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TECHNICAL EFFICIENCY OF MAIZE-BASED FARM IRRIGATORS IN THE EASTERN CAPE PROVINCE: A STOCHASTIC FRONTIER MODEL APPROACH

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Abstract. Maize production is the most important field crop in South Africa. It has been produced from ancient years, with Mpumalanga and North West Provinces being principal producers. Maize is a widely produced and dominant ground crop because it is resistant, requires less labour, is rich in nutritional power and starch, grows relatively fast and is easily cultivated like other ground crops. Most of the maize produced in South Africa is consumed domestically. Despite the vast tracts of arable land and the universal land reform that has been implemented for 25 years, farmers in South Africa's former homelands cultivate only small food plots on which they primarily cultivate maize and a small number of vegetables. The objective of this study was to investigate the technical efficiency of maize farmers under small-scale irrigation systems. A multi-stage sampling procedure was used to select 120 maize farmers. The study used the STATA 15 program for analysis and utilised descriptive statistics and a stochastic production front model. Maize production in the study area was dominated by men (78%) with an average age of 60 years and an average family size of 4 persons per household. Smallholder irrigators have primary education, which means that they can read and interpret agricultural information. Farmers have at least ten years of agricultural experience on average. Taking into consideration high farm productivity, smallholder maize-based farmers were efficient in their use of resources. The allocative use of resources such as farm size, farm labour, fertiliser and seeds led to the identification of the optimum level of efficiency for the cultivation of maize. The level of technical efficiency for maize cultivation was 84%, indicating that 16% of the maize crop was not utilized by smallholder maize-based farmers in the study area. The study suggests that the Government and the private sector should improve agricultural techniques such as manure and improved seeds that are prepared early and available at a small and affordable cost to increase maize productivity.

Keywords: Eastern Cape Province, smallholder maize-based farmers, stochastic frontier analysis, technical efficiency

INTRODUCTION

Maize (*Zea mays* L.) is one of the world's most important annual cereal crops; it serves as a staple food and is used as a source of income for many populations in developing countries (Tandzi and Mutengwa, 2020). Maize is the most widely produced cereal in the world and a staple food for many people, mainly in sub-Saharan Africa. According to Ndjodhi (2016), maize is widely used directly or indirectly across the African continent with noticeable use as food, livestock feed, raw material for industrial purposes and as a staple product in the global food market. Maize is an excellent source of carbohydrates, protein, iron, vitamins, minerals and ethanol. Ndjodhi (2016) specified that more than half of global maize production occurs in the United States of America and China, while 6.5% of global maize production occurs in Africa, with Nigeria being the largest producer, followed by South Africa.

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Maize is the main crop produced in South Africa and is the most important source of carbohydrates in the Southern African Development Community (SADC) population for livestock and human nutrition (Tandzi and Mutengwa, 2020). South Africa remains the leading producer of maize in the SADC area, with an average annual yield of 9 t, mainly for domestic consumption (Southern African Regional Maize Market Fundamentals, 2016). Both commercial and smallholder farmers produce maize, although most production comes from commercial farmers (Sihlobo, 2018).

Although South Africa is the largest producer of maize, maize cultivation by smallholder farmers is mainly traditional, with little production equipment and small-scale, subsistence farming and slight market surplus (Baloyi, 2011). Baloyi et al. (2011) have also found a lack of strong support mechanisms for smallholder farmers. Furthermore, inadequate access to agricultural credit by smallholders probably resulted in low maize production. As a result, maize is produced throughout South Africa. Still, about 73% of total maize is produced in Mpumalanga, Free State and North West Province, while Eastern Cape is the second to last province with 1% production (DAFF, 2017). According to DAFF (2017), Eastern Cape province is the second-lowest maize producing province with 76t, causing the province to buy maize from Mpumalanga (2319 t), Free State (2214 t) and North West (1141 t).

