Influencing Factors of Maize Production in South Africa: The Case of Mpumalanga, Free State and North West Provinces

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Authors' contributions

This work was carried out in collaboration between both authors. Author WJ designed the study, fund acquisition and supervision. Author AD managed the literature search and review, performed the statistical analysis, wrote the first draft of the manuscript and prepared the final draft. Both authors read and approved the final manuscript.

Article Information

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ABSTRACT

Aims: Maize is of great significance in the national food security of South Africa. Maize production levels in South Africa continue to decline, further deteriorating the situation of increased food insecurity, unemployment and increased poverty levels in the face of increasing population. This paper investigated fundamental variables influencing maize yield in the South African major maize producing regions.
Study Design: A multi-stage stratified sampling method was employed to select maize producing farmers in the major maize producing provinces, namely Mpumalanga, Free State and North West provinces of South Africa. Furthermore, three districts were selected from which maize farmers were then selected.
Methodology: Using linear multiple regression for a sample of 202 maize farmers, maize yield as a dependent variable was regressed against land size, fertilizer usage, labour, herbicides and seeds as independent variables. The paper employed the Cobb-Douglas production function to estimate parameters. The data obtained from the field were subjected to analysis using inferential statistics using SPSS v20.

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Results: The study showed that fertilizer, labour, and herbicides used in the production of maize in the study area were positively and statistically significant at a 5% confidence interval ($P<0.05$) with elasticity coefficients of 0.55, 0.47 and 0.198 respectively. The independent variables computed in the model had positive elasticity coefficients indicating a direct positive relationship between the input variables and maize output. The study also revealed that farmers in the study area were applying fewer amounts of fertilizer than the recommended rates per hectare.

Conclusion: The study recommends that the South African government should supply inputs to maize farmers at subsidized rates to promote correct application rates and attain higher yields. The promotion of good quality extension services to foster good agricultural practices in the production of maize is also recommended.

1. INTRODUCTION

Maize is the most important crop in South Africa [1]. Grain production in South Africa consists of maize, followed by wheat and sorghum in order of importance [2,3]. Maize accounts approximately for 83% of the national grain production, wheat accounts for 14,7%, while sorghum accounts for 1,3% [4].

In many populations worldwide, maize is a dietary staple, making up the primary portion of calories consumed in many lower-income countries [5,6]. Similarly, maize is the largest locally produced field crop and a staple food for the bulk of the population in South Africa, particularly of the poor, and is a crucial crop for food security [7,8,9]. Notwithstanding from providing nutrients for humans and animals, maize serves as a basic raw material for the production of starch, oil, protein, alcoholic beverages, food sweeteners, and fuel [5,10]. With changes in consumption structure such as grain ration consumption, animal feed consumption and industrial consumption, the demand for maize is increasing globally [11,10]. It is estimated that the overall demand for maize will continue to increase resulting from the increased demand for food driven by population growth. Such an increase in demand must be met by increasing the productivity of maize per unit of land [12].

Maize is produced throughout South Africa, with the Free State, Mpumalanga and North West provinces constituting the major maize producing regions, thus, forming the "maize belt" of South Africa accounting for approximately 87% of the total maize production [13,4,14]. The Free State province has the largest area planted to maize as well as the largest production, accounting for about 44.45% of the total maize area planted in the 2018/2019 production season. The second largest maize producing area planted is in Mpumalanga province, accounting for 24.74% of the total area planted in 2018/2019. The third largest maize area planted is in North West province, accounting for 18.60%. The other provinces, such as the Eastern Cape, KwaZulu-Natal and Limpopo provinces, are also significant players in South African maize production, but most importantly in small-scale farming, which contributes significantly to household food security [13]. The maize industry is pivotal in the South African economy with regard to revenue generation and employment [15]. The share of the agriculture sector in employment is estimated at 7% of the South African labour workforce [16] [17].

Maize hectares (area) planted vary from year to year, depending on the weather (climatic conditions) and market conditions, but on average 2.5 to 2.75 million hectares of hybrid maize is planted in South Africa each year [4]. In the 2016/17 production season, 17.5 million tons of maize were produced. This figure declined to 13.1 million tons in the 2017/18 production season and further fell to 11 million tons of maize output in the 2018/19 production season. Maize yield produced per hectare averaged at 6.3 t/ha, 5.2 t/ha and 4.9 t/ha for the 2016/17, 2017/18 and 2018/19 production seasons, respectively. For the same period maize production output for the three biggest producing regions in the country, a similar trend was observed. Free State province, the biggest producer in the country, recorded 7.3 million tons, 5.2 million tons, and 4 million tons of maize for the 2016-2019 growing period. Mpumalanga province recorded 3.4 million tons, 2.8 million tons, and 2.6 million tons, for the same period North West province recorded 3.1 million tons, 2 million tons, and 1.6 million tons of maize. The downward production trend in the country is an indication of decreasing maize production output, thus studying factors influencing maize production in the largest maize producing regions in the country is great importance.

