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Economic Efficiency of Irrigated Vegetable Production in Borno State Nigeria: A Stochastic Frontier Cost Function Approach

B. G. Shettima[1*], A. Ibrahim[1], S. T. Mohammed[1] and B. A. Zongoma[1]

[1]Department of Agricultural Economics, University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author BGS designed the study, wrote the first draft of the manuscript and carried out the statistical analysis. Author AI carried out the protocol and proof-read the manuscript. Author STM supervised and edited the work. Authors BAZ managed the analysis and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study analysed the economic efficiency of irrigated vegetable producers in Borno State, Nigeria. Multistage sampling technique was used to select the respondents. Structured survey questionnaires were used and administered to 300 respondents to obtain primary data. Both descriptive and inferential statistics were used to analyze the data obtained. Descriptive statistics used were mean, frequency and percentage. The inferential statistics used was stochastic frontier cost function to analyze the level and determinants of economic inefficiency in the studied enterprises. The result of the socio-economic indicated that almost all (99.7 percent) of the respondents were male with 45.9 percent of them falling on the age range between 41-50 years. About 46 percent of the respondents had household size ranging between 6-10 persons. The result

**Corresponding author: E-mail: babagshettima@yahoo.com;*

further disclosed that 70.9, 54.4 percent had less than 5 years of formal education, 54 percent had farming experience of 11-20 years in vegetable production and 28.7 percent had rented or leased their farm. About 28 percent of the respondents had farm size of 0.51- 1.00 hectare of land for cultivation, most of the respondents cultivate onion/tomato mix of the studied vegetable and 65 percent do not belong to any farmers association. Mean economic efficiency of the irrigated vegetable enterprises were 0.72, 0.86, 0.73, 0.78, and 0.78 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper respectively. The maximum likelihood estimates of the cost function indicate sigma square values of 0.248, 0.031, 0.363, 0.228 and 0.122 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper respectively and significant at one percent. Variance ratio (gamma) values indicate presence of economic inefficiency in irrigated vegetable production in the study area with coefficients of 0.945, 0.932, 0.945, 0.173 and 0.122 for sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper enterprises respectively. The coefficients of production variables in the stochastic frontier cost function were positive and significant at one percent level. The most significant variables were costs of labour, planting materials, depreciation, seeds/seedling and fuel and maintenance. The economic inefficiency variables also showed negative coefficient and significant at different levels. The study concluded that there was economic inefficiency in irrigated vegetable production in the study area despite high levels of economic efficiencies among the studied farmers. It is recommended that there is need for the concerned agencies to promote both formal and none-formal education. It is recommended that government should provide support in respect to price stability, good market facilities and market information to enhance efficiently of vegetable production in the study area.

Keywords: Economic-efficiency; vegetable; production; irrigated; stochastic; cost-function.

1. INTRODUCTION

Vegetables play very important role in the diet of human. The consumption of vegetable as a cheap source of minerals and vitamins to supplement people's diet cannot be over emphasized. They help in protecting body against diseases. Almost all vegetables are low in fat and calories and many of them are good sources of fibre. The high level of fibre in vegetable keeps the digestive system healthy and prevents constipation. Vegetable production also serves as sources of livelihood for small-scale farmers, create employment opportunities for the populace, generate income and reduce poverty [1,2].

Nigeria is one of the vegetable producing nations in Africa. In the past, it was found to be producing below major African producing nations, but currently there is improvement in the production level. As at 2012, production records were put at 643,312 million metric tonnes, which is highest compared to other African vegetable producing nations [3].

Borno State is one of the States where vegetable production is highly practised. Production of vegetable is largely carried out during dry season under irrigation condition, although it is also grown under rain fed agriculture. About 10,000 hectares of land is devoted to vegetable cultivation in Borno State BOSADP [4]. The vegetable crops commonly grown in Borno State include onion, tomato, pepper, okra, egg-plant, amaranthus, sorrel, lettuce, cabbage and carrot. Most of these are grown as mixed crops especially onion, tomato and pepper, amaranthus and sorrel, cabbage and lettuce and so on. An average yield of about 15.25 tonnes per hectare, 6.09 tonnes per hectare and 9.65 tonnes per hectare of onion, tomato and pepper respectively were reported to be produced in the State [5,6]. Production of vegetables in the State is still at small-scale level, in spite of its economic growth potentials. Studies involving farmers' efficiency and productivity measure could be sound bases for harnessing the growth potentials in vegetables farming. The objectives were to estimate the levels and determinants of economic efficiency of irrigated vegetable production in Borno State Nigeria. This study was concerned with the analysis of economic efficiency among irrigated vegetable producers in Borno State, Nigeria. The study covers the single production season of 2012/2013 season. The enterprises considered under this study were onion, tomato and pepper, which were known to be of high economic value in the study area and can be produced under similar production conditions.