Despite the Government's efforts on behalf of smallholder farmers, the transition from subsistence farming to small-scale commercial agriculture has been slow, leading to increased food insecurity and widespread poverty among rural communities (Ramaila et al., 2011). There is a downward trend in agricultural productivity among smallholder farmers, particularly maize production (Kibirige and Obi, 2015). Consequently, more efforts and commitments are being made by the current Government to encourage more innovations aimed at increasing the productivity of smallholder farmers (Zuma, 2015). Innovation and adoption of new technologies such as irrigation farming are a safe bet for uplifting smallholder production in order to reduce poverty and quickly restore smallholder livelihoods.

However, the stated innovation and adoption of new technologies may not be the only factors responsible for the increase in maize productivity. There are likely to be invisible factors such as farmers' socio-economic characteristics (Ali et al., 2013; Ali and Jan, 2017; Kibirige et al., 2016; Nyariki et al., 2015). Nevertheless, Muchara (2011) observed low use of irrigation systems in South Africa, mainly in the Eastern Cape region, among smallholder farmers. At the same time, farm sizes remain small, and most resource-poor farmers can only manage small food plots organised under government-run small-scale irrigation schemes.

Efficiency comprises two concepts, namely technical efficiency and allocative efficiency. Belete (2020) defines technical efficiency as the ability of a farm to obtain the maximum possible output from a given set of physical inputs at the lowest cost. On the other hand, allocative efficiency is defined as the ability of a farm to use factors of production in optimal proportions given their respective prices (Rukuni, 1994). Allocative efficiency is assessed from the producer's growth point of view. The study of efficiency focuses on the ability to increase maize production while preserving resource use. According to Kibirige and Obi (2015), Baloyi et al. (2011), they need to combine resources in the smallest combinations to produce maximum output and maintain minimum cost to earn maximum income. This paper focuses on technical efficiency as it is critical in developing agriculture where resources are scarce, and high population growth is common. According to Mokgalabone (2015), the food balance in Africa has gone from positive to negative. Therefore, this paper aims to examine the technical efficiency of maize-based production by smallholder irrigators and the main factors contributing to technical efficiency in the Eastern Cape province of South Africa.

The remainder of the paper is organised as follows: Section two discusses the methodology, section three addresses the results and implications of the findings, and section four presents the conclusions and policy implications.

METHODOLOGY

Description of the study area

The study was conducted in the Eastern Cape Province, the second most populated province in South Africa. The province is made up of five districts and two metropolitan municipalities. The Eastern Cape is home to 6,562,053 (12.7%) people (Hlomendlini, 2015; DEDEAT, 2013), the majority of whom (60%) live in rural areas where poverty rates are high. An estimated 2.5 million people are unemployed, forcing a large

Fig. 1. Map showing all district municipalities of the Eastern Cape Province in South Africa
Source: ECDC, 2015.

proportion of the population to rely on varying government grants (Obi and Ayodeji, 2020). The average poverty level in the province has been estimated at 74.9%, and the level of food insecurity in the province (78%) is above the average national level of 64% (DEDEAT, 2013). The province has high levels of food insecurity, with about 78% of households in the province classified as food insecure. The majority of residents in the Eastern Cape derive their livelihoods from agriculture. Hlomendlini (2015) stated that many households in the province are involved in agriculture and, in most cases, cultivate for home consumption and income purposes.

Resource-poor farmers produce maize mainly in low-input environments in the province. The main reason for the high maize cultivation rate is that it is mainly used as staple food by many households and as feed for livestock. The climatic conditions in the EC province are favourable for maize production as the province has moderate climatic conditions such as moderate temperatures and rainfall. However, maize production levels are not sufficient, unlike the North West, Free State and Mpumalanga, which are the leading maize producing provinces in South Africa. It is recognised that the level of production needs to be increased, which can be done by providing better input factors at subsidised rates and in a timely manner. The cross-sectional survey collected data from a single point in time using a structured questionnaire.