Lack of access to land, lack of access to inputs/implements, lack of access to financial capital, limited access to extension services and input/output market, low adoption of appropriate modern technologies, uncertainties in climate change and farm risks are among factors reported to impede increased agricultural productivity [16]. Many factors influence maize production, ranging from inputs to climatic conditions. Successful maize production depends on the correct application of production inputs that will sustain the environment, soil conditions, availability of irrigation or rainfall as well as agricultural production [14]. The foregoing factors are blanket impediments theorized to affect maize production, this study, therefore, seeks to investigate factors influencing maize production that are particular to the study area.

There have been several attempts by the South African government to improve agricultural productivity, through the establishment of irrigation schemes, agricultural market liberalization policies, provision of credit facilities, and legislating of several land reform policies [13]. In addition to the establishment of irrigation schemes, the South African government provided farm inputs and implements through programs like the Cropping Programme and Massive Food Production Programme (MFPP) [18,19,16]. The Comprehensive Agricultural Support Programme was moreover enacted to facilitate capacity building for farmers with the provision of agricultural infrastructure [17]. Furthermore, the government has established credit and microfinance institutions such as the Micro Agricultural Financial Institutional Scheme of South Africa (MAFISA) to create links between banks and farmers for improved access to input credit. Nevertheless, maize yields and subsequently maize output levels in South Africa continue to decline [13]. South Africa is a breadbasket for the Sub-Saharan African countries, consequently, decreasing maize production levels have an adverse connotation for the food security of these countries as well as that of South Africa. Albeit South Africa being a net maize exporter for most years, on years where maize demand exceeds maize production South Africa imports maize from countries like Argentina, Brazil and the USA [4].

Research studies have deliberated maize production in South Africa. However, there are comparatively few studies that assess in comprehensive detail the shifting historical structure of South African maize production and determinants thereof. Van Zyl & Nel [15]

evaluated the macro-economic role that the maize industry played in the South African economy during the 1970s and 1980s, but did not delve into details of the structural trends within the industry. Breitenbach & Fenyes [2] quantified production trends within the commercial maize and wheat industries during the 1985 to 1999 period, including a breakdown of maize production into its output and planted area components for South Africa. A study by Greyling & Pardey [20] highlighted key insights about the South African maize production in terms of commercial and smallholder share contribution. The study presented a comprehensive historical picture of South African maize production, and the changes in area planted, spanning from the year 1904 to 2015. The paper, however, did not investigate into influencing factors for the observed changes in the area and total production of maize. Meanwhile, other scholars focused on mapping the position of the south African maize in the global context [4].

This study sought to examine the determinants of maize production in South Africa and provide insights which will be of great significance for maize farmers in South Africa, the academicians and policymakers in formulating future policies on the modernization of agriculture in general and the maize sector in particular to address the current problem of low maize yields. Stabilizing, organizing maize production and ensuring a continuous supply of maize is a critical component of national food security. South Africa has a long history of maize production and a vast area of maize production, thus, determining the influencing factors of maize output is of crucial significance for formulating effective grain production and trade policies.

2. METHODOLOGY

2.1 Description of the Study Area

The study was carried in the "maize belt" of South Africa which consists of the Free State, Mpumalanga and North West provinces. Maize production in South Africa is concentrated in the studied provinces. The major maize-growing area cuts across the central and western parts of the North West province, the north-western Free State province, and the central to south-western parts of Mpumalanga province. In the west of this major maize-growing area, the mean annual rainfall ranges between 550 and 650 mm. Precipitation is relatively erratic and has an immense influence on crop production. Although

the start and duration of the rainfall season in this region restrict the length of the growing season, the high heat units make it substantially suitable for crop production.