2. METHODOLOGY

2.1 The Study Area

The study was conducted in Borno State, Nigeria. The State lies between latitudes 10°02′N and 13°04′N and longitudes 11°04′ E and 14°04′E [7]. The State shares borders with Adamawa State to the south, Yobe State to the west and Gombe State to the southwest. It also shares international borders with Cameroon Republic to the east, Chad Republic to the north-east and Republic of Niger to the north. The State has a land mass of about 69,434 square kilometers [8]. Administratively, it has 27 Local Government Areas (LGAs) with a projected population of about 4.8 million people based on 2.8 percent growth rate [9].

The State is divided into three agro-ecological zones; Sahel to the north, Sudan Savannah in the central and southern parts of the State and Guinea Savannah in the southern part. The average rainfall per annum is 300 mm in the north and about 1000mm in the south [7]. The rainy season in the State usually starts in April and ends in October. The temperature ranges from 25°C - 47°C but instantaneous temperature might reach up to 47°C during the hottest months of March-May [4]. The state is also blessed with lakes and rivers such as Lake Chad, Lake Alau, Lake Tilla, River Ngada, River Yazaram, and River Yare where irrigation farming is carried out especially during dry season.

The major occupation of the inhabitants is farming. Food crops commonly cultivated include millet, sorghum, maize, groundnut, cowpea, rice and wheat. Fruits and vegetables grown include mango, orange, guava, tomatoes, onion, pepper, carrot, amaranths and garden-egg. The State is known for its vegetables production, produced throughout the year, which can be grown both under irrigation and in the rain. Most of the vegetables can be grown as sole or mixed cropping. The vegetable production is carried out during dry and cool seasons under irrigation around November to January.

2.2 Sampling Procedure

Multistage sampling techniques were used to select respondents for this study. The first stage involved selection of three Local Government Areas (LGAs) known for production of vegetables, one from each of the three main agro-ecological zones. The LGAs selected were Hawul in Guinea Savannah, Mobbar in Sahel Savannah and Bama in Sudan Savannah.

The second stage involved random selection of four villages each from the selected LGAs. This was based on the list of major vegetables producing villages obtained from the Borno State Agricultural Development Programme (BOSADP). The third and final stage involved random selection of 300 respondents based on a 25% proportion of vegetable farmers in each of the selected villages. However, 296 questionnaires (98.6%) were retrieved and used for analysis.

2.3 Sources of Data

Primary data and secondary information were used for this study. The relevant primary data were collected through administration of structured questionnaires. Trained enumerators were used to administer the questionnaires. The secondary information was obtained from published materials such as government publications, BOSADP, CBN bulletins, annual statistical data and journals.

2.4 Analytical Techniques

Both descriptive and inferential statistics were used for the analyses of data obtained. Descriptive statistics used include means, frequencies and percentage distributions. The descriptive statistics were also used to examine socio-economics characteristic of vegetable producers anddistribution of levels of economic efficiency irrigated vegetable producers. The inferential statistics used was stochastic frontier cost function to analyze the level determinants of economic efficiency of irrigated vegetables enterprises.

2.4.1 Stochastic frontier cost function

Stochastic frontier cost function was used to estimate the economic efficiencies of irrigated vegetable producers. The farmers' frontier cost function model is explicitly expressed as:

$$\ln C = \alpha_0 + \alpha_1 \ln Q_1 P_1 + \alpha_2 \ln Q_2 P_2 + \alpha_3 \ln Q_3 P_3 + \alpha_4 \ln Q_4 P_4 + \alpha_5 \ln Q_5 P_5 + \alpha_6 \ln Q_6 P_6 + \alpha_7 \ln Q_7 P_7 + \alpha_8 \ln Q_8 P_8 + V + U \quad (1)$$

Where:

C_i = total input cost of i^{th}farm (₦)
Q_i = output quantity of the i^{th} farm (kg)

P_1 = cost per man-day of labour (₦)
P_2 = cost of inorganic fertilizer (₦/ kg)
P_3 = cost of organic fertilizer (₦/kg)
P_4 = cost of planting materials (₦/kg)
P_5 = cost of agrochemicals (₦/lit)
P_6 = depreciations of farm tools (₦)
P_7 = cost of seed/seedling (₦)
P_8 = cost of fuel and maintenance of machines (₦)
α_0 = constant
α_{1-8} = estimated parameters
V = random variable assumed to be independently and identically distributed as μ (0, σ^2_v) and independent of U_is; that represent the stochastic effect outside the farmer's control
U = one sided ($U_i \geq 0$) efficiency component that represents economic inefficiency in production which is assumed to be independently and identically distributed as truncation (at zero) of the normal distribution with mean, K_i σ and variance

σ_u^2 (|μK_iσ, σ^2u|).

