www.jard.edu.pl http://dx.doi.org/10.17306/J.JARD.2021.01416

Journal of Agribusiness and Rural Development

pISSN 1899-5241
eISSN 1899-5772

4(62) 2021, 429–434
Accepted for print: 20.11.2021

ECONOMIC EFFICIENCY ANALYSIS OF SMALL-SCALE TOMATO FARMERS IN GREATER LETABA MUNICIPALITY, LIMPOPO PROVINCE, SOUTH AFRICA

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Abstract. This paper analysed the economic efficiency of small-scale tomato farmers in the Greater Letaba municipality of South Africa's Limpopo Province. Primary data were collected from 68 tomato farmers based on structured questionnaires and using convenience and purposive sampling procedures. The Cobb-Douglas production function was used to analyse the level of economic efficiency. The study utilised the output approach, where the output achieved by the farmers is compared to the maximum output attainable using the given inputs. The empirical results reveal that mean technical, allocative, and economic efficiency levels are at 0.95, 0.41 and 0.39, respectively. The study also found that land (farm size), seedlings, labour, pesticides and water have a positively significant relationship with the production of tomatoes in the study area. Therefore, it is recommended that the Department of Agriculture, Land Reform and Rural Development provide farmers with enough extension services by employing more extension personnel. Government programmes such as the Comprehensive Agricultural Support Programme should be intensified – through the pillar of training and capacity building – to reach the small-scale farmers in the municipality, whereby farmers should be provided with training on the recommended minimum and maximum application of inputs like pesticides, fertilisers, seedlings and water in tomato production.

Keywords: economic efficiency, technical efficiency, allocative efficiency, tomato, and small-scale farmer

INTRODUCTION

The tomato (*Lycopersicon esculentum)* is a vital vegetable crop in South Africa, being the second most popular crop after potato. It is not only cultivated commercially but also commonly grown by subsistence, resource-poor farmers and home gardeners. Tomato production contributed approximately 18.2% in 2013, and 18.3% in 2015, to the gross value of vegetables in South Africa, with a 5.8% increase in tomato production observed in 2017. South Africans typically use tomatoes in stews to complement their staple diet of maize meal; they are also among the vegetables used by hawkers and street vendors to generate income. Due to its climate, Limpopo Province plays a critical role in the production of tomatoes in South Africa, with about 75% of South Africa's total area planted with tomatoes being located there (DAFF, 2018). Tomato consumption in South Africa amounts to 12 kg per annum in metropolitan areas, and this is affected by such factors as population growth, urbanisation and per capita income. Moreover, the average South African household consumes about five to ten tomatoes per week (DAFF, 2011). However, the demand for tomatoes in rural areas is not reflected by the statistics despite such areas accounting for the largest share of tomato consumption. Technical efficiency can be defined as the production of the maximum possible output by the farm from a given set of inputs (Rukuni, 1994). Furthermore, it can be defined by comparing actual and

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expected output from a set of inputs. It consists of two sides – the input and output (Chiona, 2011). This study makes use of the output, where the output achieved by the farmers is compared to the maximum output attainable from the given inputs. Allocative efficiency is the ability of the farmers to use the available inputs in optimal proportions given their prices and the available production technology (Ali et al., 2012 and Sujan et al., 2017). Furthermore, it can also be defined as the ability of the farmer to produce at an optimal level of output using cost-minimising input ratios. Economic efficiency is the farmer's ability to maximise profit through resource use and costs of the output per unit; moreover, it is a product of technical and allocative efficiency (Adeniji, 1988; Haji, 2008; Asogwa et al., 2011; Mburu et al., 2014 and Maina et al., 2018). This means that to analyse the farmers' economic efficiency, it is necessary to determine their technical and allocative efficiency, and thus, economic efficiency is dependent on the level of technical and allocative efficiency. Biam et al. (2016) expanded this explanation by indicating that economic efficiency presents costs per unit of output for a firm that perfectly attains both the technical and allocative or price or resource use efficiency.

