare)	0.368***	0.025	14.52
Human labor (Man-days)	0.010	0.009	1.20
Seed (kg/ha)	11.066	0.258	42.78
Urea (kg/ha)	-0.004	0.017	-0.26
TSP (kg/ha)	-0.008*	0.005	-1.65
MoP (kg/ha)	-0.115*	0.068	-1.68
Magnesium	0.030	0.026	1.13
Tractor Charge (Tk./ha)	0.254***	0.008	28.49
Lime (kg/ha)	0.036*	0.021	1.64
DAP (kg/ha)	0.013**	0.006	2.05
Irrigation cost (Tk./ha)	0.107***	0.005	18.40
Pesticide (ml/ha)	0.025**	0.010	0.018
Cow dung (Tk./ha)	0.167***	0.001	98.26
Vitamin (ml/ha)	0.054	0.035	1.54
Wald chi-square	310.20***	-	-
Sigma (σ_v)_v	0.340	0.0149	-
Sigma(σ_u)_u	0.003	0.00514	-
Sigma-squared($\sigma_s^2 = \sigma_v^2 + \sigma_u^2$)	0.118	0.040	-
Gamma (γ) [σ_u^2 /(σ_u^2+ σ_v^2)]	0.025	-	-
Lambda	0.116	0.0065	-
Log likelihood	14.212	-	-
Number of observation	------------------------------ 51 --------------------------		

Source: Survey results, 2020 (Computed by Author)

Note: *, ** and *** refers to 10%, 5% and 1% significance level, respectively.

In the table 06, the gamma (γ) was estimated at 0.025 with 1% level of significant. This finding from survey farmers implies that a change of 2.5% in their total cost of garlic production resulted from their variation of cost efficiencies.

Estimation of Technical, Allocative and Economic Efficiencies of Garlic Producers: Table-07 reflects the scenery of technical efficiency among all the garlic farmers. For them, the mean technical efficiency is estimated as 0.69 implying that the farmers can raise their output by having effort to raise their level of efficiency about 31% on average through optimum allocation of resources. The highest quantity of farmers for technical efficiency is found between 0.41 and 0.50 tracing out 15.69% of total garlic farmers.

Table 7. Technical efficiency of Garlic producers.

Efficiency score	Frequency	Percents
0.00-0.10	1	1.96
0.11-0.20	7	13.73
0.21-0.30	4	7.84
0.31-0.40	6	11.76
0.41-0.50	8	15.69
0.51-0.60	7	13.73
0.61-0.70	5	9.80
0.71-0.80	3	5.88
0.81-0.90	4	7.85
0.91-1.00	6	11.76
Mean Technical Efficiency	**0.69**	

Source: Survey results, 2020 (Computed by Author)

Table-08 represents the allocative efficiency of garlic producers where the mean allocative efficiency is seen as 0.82 with having largest quantity of farmers' allocative efficiency ranges from 0.71 to o.80 which is around 19.61% of total farmers on average.

Table 8. Allocative efficiency of Garlic producers.

Efficiency score	Frequency	Percents
0.00-0.10	2	3.92
0.11-0.20	4	7.84
0.21-0.30	3	5.88
0.31-0.40	5	9.80
0.41-0.50	8	15.69
0.51-0.60	7	13.73
0.71-0.80	10	19.61
0.81-0.90	5	9.80
0.91-1.00	7	13.73
Mean Allocative Efficiency	**0.82**	

Source: Survey results, 2020 (Computed by Author from Field Survey)

The mean economic efficiency is estimated as 0.57 consisting of largest number of farmers fall in efficiency score at 0.41- 0.50 while only five (9.80%) is found at efficiency score of 0.81 to 0.90 and same for o.91 to 1.00 (Table-09). As presented in table 10, about >50% of the sampled farms' economic efficiency was below mean efficiency suggesting the requirement of better management of garlic cultivation system with modern improved technology to have better fruitful results from already applied raw materials by the garlic producers.

Table 09. Economic efficiency of Garlic producers

Efficiency score	Frequency	Percents
0.00-0.10	3	5.88
0.11-0.20	2	3.92
0.21-0.30	4	7.84
0.31-0.40	8	15.69
0.41-0.50	11	21.57
0.51-0.60	7	13.73
0.71-0.80	6	11.76
0.81-0.90	5	9.80
0.91-1.00	5	9.80
Mean Economic Efficiency	**0.57**	

Source: Survey results, 2020 (Computed by Author)

Conclusion: By observing the above estimated results, it is clear that the garlic producers in the selected study area are not much efficient notifying a lower mean efficiency for small, medium and large size of garlic producer. The estimated efficiency score shows that only 25.49% of the sampled farmers have technical efficiency score greater than 0.70 out of 1.00. Similarly, 43.14% garlic farmers of the study area have allocative efficiency score greater than 0.70 while 31.36% garlic producers have economic efficiency score greater than 0.70 out of 1.00 which are really very low relative to their resources investment. However, the efficiency level can be enhanced by providing adequate facilities from local governmental agricultural extensions along with NGOs providing them trainings, keep an observation during harvesting time and monitoring the local market price for garlic as well as fertilizers and pesticides also. They also support for storage facilities of garlic producers. After having these requirements fulfill, we may hope to have betterment in their efficiency and productivity levels of the farmers alongside higher level of garlic output ensuring optimum allocation of resources. This study has several limitations including limited study areas, small sample size and limited by the stochastic frontier analysis. This study can further enhanced by consisting of large sample size, large areas, considering farming system rather than one farming output in a season. This study can also improved for estimating efficiency by using Data Evolvement Analysis (DEA).

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