The economic inefficiency model is explicitly expressed as:

$$\mu = \sigma_1 \ln K_1 + \sigma_2 \ln K_2 + \sigma_3 \ln K_3 + \sigma_4 \ln K_4 + \sigma_5 \ln K_5 + \sigma_6 \ln K_6 + \sigma_7 \ln K_7 + \sigma_8 \ln K_8 + wi \quad (2)$$

Where:

μ = economic inefficiency
K_1 = farming experience (years)
K_2 = formal education (years)
K_3 = extension contact (number of visit)
K_4 = credit availability (Dummy = 1 if available and 0 otherwise)
K_5 = distance to market (km)
K_6 = membership in farmers association (Dummy = 1 if member and 0 otherwise)
K_7 = ownership of irrigation facilities (Dummy = 1 if available and 0 otherwise)
K_8 = off-farm income (₦)
σ_{1-8}= parameters estimated
w = random variable defined by the truncation of the normal distribution with zero mean and variance σ^2_usuch that the point of truncation is $K_i\sigma_i$, iew$_i \geq -K_i \sigma$.

The coefficient of explanatory variables in the cost function such as wage rate, cost of planting material, cost of agrochemical, cost of farm tools and cost of seedlings a*re a priori* expected to be negative. The signs of coefficients of variables in the inefficiency model such as farming experience, distance to market, membership of farmers association, level of formal education, extension contact, credit availability, fuel and maintenance of machines are also *a priori* expected to be positively related to cost efficiency.

U_i provides information on the level of economic efficiency of the i^{th} farm. The economic efficiency of individual farmer is expressed in terms of the ratio of the predicted minimum cost (C_i*) to the observed cost (C_i) as:

$$EE = C_i^*/C_i = \exp(U_i) \quad (3)$$

The maximum likelihood estimate (MLE) of the parameters of the model defined by equation (1) and (2) and farmer specific EE defined in (3) were estimated using the computer programme FRONTIER version 4.1 package [10].

In the process, the variance parameters σ^2_u and σ^2_v are expressed in terms of parametization as:

$$\sigma^2 = (\sigma^2_u + \sigma^2_v) \quad (4)$$

$$\gamma = (\sigma^2_u / \sigma^2) \quad (5)$$

where,

γ = total variation in output from the frontier which is attributed to economic inefficiency.

The value of γ ranges between zero and one. When γ equals zero, variation in cost is due to factors not directly under the control of the farmers. The economic inefficiency ranges between zero and one indicating the extent of producers' deviation above the frontier.

3. RESULTS AND DISCUSSION

3.1 Socio-Economic Characteristics of Respondents

The socio-economic characteristics of the vegetable farmers studied were sex, household size and years of farming experience. Others socio-economic characteristic studied were primary occupations, secondary occupations, annual farm income, annual non-farm income

and membership of cooperatives/associations. The distributions of socio-economic characteristics of the respondents are presented in Table 1.

3.1.1 Sex of the respondents

The distribution of sex of the respondents presented in Table 1 revealed that vegetable production in the study area was dominated by male (99.7 percent) as against female with 0.3 percent. This indicates dominance of male folk in vegetable production in the study area. This could be attributed to the fact that irrigation farming required rigorous labour which male farmers can provide easily than their female counterpart. The dominance of male farmers in vegetable production in the study area may also be due to upper hand enjoyed by male farmers in terms of accessibility to farm land and production inputs. These results compare favorably with the findings of [11] who noted that 78.1 percent of respondents in dry season tomato production in Kwara State of Nigeria were males.