Debebe et al. (2015) analysed economic efficiency among smallholder maize farmers. The study collected data from 385 farmers and analysed it using the Stochastic Frontier Model (Cobb-Douglas). Such factors as family size, education level, extension services and cooperative membership were found to be positively significant, whereas farm size was negatively significant in influencing the economic efficiency of maize farmers. The results obtained by Cobb-Douglas indicated that such inputs as land, labour and fertilisers were positively significant. Moreover, technical, allocative and economic efficiency mean levels were at 62.3%, 57.1% and 39%, respectively. The results indicate that 19 farmers in the study area are economically inefficient. Furthermore, Akinsola et al. (2020) indicate the importance of farmer education and extension visits in improving farmers efficiency, thus supporting the conclusions of the latter study. However, the results contradict the study by Eze and Nwibo (2014) who found that labour was insignificant, while fertilisers and herbicides were negatively significant, with farm size being positively significant. Moreover, factors such as farm size, labour, fertilisers and cassava cuttings were under-utilised as their efficiency ratio was above one. The study made use of the data from 120 farmers and the coefficient of determination was found to be at 83.8. The study by Kazeem (2020) contradicts the latter study as it indicates that herbicides have a positive influence on farmer efficiency. This goes a long way to show that efficiency is imperative in improving input allocation and production.

MATERIALS AND METHODS

Study area

This study was conducted in the Greater Letaba municipality situated in the Mopani District of the Limpopo Province. The Greater Letaba municipality is regarded as the smallest of Mopani District's five municipalities and has an area of approximately 1,891 km^2. It consists of 131 rural villages and its annual rainfall amounts to about 300-600 mm.

Sampling procedure and data collection

The study used purposive and convenience sampling techniques. The purposive sampling method was employed to interview small-scale tomato farmers only since the study aimed to analyse the economic efficiency of small-scale tomato farmers. The convenience sampling method was used as well because the farmers who produce tomatoes in the study area are scattered throughout the municipality and the resources to reach them are limited; hence, data were collected from 68 small-scale tomato farmers who were easily accessible and conveniently available to participate in the study. The interviews were conducted between June and December 2019, using semi-structured questionnaires consisting of open-ended questions where providing additional information was required.

Analytical techniques

Descriptive and quantitative methods were used to analyse the data collected. The Cobb-Douglas production function was used to analyse variables that affect tomato production. The model is presented as follows:

$$Y = AK^{\alpha}L^{\beta}U$$

where: Y – output; K – capital; L – labour; A – constant, and U – error term.

For the returns to scale, the study makes use of β and α; the sum of α and β is greater than one for increasing returns to scale, less than one for decreasing returns to scale, and equal to one for constant returns to scale (Ike and Inoni, 2006). The returns to scale are computed as follows:

$$\alpha = \frac{\delta Y/Y}{\delta K/K} \qquad \beta = \frac{\delta Y/Y}{\delta L/L}$$

The operational model that relates the output (Y) as a dependent variable, with independent variables (X) or the production factors in the study, is given as follows:

$$Y = aX_1^{B1}X_2^{B2}X_3^{B3}X_4^{B4}X_5^{B5}\,X_6^{B6}X_7^{B7}e$$

The model is linearized to be able to use the ordinary least square (OLS), by introducing the natural logarithm on both sides of the equation, which is represented as follows:

$$\ln(Y) = B_0 + \ln B_1X_1 + \ln B_2X_2 + \ln B_3X_3 + \ln B_4X_4 + \\ + \ln B_5X_5 + \ln B_6X_6 + \ln B_7X_7 + U$$

where: Y – is the total quantity of output (kg of tomato in this case); X_1 – is the land devoted (ha); X_2 – is capital (tractor hours); X_3 – is family and hired labour (man-days); X_4 – is the fertiliser used (kg); X_5 – is the seedlings used; X_6 – is the pesticides used (litres); X_7 – is the water used (litres); $B_1 \ldots B_7$ – are the parameters to be estimated, Ln (Natural logarithm and B_0 is the constant value, and (U) is the disturbance term.