Sampling procedure and sample size

The study was conducted in the Eastern Cape Province of South Africa in three district municipalities of the province. These districts are known for their large areas of good arable land and excellent soils that are suitable for crop production and livestock farming. A two-stage sampling procedure was used to select smallholder maize irrigators in the Eastern Cape region. The first stage consisted of the deliberate selection of three districts: OR Tambo, Amatole and Christ Hani. These three district municipalities contain a large number of functional smallholder maize irrigation farmers. In the second stage, local municipalities and four villages per municipality where maize was grown under the irrigation scheme were randomly selected. A list of all maize farmers was obtained from the Department of Agriculture. The list of villages served as the sampling frame for selection purposes in the three district municipalities. In each village, twelve maize farmers were randomly selected from households in the area to form a sample size of 120.

Data collection

The study adopted a systematic and multipronged data collection procedure to collect primary data.

Primary data were collected using a structured questionnaire through a cross-sectional survey of maize farming households to obtain demographic, production and marketing information. The questionnaire was structured in such a way that the first part covers socio-economic variables such as the age of the head of a household, household size, off-farm income and gender. The second part of the questionnaire focused on factors of production such as land, labour, cost of tractor labour hours and the input materials such as fertiliser and seeds. Table 1 shows the relevant data collected through this process.

Analytical techniques

This study used the Stochastic Frontier Model to estimate factors affecting the technical efficiency of food plot maize irrigators in the Eastern Cape Province of South Africa. The study used the Cobb-Douglas production function to estimate the stochastic frontier production function. The functional form mainly was chosen because it is flexible, self-dual and its returns to scale are easily interpreted (Bravo-Ureta and Evenson, 1994). Also, empirically, the Cobb-Douglas production function has been widely used in technical efficiency estimation (Hassan and Ahmad, 2005; Essilfie et al., 2011). The formal model is simplified as:

$$Q = AL^{\alpha}K^{b} \quad (1)$$

where:

Q – is maize output crop in grain equivalent.
A, α, b – are constants, and
L and K – are labour and capital, respectively.

Capital can be interchanged with labour without affecting output. Or

$$P(L,K) = bL^{\alpha}K^{b} \quad (2)$$

where:

P – land/area (measured as the total cultivated plot area in hectares)
L – labour input (the total number of person-hours worked in a year)
K – capital input (the monetary worth of all machinery, equipment, and buildings)
b – total factor productivity

The terms α and b are the output elasticities of labour and capital, respectively. These values represent constants determined by the available technology. Output elasticity measures the responsiveness of output to a change in levels of either labour or capital used in production, ceteris paribus [20].

After applying the preceding correlations to the case under consideration, the stochastic frontier production function can be expressed as:

$$Y_i = f(L_{it}, K_{it}, X_{it}); A; e_i \quad (3)$$

where:

Y_i – is the maize output by farmer i, and L_{it}, and K_{it}, are Labour and Capital inputs as defined in equation (2) above, X_{it} – represents a range of other factors

Table1. Sample selection of irrigation schemes in District and Local Municipalities

Province	District municipalities	Local municipalities	Irrigation schemes	Maize-based farmers
Eastern Cape	O.R. Tambo	Mhlontlo	Ntshongweni	40
	Chris Hani	Intsika Yethu	Qamata	40
	Amathole	Ngqushwa	Tyefu	40

Source: own elaboration.

deployed by the farmer, including locational and seasonal dummies, while A – is a vector of parameters, and e_i – is the disturbance term. The Stochastic Frontier Analysis (SFA) assumes that the disturbance term consists of two components, a stochastic error component V which is assumed to be symmetric. It depicts the random variability of the production function across farms and can be caused by factors such as measurement error and factors that are beyond the farmer's control. On the other hand, the second error component, U, represents the technical inefficiency relative to the optimum.

Defined in logarithmic form, the stochastic frontier production function, in this case, can be expressed as:

$$\ln(Y_i) = \beta_0 + \beta_1\ln(L_{it}) + \beta_2\ln(K_{it}) + \ldots + \beta_n\ln(X_{it}) + V_{it} - U_{it} \quad (4)$$

where:

i and t subscripts – refer to the i^{th} farmer and t^{th} observation, respectively, and Ln is the natural logarithm,

Y – represents the total value of maize output,

L, K, X – are the inputs of labour, capital, and others, respectively. Labour and equipment used were inserted in the model as a dummy where 1 = mechanical power used, otherwise = 0,

The X's represented all the other factors such as age, land, fertiliser, seed, the output of the two principal crops (maize and soybean), livestock, and irrigation that formed part of the production package,

β – are the regression coefficients or parameters to be estimated,

$V_{it} - U_{it}$ – constitute the disturbance term or errors.