Table 1. Distribution of respondents by socio-economic characteristics of the respondents (n=296)

Variables	Frequency	Percentage	Mean
Sex			
Male	295	99.70	
Female	01	0.30	
Age			
≤20	03	1.00	37.0
21-30	99	33.40	
31-40	136	45.90	
41-50	44	14.90	
51-60	08	2.80	
>60	06	2.00	
Household size			
≤5	46	15.50	10.6
6-10	137	46.30	
11-15	81	27.40	
>15	32	10.80	
Years of formal education			
≤5	210	70.90	7.0
6-10	48	16.20	
11-15	26	8.80	
>15	12	4.10	
Years of farming experience			
≤10	116	39.20	15.5
11-20	161	54.40	
21-30	10	3.40	
>30	09	3.00	
Type of ownership			
Family	42	14.10	
Rented/Lease	161	54.30	
Inherited	49	16.55	
Purchase	31	10.45	
Communal	14	4.60	
Farm size			
≤0.5	46	15.54	2.5
0.51 – 1.00	85	28.70	
1.01 - 1.50	61	20.61	
1.51 - 2.00	79	26.69	
> 2.00	25	8.46	
Type of vegetable (Enterprise)			
Sole onion	58	19.60	
Sole tomato	48	16.22	
Sole pepper	44	14.87	
Onion/tomato	74	25.00	
Onion/pepper	40	13.51	

Variables	Frequency	Percentage	Mean
Tomato/pepper	18	6.08	
Onion/tomato/pepper	14	4.71	
Primary occupation			
Vegetable farming	261	88.20	
None vegetable farming	12	4.10	
Trading	09	3.00	
Civil servant	12	4.10	
Artisan	01	0.30	
Transporter	01	0.30	
Annual farm income			
≤50,000	28	9.50	
50,001-100,000	76	25.60	120,000.0
100,001-150,000	43	14.50	
150,001-200,000	44	14.90	
200,001-250,000	48	16.20	
>250,000	57	19.30	
Non-farm income			
≤50,000	95	32.10	
50,001-100,000	145	49.00	140,000.0
100,001-150,000	33	11.12	
150,001-200,000	5	1.69	
200,001-250,000	5	1.69	
>250,000	13	4.40	
Membership of associations/Coop.			
Non-member	195	65.90	
Member	101	34.1	

Source: Field Survey, 2013

3.1.2 Age of the respondents

The age distribution of the sampled farmers presented in Table 1 reveals that majority (80.3 percent) of the respondents were within the age group of 40 and below. The result implies that there is presence of young and middle aged individuals known to be active in agricultural production. The dominance of young persons among the respondents might be due to the fact that irrigation requires a lot of management practices and high labour. This result also indicates an availability of labour required for the farm activities.

3.1.3 Household size

In agricultural production, household size contributes immensely in terms of availability of family labour and area put under cultivation. The distribution of household size of the respondents is also presented in Table 1. The result revealed that 61.8 percent of the respondents had a household size of below 10 persons, while about 38.2 percent had a household size of 11 persons and above. The relatively large family size could be as a result of the practices of polygamy in the study area. The implication is that the needed labour in irrigation vegetable production can be provided through family labour for the execution of farm activities to enhance efficiency.

3.1.4 Years of formal education

The distribution of level of formal education of the respondents is presented in Table 1. The result revealed that 87.1 percent of the respondents had level of formal education below 10 years. This means that the respondents were educated not beyond secondary school level. The implication of low level of education is that they could not be easily exposed to/and adopt production technologies and innovations. Hence, this could have negative effect on the efficiency of vegetable production in the study area. Educated farmers are expected to manage their resources wisely. Hence education contributes positively in enhancing agricultural productivity especially in this era of technological advancement, which leads to efficiency in vegetables production.

3.1.5 Years of farming experience

Farming experience among the vegetable farmers is presented in Table 1. The result revealed that majority (93.6 percent) of the respondents had farming experience of equal to or less than 20 years in vegetable production. The result also indicated that very few (6.4 percent) were in the vegetable production for longer period of more than 20 years. This implies that vegetable farmers in the study area are

experienced which could help production favorably since they learn more by doing regularly.

3.1.6 Distribution of land ownership

The distribution of ownership of land among the respondents is presented in Table 1. The results revealed that majority (54.39 percent) of the respondents rented or leased their farms before they cultivate. This implies that the land suitable for vegetable cultivation is not available to all farmers and since they are small-scale producers they can rent for the period of the production. Therefore the respondents are expected to utilize the rented farms intensively to maximize their outputs since the farm lands are acquired for short period of time. Another implication of rented farm land is that respondents are restricted to undertake major farm investment and this affect irrigation farming negatively.

The Table also showed that 14.19 percent cultivated family land. This implies that users of family lands are likely to have smaller farm size since each member of the family would have a right to use that particular land. The result also revealed that respondents, who inherited land for cultivation constituted 16.55 percent, those that purchase their land for cultivation of vegetable were 10.47 percent and 4.73 percent of the respondents owned communal land for cultivation. In all, ownership of land could affect profit of the vegetable producers as part of the profit goes to the payment of rent, purchasing of land and other land related expenses.