The technical efficiency measure for an individual farmer is as follows:

$$\text{Technical efficiency } (TE) = \frac{OBSERVED\ OUTPUT(Y)}{FRONTIER\ OUTPUT(Y^*)}$$

where: observed output (Y) is the actual output farmers produce, whereas frontier output (Y^*) is the expected output from the amount of input used. Technical efficiency is measured by using a scale between zero (0) and one (1). If the ratio is closer to zero, the given farmer is regarded as being technically inefficient while values closer or equal to one indicate that the farmer is efficient. According to Ogunniyi et al. (2013), technical efficiency can be defined as the farmer's ability to achieve an output closer to the frontier output.

According to Ike and Udeh (2011), allocative efficiency can be determined by equating the marginal value product (MVP) of the i^{th} input to its marginal factor cost.

$$\text{MPP} = \frac{dY}{dXi} = \frac{\beta y}{Xi}. \text{ Thus,}$$

$$\text{Allocative Efficiency} = \frac{MVP}{MFC}$$

If $MVP > MFC$, the farmers are regarded to be under-utilising the inputs at their disposal and farm profit can be increased by increasing the amount of inputs applied. If $MVP < MFC$, the farmers are regarded to be over-utilising the inputs at their disposal and the farm profit can be increased by reducing the amount of inputs used. If $MVP = MFC$, then it is deemed that the farmers are maximising profit and hence there exist allocative efficiency.

Economic efficiency is measured using the results of technical and allocative efficiency, as analysed above. Thus, it is measured as follows:

Economic efficiency (EE) = $TE \times AE$

where: EE – is economic efficiency, TE – is technical efficiency and AE – is allocative efficiency. The economic efficiency takes the value between 0 and 1; if the EE is closer to zero the farmers are economically inefficient, whereas a value closer to one shows overall efficiency – which is economic efficiency.

RESULTS AND DISCUSSION

Description of socio-economic characteristics of tomato farmers

Table 1 indicates that 21% of the small-scale tomato farmers are aged between 18 and 35, and 79% are above the age of 35. About 62% of the farmers are females, with males constituting only 38%. An average of 1.265 hectares of land is typically devoted to tomato production. The number of seedlings used per hectare averaged 9,060.29 while the recommended number of seedlings per hectare is 18,000. Farmers apply about 257.75 kilograms of fertilisers per hectare in the production of tomatoes.

Furthermore, the labour force works about 4 days per week on average, even though the farmers have more labour force due to the availability of family members. On average, the farmers spend an amount of R1,206.47 per hectare for ploughing and preparing the land using a tractor and about 18,641.03 litres of water per hectare when irrigating the land. Moreover, they apply an average of 21.44 litres of pesticides per hectare.

Table 1. Socio-Erconomic characteristics of tomato farmers

Variables	Percentage mean
Age of the farmers	
between 18 and 35 years	21
above 35 years old	79
Gender of the farmers	
males	38
females	62
Inputs per season	
land (ha)	1.265
capital (rand/ha)	1 206.47
labour (man days/ha)	4.47
fertilizers (kg/ha)	257.75
seedlings (no./ha)	9 060.29
pesticides (litres/ha)	21.44
water (litres/ha)	18 641.03

Source: own elaboration, 2019.

Cobb-Douglas production function results

Table 2 indicates that coefficients of all the independent variables in the model have expected signs. variables such as land and seedlings, labour, pesticides and water were positively significant at 1, 5, and 10% respectively. Whereas, fertilizers and capital (tractor cost per hour) were insignificant but with positive signs. The results indicate that an increase in each of the inputs will lead to an increase in tomato output. Furthermore, a 1% increase in land size, labour, seedlings usage and water usage respectively will result in a 0.501, 0.192, 0.265, 0.157 and 0.166% increase in tomato output.

Table 2. Cobb-Douglas production function results

Model	Coefficient of elasticity	Standard error	*t*-ratio
(Constant)	2.508	1.287	1.949
Land	0.501***	0.175	4.777
Capital	0.006	0.048	0.058
Labour	0.192**	0.527	2.148
Fertilizer	0.016	0.074	0.156
Seedlings	0.265***	0.080	3.079
Pesticides	0.157*	0.076	1.708
Water	0.166*	0.062	1.857
Sum of B's	1.303		
Adjusted R^2	52%		

10%*, 5%** and 1%*** significance level.
Source: own elaboration, 2019.