2.2 Sampling Procedure

The study adopted a multi-stage stratified sampling technique to select respondents and maize farmers were the targeted population in this study. A combination of purposive and random sampling method was employed for the selection process of respondents. The stratified sampling is a method of sampling that involves the division of a population into smaller groups known as strata. In stratified random sampling, the strata are formed based on members sharing similar attributes or characteristics [21]. A random sample from each stratum is then selected. In this study, the strata consisted of maize producing farmers. Three (3) major producing provinces (Free State, Mpumalanga and North West) were selected and from the chosen provinces maize producing farmers were selected. Thereafter, major maize producing districts were identified for the chosen provinces respectively. The services of agricultural extension agents in the selected districts were considered for data collection. The sample size of the respondents was 202 maize farmers and the selection of participating farmers was random within the identified districts. Table (1) below gives details of the population of respondents selected for each chosen study site in the respective provinces.

2.3 Data Collection

Primary data was collected using structured questionnaires through face to face interviews. The questionnaires captured data on socio-economic characteristics of maize farmers, production statistics, farming enterprises and extension services. The study additionally employed secondary data collected. Production Statistics were extracted from the Department of Agriculture, Forestry & Fisheries (DAFF) abstracts for the period 1986-2019.

2.4 Data Analysis

The data obtained from the field were subjected to analysis using inferential statistics generated from the Statistical Package for Social Scientists (SPSS v20). A Stochastic frontier production model was formulated to determine the relationship between the dependent variable (maize output) and deterministic independent variables. The study adopted the Cobb Douglas production function. The Cobb-Douglas model was developed by Charles Cobb and Paul Douglas (1927-1947) [22]. The model was used to represent the technological relationship between the amounts of two or more inputs (particularly physical capital and labour) and the amount of output that can be produced by those inputs. The Cobb-Douglas functional form was adopted on the basis that it is self-dual and has been widely applied in agricultural production technologies in many developing countries [23]. SPSS v20 was used to generate parameter estimates of the Cobb-Douglas model adopted in the study.

The model is expressed in its general form as follows:

$$Y = AL^{\beta} K^{\alpha} \tag{1}$$

Y= Total maize production in tonnes/year
L= Labour input (hours/year)
K= Capital input
A= Total factor productivity
α and β are the output elasticities of capital and labour, respectively.

2.5 Conceptual Framework

This study theorizes that maize production is dependent on the physical production relationships between maize output and independent variable inputs. Thus, a relationship between the amount of maize output and land size, amount of fertilizer, herbicides, labour and maize seeds. Figure 1 gives the conceptual framework underpinning the adoption and development of the empirical analysis.

Table 1. The selection of respondents

Major maize producing provinces	Name of selected district	Target Population
Mpumalanga province	Gert Sibande	57
North West province	Bojanala	60
Free State province	Motheo	85
Total sample size		**202**

Independent variables   Dependent variable
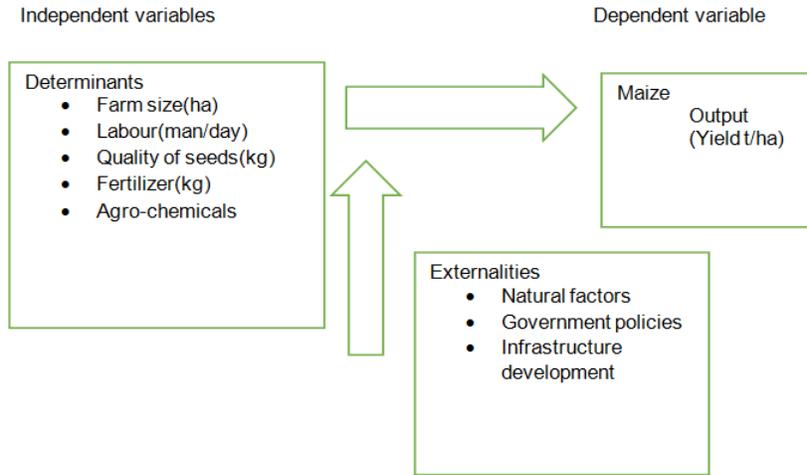

Fig. 1. Flow chart of selected variables

2.6 Empirical Model

Several functional forms have been developed to measure the relationship between inputs and outputs. The study adopted the Cobb-Douglas and trans-log production functions. The idea of a production function can be illustrated with using *n* inputs: X_1, X_2 Xn to produce *Y* output, which shows the maximum output obtainable from various inputs used in production [24].