3.1.7 Farm size

Farm size plays a significant role in agricultural production which largely determines the ability of the farmers to source for labour and production inputs. The farm size is the estimate of the total land area cultivated by the respondents in this study. The distribution of farm size among the respondents in the study area is presented in Table 1. The result showed that respondents had a mean farm size of 2.5 hectares. This revealed that irrigation practice in the study area is carried out by small-scale farmers. The results in the table also revealed that majority (64.87 percent) of the respondents cultivated less than 1.5 hectares of farm land for vegetable production. It was also revealed that 35.15 percent of the respondent cultivated vegetable farm land of more than 1.5 hectares. The implication is that respondents could manage their farm lands with ease and intensify utilization of inputs to maximize productivity. However, they cannot increase output through land expansion due to limited farm size; hence the output can only be improved by increasing the efficiency of available inputs and technologies.

3.1.8 Types of vegetables grown

The respondents in the study area cultivate different types of vegetables. However, about seven cropping enterprises were commonly practiced and were studied. The distribution of combinations studied is presented in Table 1. The results revealed that onion/tomato enterprise was mostly practiced by vegetable farmers as indicated by 25 percent of them. This implies that farmers practice more of onion/tomato enterprise than other enterprises. This may be due to the fact that onion and tomatoes are always in high demand in the study area than other vegetable crops. The table also shows that sole onion, sole tomato and sole pepper constituted 19.6 percent, 16.22 percent and 14.87 percent respectively. Only very few farmers practiced tomato/pepper and onion/tomato/pepper enterprises as indicated by 6.08 percent and 4.73 percent respectively. The common cultivation of mixed vegetables may be due to the fact that they can be easily cultivated in the same piece of land, having very close fertilizer requirements. They are also not harvested at the same time, which gives room for convenient harvesting for the farmers.

3.1.9 Primary occupation

Table 1 also presents the distribution of primary occupation of the respondents. The result indicates that majority (88.2 percent) of the respondents considered vegetable farming as their predominant occupation and source of livelihood. Only very few of them are involved in other economic activities such as non-vegetable farming (4.1 percent), trading (3.0 percent), civil service (4.1 percent), artisan (0.3 percent) and transporters (0.3 percent).

3.1.10 Annual farm income

The percentage distribution of annual farm income of the respondents is presented in Table 1.The results revealed that 19.3 percent of the respondents earned greater than 250,000 naira per annum as an annual farm income. The table also shows that 25.7, 14.5, 14.9, 16.2 and 19.3 percent of the respondents earned between

100,000-150,000; 150,001-200,000; 200001-250,000 and ≤ 50,000 naira respectively as annual farm income. This implies that the respondents were averagely earning well and this coupled with non-farm income could be able them to acquire farm inputs for efficient utilization.

3.1.11 Annual non-farm income

The annual non-farm income is income derived by farmers from other sources other than farming to supplement income generated through farming. The non-farm annual income of the respondents in the study area is presented in Table 1. The result revealed that most (49 percent) of the respondents earned between 50001-100,000 naira as annual non-form income. This was followed by 32.1 percent who earned ≤50,000 naira, 18 percent earned >100,000 naira as annual non-farm income. This implies that the respondents have other sources of livelihood to supplement the annual farm income, in spite of their small-scale nature. This means that they can finance their farming operations without delay.

3.1.12 Membership of farming association

Being a member of farming associations or cooperative society enables a member to benefit from getting improved technology, credit facilities and extension services among other benefits. Table 1 shows the distribution of membership of farmer associations/ cooperatives among the respondents. The results revealed that majority (65.9 percent) of the respondents were not members of any associations/cooperatives. This may be due to the fact that there is no much enlightenment on the importance or benefits derived from being a member of association in the study area. The result also indicated that 34.1 percent of the respondents were members of different farming associations/ cooperatives. This implies that the respondents may enjoy from benefits derived from being a member of associations/cooperatives such as loan, information, inputs among others; which may affect productivity and efficiency.

3.2 Level of Economic Efficiency of Vegetable Producers

The distribution of economic efficiency level among the respondents for the studied vegetable enterprises is presented in Table 2. The results revealed that respondents exhibit varied levels of economic efficiency ranging from 0.44 to 0.98. The mean economic efficiency for the enterprises was 0.72, 0.86, 0.73, 0.78 and 0.78 for onion, tomato, pepper, onion/tomato and onion/pepper respectively. The observed efficiency levels show under-utilization of resources for their inability to operate on the cost frontier. The results indicate that respondents can still reduce cost by 28, 14, 27, 22 and 22 percent for the studied enterprises, respectively. Although the respondents were unable to be on the frontier but the results suggest appreciable performance of the vegetable industry. A similar result (0.73) obtained by [12] also suggests that smallholder vegetable producers in Malawi were operating at higher economic efficiency level. Studies [13,14] involving cereal crops however, showed lower average performance.