RESULTS AND DISCUSSION

Socio-economic characteristics of maize-based farmers

This section examines the socio-economic characteristics of farmers in the study area. Table 2 illustrates the socio-economic characteristics of the respondents. Results from Table 3 indicate that the majority of smallholder farmers were male (78%), and their average age was 60 years. These results were consistent with the findings of Munjuru and Obi (2020) that the majority of smallholder farmers in rural areas in the Eastern Cape province were male with an average age of 60 years.

The majority (80%) of farmers were literate because they had spent six years in school, which corresponds to primary education. These results are in agreement with Kibirige et al. (2016) that farmers in the Eastern Cape province had primary education. The average farming experience was 17 years, meaning that maize irrigators were experienced when it came to growing maize. These results agreed with Kamau (2019), as farming experience indicates critical knowledge for agricultural productivity. Years of experience further enhance the ability to expand production in order to increase farm profitability and productivity. Household size plays an important role in maize production, and most farmers mainly rely on family labour. The results showed that the average family size was five persons per household. This suggests that farmers were able to use family members as additional labour on the farm. Labour is a crucial factor in maize production, especially for smallholder farmers.

The total average farm size of smallholder maize farmers was 3 hectares. These results were in line with

Table 2. Variables used in the stochastic model

Reliant variable	Definition	Value	Hypothesized relationship
1	2	3	4
GINC	Gross farm income	Continuous	
Sovereign variable	Explanation	Value	
AGE	Age of the family head	Continuous	+/–
YRSPSCHL	Years spent in school by the household head	Continuous	+/–
TOPMZE	Maize production (kg)	Continuous	+

Table 2 – cont.

1	2	3	4
MART	Marital status of the household head	A dummy variable coded 1 if married, 0 – otherwise	+/–
LAND	Area cultivated by a farmer in hectares	Continuous	+
FEXP	Farm experience of the farmer	Continuous	+
IRR	Use of irrigation	A dummy variable coded 1 if irrigate, 0 – otherwise	+
EXT	Whether a farmer has access to extension services	A dummy variable coded 1 if access to extension services, 0 – otherwise	+
FERT	Expenditure on fertilizer (Rands)	Continuous	+
SEED	Expenditure on seeds (Rands)	Continuous	+
LABOR	Expenditure on laborers (Rands)	Continuous	+
CAPITAL	Capital usage, whether farmer used tractor and machinery	A dummy variable coded 1 if farmer use tractor and machinery, 0 – otherwise	+

+ Specifies a confident relationship; – Specifies a undesirable relationship.
Source: own elaboration.

Table 3. Demographic characteristics of the respondents

Variable	Mean	Standard deviation
Age	60.761	12.263
Years spent in school	5.650	4.406)
Family size	4.570	2.468
Farm experience	17.295	10.546
Farm size	3.456	1.026
Capital (cost of a tractor used) (Rands)	400	64.253
Labour (man-days)	20	23.254
Seeds (kg)	18.25	5.256
Fertilizer (kg)	40.256	37.256

Gender: male – 68%, female – 32%.
Source: own elaboration.

Okello et al. (2019) findings in Uganda, where farmers had 3 ha of land available for practising agriculture. The average amount of family labour used was estimated to be 20 person-days per farm. The average cost of a tractor was about R400.00 per ha. The average amount of seeds used by smallholder farmers per hectare was R18.25, while farmers who apply fertilisers used about 40.256 kg/ha of them. These results are in line with the findings of Obi and Ayodeji (2020).