The operational model for the study is illustrated mathematically below;

$$Y= f (X_1, X_2...X_n) ...+e \qquad (2)$$

Where,

Y = maize yield (ton/ha)
X_1= farm size (ha)
X_2=fertilizer (kg/ha)
X_3= labour (hours/ha)
X_4= Herbicide (L/ha)
X_5= Quantity maize seed (kg/ha)
e= error term

Thus, a linear production function is given as follows:

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+e \qquad (3)$$

From equation (3), the Cobb-Douglas functional form was considered and was expressed as:

$$lnY=\beta_0 +\beta_1lnX_1 + \beta_2lnX_2 + \beta_3lnX_3+ \beta_4lnX_4 + \beta_5lnX_5+e \qquad (4)$$

$$ln Y= \beta_0 + \beta_1 ln (farm\ size) + \beta_2 ln (fertilizer) + \beta_3 ln (labour) + \beta_4 ln (herbicides) + \beta_5 ln (seed) +e \qquad (5)$$

Where ln is the natural logarithm, Y is maize output per hectare in tons of the ith farmer, β_0 is a Constant, βi is a Coefficient,

3. RESULTS AND DISCUSSION

In this chapter the findings of the study are presented and discussed in three main sections, namely: the socio-economic characteristics analysis, maize input levels and Multivariate analysis of the variables using charts, graphs and tables respectively.

3.1 Socio-economic Characteristics of Respondents

The survey drew information about farmers including age, gender, experience in maize production, total farm size under cultivation, labour used, extension contact, etc. Table 2 presents a summary of the socio-economic characteristics of the maize farmers in the study area.

The results indicated that 79% of the respondents were male farmers and only a fraction of 21% were females. The study further revealed that 50% of the respondents had between 6-15 years of maize farming experience, 43% had 15 and above years of maize farming experience while 6.44% had less than 5 years of maize farming experience. The ages of the respondents corresponded with the years of

farming experience as 96% were found to be 35 years of age and older. Youth in South Africa and the world at large prefer jobs in other non-agricultural economic sectors [25].

Results suggested that the largest proportion of respondents were literate and had some form of education or formal training, secondary school education (62%), no formal education (2%), primary education (13%) and tertiary education (20%). The high level of education among the respondents is hypothesized to be an advantage as it directly translates to high literacy levels which are vital in the adoption of

information and technological advances in the agricultural production sector. The average household size ranged between 4-7 persons per household. The household size in most farming communities of Sub-Saharan Africa is known to be a source of farm and off-farm labour.

3.2 Maize Input Use Levels

Table 3 illustrates the results of the inputs used for maize production, namely seeds, land, labour, fertilizer and agrochemicals in the study area.

Table 2. Socio-economic characteristics of respondents

Characteristics	Frequency	Percentage
1.Farming Experience		
1-5 years	13	6,44
6-15 years	102	50,50
15& above	87	43,07
Total	**202**	100,00
2.Age		
18-35 years	10	4,95
36-55 years	93	46,04
56 and older	99	49,01
Total	**202**	100,00
3.Gender		
Male	160	79,21
Female	42	21,00
Total	**202**	100,21
4.Education		
No formal Education	6	2,97
Primary	28	13,86
Secondary	126	62,38
Tertiary	42	20,79
Total	**202**	100,00
5.Household Size		
1-3	10	4,95
4-7	173	85,64
7 or above	19	9,41
Total	**202**	100,00

Source: Survey, 2020

Table 3. Input use among farmers

	Minimum	Maximum	Mean	Std. Deviation
Land size (Ha)	9	325	118.02	75.666
Fertilizer mixture N:P:K kg/ha	150	750	394.58	101.573
Labour man/hours/ha	23.0	36.0	29.564	1.9984
Herbicide L/ha	0.28	3.00	1.3166	0.42915
Seeds(kg/ha)	18.0	25.0	22.003	14.0274

Hectare (ha), kilograms (kg), litres per hectare (L/Ha)

The mean value for land size allocated for maize production in the study area was found to be 118,02 ha. It is noted that, while farm size is a key determinant of economic efficiency in maize production, its effect on technical efficiency is still contested [9]. The results further indicated that the fertilizer mixture applied per hectare averaged 394,58 kg/ha. The recommended fertilizer rates for maize vary depending on the yield potential but can be as high as 500 kg/ha in South Africa [1]. The mean value of fertilizer applied amongst the respondents was 394.58 kg/ha indicating that maize farmers in the study area apply far less than the recommended application rate per hectare. [26] reported that expensive chemical fertilizers affect maize production by farmers. Some farmers cannot afford chemical fertilizers because these are expensive. This finding is in line with that of [4], who postulates that South African farmers establish maize at higher costs than farmers in the United States, Argentina and Ukraine, owing to high fertilizer costs.