The important attributes of the most economically efficient vegetable farmers in the enterprises were higher level of formal education (indicate mean years spent in school), membership of farmers' association, access to credit (which could be used to procure inputs especially improved seeds and irrigation facilities). The distribution of level of economic efficiency in Table 1 indicates that respondents are operating at higher level of economic efficiency. This may be due to the fact that the inefficiency variables included explained the model in all the enterprises.

3.3 Determinants of Economic Efficiency

The results of the maximum likelihood estimates of the stochastic frontier cost functions for the considered vegetable enterprises are presented in Table 3. The results reveal that the sigma square estimates for the studied enterprises were less than 1 (0.248, 0.031, 0.363, 0.228 and 0.122, respectively for the sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper) and statistically significant. This attests to the goodness of fit of the model and correctness of the specific assumptions of the composite error terms distribution [15]. The variance ratio (gamma), indicates that inefficiency effect exist (thus justifying the use of the stochastic frontier model) as indicated by 0.945, 0.932, 0.945, 0.173 and 0.266, respectively for the sole onion, sole tomato, sole pepper, onion/tomato and onion/pepper and were all significant at one percent level. The higher percentages of variation in the production cost of vegetables were due to differences in cost inefficiency.

Table 2. Distribution of the levels of economic efficiency of vegetable enterprises producers

Efficiency level	Enterprises									
	Sole onion		Sole tomato		Sole pepper		Onion/Tomato		Onion/Pepper	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
0.40 - 0.50	1	1.1	00	00	1	2.3	5	6.8	00	00
0.51 - 0.60	14	15.9	1	2	3	6.8	3	4.1	5	12.5
0.61 - 0.70	28	31.8	5	10	12	27.3	14	18.9	8	20
0.71-0.80	25	28.4	12	24	20	45.5	20	27.0	13	32.5
>0.80	20	22.7	32	64	8	18.2	32	43.2	14	35
Total	88	100	50	100	44	100	74	100	40	100
Mean	0.72		0.86		0.73		0.78		0.78	
Min	0.46		0.60		0.50		0.44		0.58	
Max	0.99		0.99		0.96		0.99		0.99	

Source: Field Survey, 2013

Table 3. Maximum log-likelihood estimate of cobb-douglas cost function for vegetable production

Variables	Parameters	Enterprises									
		Sole onion		Sole tomato		Sole pepper		Onion/Tomato		Onion/Pepper	
		Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Constants	β_0	2.954	7.180***	5.539	7.989***	4.115	5.532***	4.501	3.994***	9.538	6.484***
LnWage rate of Labour (X_1)	β_1	9.936	14.335***	0.341	12.095***	0.154	2.630***	1.464	6.811***	0.128	1.898^{NS}
Ln Cost of Inorg. Fert. (X_2)	β_2	0.005	1.96*	0.100	9.560***	0.176	8.253***	0.195	7.908***	0.252	6.906***
LnCost of OgFert.(X_3)	β_3	0.040	9.597***	0.033	2.168**	0.816	6.835***	0.424	12.569***	0.385	13.780***
Ln Cost of Planting Material(X_4)	β_4	0.030	5.707***	0.077	3.325***	1.503	5.976***	0.306	6.075***	0.119	12.641***
Ln Cost of agrochemical (X_5)	β_5	0.727	19.744***	0.202	14.171***	1.917	5.418***	0.588	14.634***	0.094	2.193**
Ln Cost Depreciation (X_6)	β_6	0.051	2.933***	0.327	17.338***	0.641	11.754***	0.515	12.696***	0.579	8.774***
Ln Cost price of Seed/seedling (X_7)	β_7	0.074	13.384***	0.007	0.257^{NS}	0.147	2.928***	0.128	2.371**	0.730	9.535***
Ln Cost of Fuel & maintenance (X_8)	β_8	9.929	14.346***	0.075	3.534***	1.762	4.314***	3.190	15.105***	0.766	14.434***