Estimates of stochastic production frontier of maize production

The estimates of the maximum likelihood ratios for the parameters in the reduced single equation form proposed in equation (3) above are shown in Table 4. Table 4 shows the estimated maize parameter results obtained from the Cobb-Douglas production function model. Looking specifically at Table 4, land ownership and tractor use are essential factors that affect smallholder maize production. The land coefficient was positive and significant at the 5% level. This means that an increase in land ownership by one unit will provide an additional hectare available for ploughing; as a result, maize production and yield will increase, resulting in profit maximisation. The use of a tractor proved to be significant at a 1% level, and its coefficient is positive. This means that an increase in the use of a tractor will result in an increase in maize production because the tractor provides additional mechanical power and therefore increases maize production, leading to profit maximisation for the farmers.

Table 4. Estimated Cobb-Douglas production function for maize enterprise

Independent variables (in natural logarithm)	Parameter β	Maize output (Y) = dependent variables		
		coefficient	S.E.	P > |z |
Land size under maize farming (ha)	β_1	0.0722**	1.724	0.042
Capital (tractor hours/Rand)	β_2	0.0156***	2.896	0.006
Fertilizer applied (kg/ha)	β_3	0.0596*	1.585	0.037
Seed planted (kg/ha)	β_4	0.0316***	5.456	0.006
Labour used (hours)	β_5	–0.0897	1.045	0.086
Constant	β_0	0.0719	0.090	0.066
V = random variables		0.336	0.167	
U = non-negative random variables		1.440	0.183	
Sigma square		1.546***	0.346	
lambda((λ)		6.284	0.268	

Log likelihood = –551.86
Prob > chi^2 = 0.0000
Wald chi^2 (4) = 141.32
Number of observations = 120
Average technical efficient = 84%
***$p < 0.001$; **$p < 0.05$; significance level R square = 0.723; adjusted R = 0.684.
Source: own elaboration.

The indications in Table 4 further state that purchased inputs such as seeds and fertilisers strongly influence maize output in the studied farming system. Fertilisers were found to be significant at the 5% level, and their coefficient was positive. This means that an increase in the use of fertilisers will increase maize production as fertilisers provide the necessary nutrients for plant growth, thus increasing productivity. As a result, productivity per hectare also increases, resulting in high returns for farmers. The results are in line with Salau (2013), who found out that increasing fertilizer use will increase maize-based output. This implies that fertilizer availability at affordable prices generally determines the increase in land under maize production in any particular year in the province. The coefficient for farm size under maize cultivation implies that increasing the farm size can raise maize output and land is the crucial factor in the production of maize. The results concur with the findings of other studies such as Mokgalabone (2015), Baloyi et al. (2011), and Amos (2007), who reported that an increase in farm size would increase the technical efficiency of maize production. These findings are in line with Nwachukwu and Onyenweaku (2007), while Mokgalabone (2015) found that an increase in the use of fertiliser and area will increase the technical efficiency of maize producers.

The seeds planted by farmers were found to be significant at the 1% level and have a positive coefficient. This means that an increase in the use of improved seeds results in an increase in farm profitability and, consequently, increase maize technical efficiency. These results were in line with Obi and Ayodeji (2020); Nwachukwu and Onyenweaku (2007) detailed that an adequate increase in this input (seed) will increase maize production. The paper used a tractor as an indicator to estimate the capital used on the farm. The elasticity of capital was found to be 0.156. This capital was positively significant at the 5% threshold for maize production.

Implications of technical efficiency show a log-likelihood ratio of 106.55 and a lambda value of 0.015. The estimated stochastic frontier showed a significant Wald chi-square value of 12.26 for the whole sample and was significant at the 1% and 5% levels.

Table 5. Distribution of technical efficiency indices of maize farmers

Efficiency class index	Frequency	Percentage
<0.40	18	12.63
0.41–0.50	11	05.68
0.51–0.60	11	05.68
0.61–0.70	12	07.23
0.71–0.80	19	15.62
0.81–0.90	13	09.23
0.91–1.00	34	43.93
Total	120	100

Maximum value = 0.960; Minimum value = 0.201; Mean = 0.840
Source: own elaboration.