The coefficients of elasticity for significant variables indicates that the tomato output is inelastic to changes in all the used variables. The results also reveal the adjusted R^2 of 0.52 indicating that the independent variables included in the model explained about 52% of the variation in tomato production. Whereas, the study by Mushunje and Belete (2001) suggested that the adjusted R^2 above 50% is not a bad result for the cross-sectional data.

Allocative efficiency results

The Marginal Value Product (MVP) of inputs must be equal to one for the farmer to be regarded as allocatively efficient. The results in Table 3 indicate that the farmers in the Greater Letaba municipality are under-utilising land, labour and seedlings while over-utilising such variables as capital, fertilisers, pesticides and water. The results also indicate that farmers are allocatively inefficient in the production of tomatoes.

Moreover, for the farmers to increase tomato productivity, they must increase the rate of land, labour and seedling use. Furthermore, they must reduce the rate at which they use capital, fertilisers, pesticides and water to increase tomato productivity in the study area. The results

Table 3. Results from allocative efficiency analysis

Variables (Inputs)	MVP	MFC	AE = MVP ÷ MFC
Land	0.501	0.281	1.78
Capital	0.006	0.262	0.02
Labour	0.192	0.086	2.23
Fertilizer	0.016	0.086	0.19
Seedlings	0.265	0.141	1.88
Pesticides	0.157	–0.075	–2.09
Water	0.166	0.362	0.46

Source: own elaboration, 2019.

contradict the study by Mokgalabone (2015), who found that farmers were over-utilising seeds and seedlings. However, the results concur with the study by Ogundari and Ojo (2006), who revealed that farmers were indeed over-utilising variables such as capital and fertilisers.

Technical, allocative and economic efficiency

Table 4 indicates that the economic efficiency level of tomato farmers in the Greater Letaba municipality is low at a mean of 0.39, whereas the mean technical and allocative efficiency amount to 0.95 and 0.41, respectively. The low economic efficiency is due to the low level of allocative efficiency.

Table 4. Technical, allocative and economic efficiency index

No. of farmers	TE	AE	EE
1–17	0.94	0.236	0.222
18–34	0.92	0.355	0.327
35–51	0.97	0.545	0.529
52–68	0.97	0.508	0.493
Mean efficiency	0.95	0.41	0.39

Source: own elaboration, 2019.

Moreover, it can be concluded that farmers in the study area are closer to the technical efficiency level. However, they are allocative and economically inefficient. The efficiency of the farmers could be increased by 0.05, 0.59 and 0.71% for technical, allocative, and economic efficiency, respectively. The mean economic efficiency of 0.39 suggests that farmers can reduce their input cost by 61% and still be able to produce the same amount of output.

CONCLUSION AND RECOMMENDATIONS

The analysis revealed that farmers in the Greater Letaba municipality are economically inefficient. Therefore, it is recommended that the government improve the farmers' access to extension services. Furthermore, it is recommended that the Comprehensive Agricultural Support Programme be intensified through the pillar of training and capacity building to reach the small-scale farmers in the municipality, whereby farmers should be provided with training on the recommended minimum and maximum application of such inputs as pesticides, fertilisers, seedlings and water in tomato production. Farmers with small plots of land should be encouraged to use alternative ways of ploughing (e.g. animal power) to reduce the costs of hiring tractors. Furthermore, farmers should be encouraged to continue farming tomatoes, and they should also be encouraged to improve their knowledge and skills in terms of farming practices, which can be achieved by making government agricultural grants readily available and easily accessible.

ACKNOWLEDGMENT

This work is based on research supported entirely by the National Research Foundation of South Africa (Grant Number: UID 108039).

SOURCE OF FUNDING

National Research Foundation of South Africa (Grant Number: UID 108039)

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