Variables	Parameters	Enterprises									
		Sole onion		Sole tomato		Sole pepper		Onion/Tomato		Onion/Pepper	
		Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Inefficiency											
Ln Farming exp. (Z_1)	α_1	-0.035	-1.981*	-0.480	-8.910***	-4.634	-3.320***	-0.679	-6.082***	-0.608	-5.040***
Ln Level of formal Edu.(Z_2)	α_2	-0.010	-1.998**	-0.103	-3.064***	-0.615	-8.073***	-0.478	-7.377***	-0.373	-3.778***
Ln Ext. Contact (Z_3)	α_3	-0.118	-5.509***	-0.201	-3.258***	-0.739	-3.107***	-0.403	-2.828***	-0.602	-2.157**
Ln Credit Avail. (Z_4)	α_4	-0.018	-0.254^{NS}	-0.928	-8.699***	-0.304	-2.561***	-1.241	-4.713***	-1.801	-6.329***
Ln Dist. to Mkt. (Z_5)	α_5	-0.365	-5.477***	-0.193	-2.131**	-0.864	-4.831***	-0.264	-1.836^{NS}	-3.144	-17.666***
Ln Memship of Farmers' Ass. (Z_6)	α_6	-0.221	-3.460***	-0.174	-1.824^{NS}	-0.314	-1.054^{NS}	-3.454	-12.948***	-0.880	-2.708***
Ln Owned Irrg.Facility (Z_7)	α_7	-0.026	-0.358^{NS}	-0.515	-2.557***	-0.672	-1.350^{NS}	-3.404	-6.415***	-1.013	-8.990***
Ln Off- farm Income (Z_8)	α_8	-0.002	-0.345^{NS}	-0.006	-0.380^{NS}	-0.029	-0.440^{NS}	-0.091	-4.837***	-0.647	-5.294***
Sigma Square	δ^2	0.248	7.448***	0.031	4.635***	0.363	6.292***	0.228	-6.478***	0.122	4.428***
Gamma	Γ	0.945	2.795***	0.932	13.867***	0.945	52.724***	0.173	-8.107***	0.266	10.546***
Log likelihood ratio		-5.679		-15.802		-9.718		50.213		-14.690	

Source: Computed from Field Survey Data 2013.

**** Significant at 1%, ** Significant at 5%, NS Not significant*

Table 3 also reveals that coefficients of wage rate for all the enterprises were positive and significant at one percent level except for onion/pepper enterprise. This indicates that a unit increase in cost of labour leads to increase in total cost of production by a value equal to the respective coefficients of the enterprises. The implication of this is that as cost of labour increases, total cost of production also increases which may likely affects the profit obtained from the vegetable production activities. The wage rate coefficient is the highest among all the coefficients in the cost function, indicating that labour may have been used most inefficiently. This relationship suggests absence of scale economies in the vegetable production industry in the study area.

The coefficient of cost of inorganic fertilizer was positive and significant at one percent level. The values of coefficients for the studied enterprises were 0.005, 0.100, 0.176, 0.195 and 0.252, respectively. The low value of the fertilizer coefficients is an indication of its high productivity in relation to labour and maintenance variables. Fertilizer is an important input in vegetable production, optimum level ranges between 150 kg/ha to 250 kg/ha [16]. Therefore, as the cost of inorganic fertilizer increases the total cost of production in vegetable production in the study area also increases.

Table 3 also indicated that coefficients of cost of organic fertilizer for the studied enterprises were positive and significant at one percent level except for tomato enterprise which was significant at five percent level. The coefficients were 0.040, 0.033, 0.186, 0.424 and 0.385 for the studied enterprises respectively. This indicates that increase in unit cost of this variable leads to increase in total cost of production equal to the value of the respective coefficients of the studied enterprises. The implication is that this variable contributes to total cost of production positively.

The cost of planting materials also had positive coefficients and significant at one percent level for all the enterprises except onion/pepper enterprise which was significant at five percent level. The coefficients as presented in Table 3 were 0.030, 0.077, 1.503, 0.366 and 0.119 for the studied enterprises. This means that there is a positive contribution of this variable to total cost of production equivalent to the respective coefficients in the different enterprises. The results imply that planting material is an important factor contributing positively to the cost of production.

The coefficients of costs of agrochemicals, depreciation, seed/seedling and fuel and maintenance were found to be positive and significant as presented in Table 3. The results indicate that cost of production of vegetable increase with values equal to the coefficient of these variables. The cost of fuel and maintenance is the second most inefficiently utilized variable in vegetable production as indicated by the coefficient in the cost function. Vegetable production in the study area is usually done under irrigation, therefore costs associated with running of water pumps including fuel, lubricants and depreciation form part of total cost of production. Inefficient use of water pumping plants could result to increase in production cost which will negatively affect profits. [17] also found a positive relationship between maintenance costs and total cost of production for irrigated vegetables.