Table 6 presents insights on the determinants of technical inefficiency in the Eastern Cape smallholder sector under maize production of the type described in this paper. Additionally, Table 6 indicates that the model is more linear and that most of the maize output from the smallholder sector examined is explained by the model. The estimated Adjusted R-square from the Cobb-Douglas production function as the production elasticity equaled 0.52, which means that the independent input variables in the model explain about 52% of the variability in maize production in the Eastern Cape.

Table 6. Determinants of technical inefficiency efficiency among smallholder maize production

Variable	α_i	Coefficient	P-value
Farm experience	α_1	0.0276***	0.007
Age	α_2	0.0389**	0.022
Years in school	α_3	–0.0450***	0.006
Access to extension services	α_4	0.0789***	0.002
Family size	α_5	0.0830 **	0.046
Access to credit	α_6	–0.0656***	0.004
Transportation to markets	α_7	0.0254***	0.013
Constant	α_0	0.0610**	0.033

Significance denoted as follows: ** for 5% and *** for 1%.
R-square = 0.540; Adjusted R^2 = 0.520
F-value = 56.53***
Prob > *F*=0.0000
Number of observations = 120
Source: own elaboration.

The explanatory variables were quantified as those related to socio-economic factors of the smallholder irrigated crop farmers in the Eastern Cape irrigation schemes. For all variables that have positive coefficients, this means that as each variable increases, maize production also increases. With regard to the age of farmers, the suggestion that there is a positive correlation between farmer's age and technical efficiency of smallholder maize production implied that when productivity from farmer's age increases by 1%, the productivity from maize production will also increase. It was found to be statistically significant at a 5% level. These results are in line with the findings of Sapkota et al. (2017) and Illukpitiya (2005), who reported similar results in Nepal and Sri Lanka, stating that ageing farmers had extensive experience. Consequently, they were more technically proficient in maize production than their younger counterparts.

Farm experience had a positive coefficient. This suggests a positive correlation between farmers' farming experience and the technical efficiency of smallholder maize production, namely that when the output from farmers' farming experience increases by 1%, maize production will also increase. If all other factors remain constant, the return to scale level of output will increase alongside the level of input. Therefore, economies of scale will be utilised because it is assumed that the more experience a farmer has, the better they use the available resources, which thus contributes to the technical efficiency of production. This conclusion was mainly based on age within farming practices. The results are in line with the findings of Okello et al. (2019) and Sapkota et al. (2017), who identified that farm experience increases technical efficiency, as experienced farmers can adopt new maize production technology and have a direct link with extension workers to inform maize farmers about new techniques and research that will improve their maize productivity. Similarly, years spent in school had a positive coefficient. This suggests a positive correlation between the number of years spent in school and the technical efficiency of smallholder maize production, namely that when the efficiency from years spent in school increases by 1%, the efficiency of maize production will also increase. The results are in line with findings of Mutenheri et al. (2017), Supaporn (2015), and Thabethe et al. (2014), which found similar results in their studies that years spent in school increased the maize output of farmers.

A positive coefficient of extension services suggests that there is a positive correlation relationship between access to extension services and technical efficiency of smallholder maize production, meaning that when production from access to extension services increases by 1%, maize production will also increase, provided all other factors remain constant. This will cause the return to scale level of output to also increase, alongside an increase in the level of input. Therefore, economies of scale will benefit, as it is assumed that whenever farmers have better access to extension services, they make better use of available resources, which thus contributes to technically efficient production. This conclusion was mainly based on age within farming practices.

Similarly, a 5% increase in household size will increase farm maize production, as it is used as a proxy for family labour. This suggests that there is a positive correlation between household size and the technical efficiency of smallholder maize production, meaning that when output from household size increases by 1%, maize production will also increase, provided all other factors remain constant. This will cause the return to scale level of output to also increase, alongside an increase in the level of input. Therefore, economies of scale will benefit, as it is assumed that whenever the household size is larger, the better the use of available resources, which consequently contributes to the technical efficiency of production. This conclusion was mainly based on age within farming practices. A negative coefficient for access to credit in maize production indicates a correction between access to credit and technical efficiency; as the level of production increases by 1%, output from maize production will decrease if all other factors remain constant. The negative sign means that if a farmer uses their social security instead of using bank credit, they may tend to maximise production, which may result in a decrease in the level of returns to scale because the proportional desired output will decrease compared to the desired inputs, thus affecting the level of technical efficiency.