In South Africa, the recommended planting rates for maize seed generally range from 20 Kg/ha to 25 kg/ha. Therefore, the findings in this study indicate that the majority of the respondents planted maize using the recommended seed rate, signalled by a mean value of 22 kg/ha of seed. Labour costs consist of hired and family labour input in hours/ man in a hectare. The use of herbicides amongst the maize farmers in the study was found to be between 0.28 L/ha and 3 L/ha of agrochemicals.

3.3 Determinants of Maize Production

Table 4 illustrates the results obtained from the double log production function.

The results of the double log functional form had the best fit to the data. The table depicts the analysis of the physical production relationships between maize yield and independent variables, thus, a relationship between maize yield in tons per hectare and land size in hectares, fertilizer in kilograms per hectare, herbicides in litres per hectare, labour in hours per hectare and maize seeds in kilograms per hectare. The variables included in the model were resources available to farmers, from which the objective was to determine the impact on the output of maize in kg/ha. The F-value revealed that the explanatory variables combined, positively influence changes

in maize yield at a 5% significance level. All the independent variables in the model had positive regression coefficients indicating a direct positive relationship between the inputs and maize output. The sign of the coefficient (β values) shows the direction of influence of the variable on the model [27]. It follows that a positive value indicates an increase in the likelihood that maize output will change in response to a percentage increase in the respectful independent variable. The coefficient of determination, R^2 was 0.902 which implied that 90.2% of the variation in the output of maize was accounted for by the independent variables computed in the model.

A Cobb-Douglas production function was estimated and the coefficients in the log-log model represented the elasticity of the Y (maize output per hectare) with respect to the computed X independent variables. The coefficients, therefore, represent the estimated percentage change in the dependent variable for a percentage change in the independent variables, respectively.

As indicated in Table 4, some predictor variables influence maize yield in the study area significantly. Fertilizer in kilograms per hectare, labour, and herbicides in litres per hectare have a positive and significant relationship with maize yield attained per hectare at a 5% level of significance in the study area. Moreover, the elasticities associated with fertilizer, labour, and herbicides were less than 1 in absolute values, this means that maize yield produced per hectare in respect to the aforementioned independent variables is inelastic. Maize yield attained per hectare increases proportionately less than the increase in fertilizer, labour, and herbicides applied per hectare.

Thus, a 1 percent increase in fertilizer, labour, and herbicides applied per hectare would result in an increase, on average, of 0.54, 0.5 and 0.2 percent of maize output per hectare, respectively. Therefore, for increased maize output per hectare in the study area, there is a need to expand the use of fertilizer, labour and herbicides.

Land under maize production and maize seeds applied per hectare have a positive but statistically insignificant relationship with maize output at 5% significance level.

Table 4. Log-log regression results

Independent Variables (natural logarithm)	Coefficients (β)	P-values	T-values
(Constant)	-3.184	0.000	-6.555
lnLandsize(ha)	0.008	0.352	0.933
lnFertilizer(kg/ha)	0.547	0.000**	11.443
lnLabour(hours/ha)	0.466	0.004**	2.941
lnHerbicides(L/ha)	0.198	0.000**	5.103
lnSeeds(kg/ha)	0.037	0.267	1.112
R square	0.902		
Adjusted R Square	0.900		
Standard error of the estimate	0.07702		
F value	363.888		
Significance F	0.000**		

*Dependent Variable: lnYield (t/ha)**statistically significant at 5%*
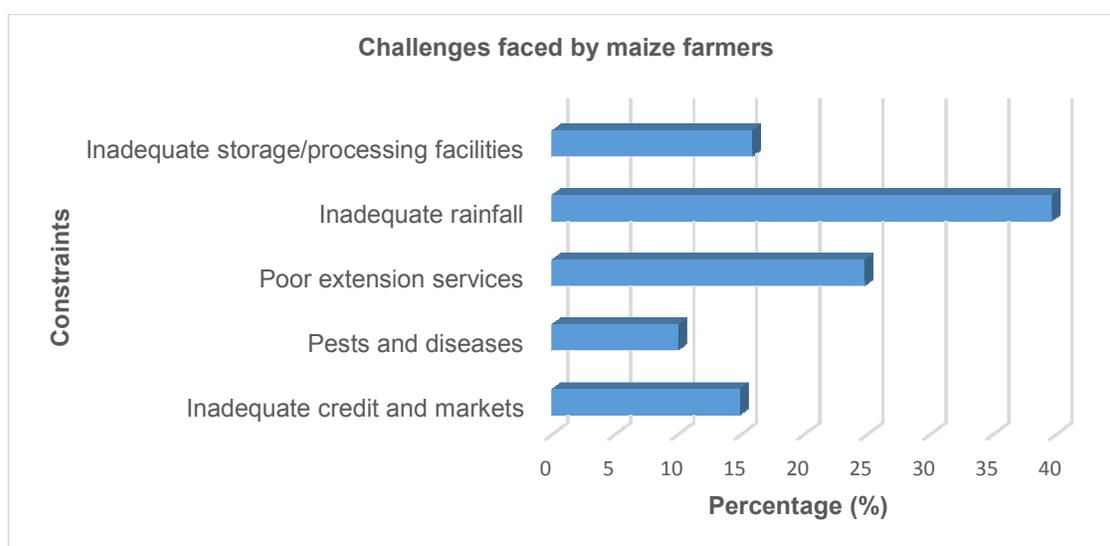
Fig. 2. Distribution of maize farmers according to constraints