The inefficiency component of the cost function is also presented in Table 3. As expected *a priori*, the coefficients of the inefficiency variables were negative and significant. The negative signs on the coefficients indicate that a unit increase in the affected variable leads to decrease in economic inefficiency in vegetable production. The coefficients of years of farming experience for the studied enterprises were negative and significant at one percent level except onion enterprise which was significant at five percent level. The coefficients were -0.035, -0.480, -4.634, -0.679 and -0.608 for studied enterprises respectively. This means that increase in years of vegetable farming experience leads to a decrease in economic inefficiency. This may be due to the fact that, with more years of vegetable production experience comes greater understanding of cultural practices and other management practices that would help reduce products losses as the vegetable grows up to the point of harvest. This may influence the economic efficiency of the vegetable farmers significantly.

Coefficients of level of formal education were negative and significant. The coefficients were -0.010, -0.103, -0.615, -0.478 and -0.373 and significant at one percent level. This indicates that as educational level of farmers increase, the economic inefficiency in vegetable production reduces. The implication is that higher level of

education, especially agricultural related education by farmers leads to higher economic efficiency. This is in agreement with the findings of [18] which reported a negative relationship between economic inefficiency and level of formal education.

The estimated coefficients of extension contact were also negative (-0.118, -0.201, -0.739, -0.403 and -0.602) and significant at one percent levels with onion/pepper enterprise being significant at five percent. This means that extension contact reduces economic inefficiencies by the values equal to the magnitudes of the respective coefficients. The implication is that providing appropriate extension services to vegetable farmers have the influence of reducing inefficiency in their production activities. A similar result was reported by [19] who maintained that extension visits had negative implication on economic inefficiency in tomato production.

The coefficients of access to credit were negative as expected with values of -0.081, -0.928,-0.304, -1.241 and -1.801 for the studied enterprises. All the coefficients were significant at one percent except for onion. This means that increasing access to credit will lead to decrease in economic inefficiency in vegetable production in the study area. The implication is that with credit availability, farmers can purchase all required inputs for efficient production, hence output per unit investment is likely to expand and leads to lower cost per unit output due scale economies. This result is similar to the findings of [11] in which access to was significant at one percent level and had negative coefficient.

The coefficients of proximity to market indicate negative values and significant at one percent levels for all the studied vegetable enterprises except for onion/tomato enterprise. The coefficients were -0.365, -0.193, -0.304, -1.241 and -1.801 for the studied enterprises respectively. The result implies that a unit increase in proximity to market leads to reduction in economic inefficiency equal to the respective coefficient of the enterprises. Proximity to market is crucial in vegetable production in terms of easy access to inputs and disposal of outputs. This is especially with fruit vegetables such as tomato and pepper. Huge losses were reported while on transit [20] to especially distant markets were premium prices are expected.

Membership of farmers' associations plays important roles in determining economic inefficiency [15]. Table 3 reveals that membership of farmers' association had negative coefficient for all the studied enterprises and significant at one percent, except for tomato and pepper enterprises were not significant. The coefficient of the significant variables were -0.221, -3,454 and -0.880 for onion, onion/tomato and onion/pepper respectively. The result indicates that participation in farmer associations leads to decrease in economic inefficiency by equal amount of the respective coefficients of the enterprises.

Coefficient of ownership of irrigation facilities and off-farm income were negative as indicated in Table 3. This means that these variables contribute negatively to economic inefficiency by an equal amount of the respective coefficients of the enterprises. The implication of this is that people who own facilities such as water pumps were more efficient as such facilities have the tendency of reducing inefficiencies through proper scheduling of irrigation and timeliness of required operations. Off-farm income can also be used in purchasing additional equipment, paying for labour for smooth operations on the farm leading to economic efficiency.

4. CONCLUSION AND RECOMMENDA-TIONS

The study concluded that economic inefficiency was present in irrigated vegetable production in the study area. The study also concluded that production variables for the studied vegetable enterprises were significant in contributing to the production of vegetables under irrigation. Costs of inorganic fertilizer, organic fertilizer, planting material, agrochemical, depreciation, seed/seedling and fuel/maintenance were contributing immensely to cost of production vegetable. The economic inefficiencies variables such as experience, level of formal education access to credit and distance to market were contributing positively to economic efficiency. Based on the findings of the study it is recommended that there is need for concerned agencies to promote both formal and non-formal education as the way forward to increase efficiency in vegetable production; vegetable farmers should be mobilized and encouraged to strengthen the activities of farmers' clubs and associations. This could help the vegetable

farmers to acquire professional advice, inputs and credit facilities and use them efficiently giving rise to efficiencies in vegetable production, Government should provide financial and material supports to farmers to improve the efficiency of vegetable production by making loans available and accessible to vegetable farmers in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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