Implications of results for maize production

The results mentioned above have far-reaching and important practical implications for maize production. A noticeable point of performance is the clear failure of the Government to support smallholder farmers with the inputs and training necessary for farming and finally, the introduction of mechanised equipment and programmes on a scale unsuited to the realities of the farming system. Estimates suggest that the maize production system was technically efficient; the sector had a noticeable shortfall in maize production, resulting in a reduction in gross income. The contribution of factors of production is not questionable. However, the agricultural situation of smallholders needs to be improved and adapted to the needs of farmers so that they have access to agricultural inputs and a market for their products, which would provide an incentive to increase production. It is clear from the results that the Government has failed to support farmers, as promised, as part of its strategy to revitalise smallholder irrigation systems.

The above results also present great opportunities (transition from smallholder to commercial agriculture) for both the Government and the private sector. The critical areas of input supply, logistics and expansion have traditionally been characterised by a high degree of government participation, which explains why government failure would have such shocking consequences. The participation of the private sector in these areas will go a long way towards alleviating much of the bottlenecks experienced by farmers at the time.

Technical efficiency ranges of maize-based farming

The indicators in Table 5 showed that the technical efficiency of the studied maize crops was less than one (less than 100%), which means that all maize crops based on irrigation in the study area yielded below the maximum efficiency limit. The mean technical efficiency is 0.840 (84%), suggesting that, on average, maize farming obtained a little over 84% of potential maize output from a given mix of production inputs. These results coincide with those of Sapkota and Joshi (2021) that TE (84%) indicates that there is still scope to increase production by 16% using the technologies and resources available in the study area. About a 16% efficiency gap from the optimum (100%) was yet attained by all smallholder maize-based irrigation farmers. About a 16% yield gap from the optimum (100%) was still to be achieved by all maize-based irrigation farmers. The main reason for this gap is the allocation of resources among farmers and technology on their farms. Farmers should focus on using existing resources and technologies wisely to increase maize seed production.

CONCLUSIONS

Maize production by smallholder farmers in the study area, particularly in South Africa, plays an important role in the alleviation of poverty and generation of income. In the study area, maize production is carried out by men with an average age of 60 years and an average household size of 4 persons, and the head of the household has at least primary education. This means that the future of the agricultural sector will collapse due to the low participation of youth in the industry as older people pass away. The owners of small irrigation farms consider agriculture as their main source of income because farming is their main occupation, and they have extensive farming experience exceeding ten years.

Smallholder farmers practice farming as their main activity, and their maize cultivation is highly profitable in terms of profitability level as they sell part of the harvest on the market and use part for home consumption. This simply shows that maize cultivation is crucial for food security and livelihood strategy development in this province, as maize is mainly used as the staple food. Smallholder maize farmers were technically efficient. The average level of technical efficiency for maize farming in the Eastern Cape Province is 0.8422, indicating that inefficiency exists among maize farming households in the Eastern Cape Province of South Africa. Therefore, there is a need for the development of programmes and policies aimed at engaging and educating young farmers. These should be catalysed by providing more land for maize production. There needs to be a fair distribution of land, irrespective of age. The study recommends that policymakers and Government should embark on an aggressive, effective awareness and sensitisation campaign to make rural youth appreciate the benefits of engaging in agriculture. The Government should revise agricultural policies to effectively include and focus on the youth and their agricultural needs. The Government should strengthen the strategy of training extension workers on new technologies and techniques in order to improve agricultural efficiency and training workers on marketing and marketing dynamics to improve farm profitability and efficiency. In addition, the study recommends improvement in agricultural inputs such as fertilizers and improved seeds, which should be available at low prices and thus will increase maize production. The study suggests the adoption of modern agricultural technologies such as improved maize varieties.

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