3.4 Challenges Facing Maize Farmers

Fig. 2 depicts challenges faced by maize farmers in the production of maize in the study area.

Fig. 2 revealed that inadequate rainfall is the major problem (39.60%) faced by maize farmers in the study area. Maize production in South Africa takes place under rain-fed production system, only 17% of the total maize planted in the country is irrigated. This results in reduced maize yields as drought is recurrent in South Africa [17]. This is followed by poor extension services (24,75%). Extension service is a vital component in the production of maize as essential production information and technological changes are disseminated through effective extension services. Inadequate storage/ processing facilities accounted for 15.85% and

inadequate credit and markets at 14,85%. Pests and diseases were listed as the least of the constraints (9.95%). Consequently, these constraints are considered to have a negative effect on maize yield and therefore further limiting maize production in the study area.

4. CONCLUSION

The study examined the determinants of maize production in major grain-producing areas in South Africa. A cross-sectional survey was used to select 202 maize farmers in the study area. Data were collected and subjected to inferential statistics which were used to determine the relationship between the dependent variable (maize output) and selected the independent input variables. The results indicated that 79% of the respondents were male farmers and only a

fraction of 21% were females. The ages of the respondents revealed that 96% were 35 years of age and older. This is an indication that the future performance of the maize and the agriculture industry is doomed to collapse due to the low participation of youth as the old generation fades away. This may worsen the situation of increased food insecurity, unemployment and increased poverty levels in the face of increasing population and limited fixed land and water resources.

The results revealed that farmers in the study area were applying fewer amounts of fertilizer than the recommended rates per hectare. The low levels of use of fertilizer in the study area were found to be one of the reasons for the low yields and declining maize output harvested in the study area. The quantities of seeds applied per hectare in the study area were found to have a mean value of 22 kg/ha and in accordance with the recommended maize seed planting rates per hectare in South Africa. Results of the Cobb-Douglas model showed that fertilizer, labour, and herbicides used in the production of maize in the study area were positively and statistically significant in the study related to elasticity coefficients of 0.547, 0.466 and 0.198 respectively at 5% confident level. Thus, a 1 percent increase in fertilizer, labour, and herbicides applied per hectare would result in an increase, on average, of 0.54, 0.5 and 0.2 percent of maize output per hectare, respectively. An increased amount of fertilizer in kilograms applied per hectare and increased labour as well as increased herbicide applications are likely to result in an increased amount of maize output in the study area.

All the independent variables in the model had positive regression coefficients indicating a direct positive relationship between the inputs and maize output. The coefficient of determination, R^2 was 0.902 which implies that 90.2% of the variation in the output of maize was accounted for by the independent variable inputs computed in the model. The study further revealed that inadequate rainfall, poor extension services, pests and diseases, inadequate storage/processing facilities, and inadequate credit and lack of market access were additional threats limiting maize productivity levels in the study area.

It is therefore recommended that the South African government should supply inputs to maize farmers at subsidized rates to promote correct application rates. There is a need for an adequate market with effective stable prices for the product of maize farmers coupled with suitable storage facilities to further boost maize production. Additionally, a strong revitalisation of the extension services sector is highly recommended.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Fanadzo M, Chiduza C, Mnkeni P. Investigation of agronomic factors constraining productivity of grain maize (*Zea mays* L.) at Zanyokwe irrigation scheme, Eastern Cape, South Africa. J Appl Biosci. 2009;17:948-58.
2. Breitenbach MC, Fenyes TI. Maize and wheat production trends in South Africa in a deregulated environment/mielie en koring produksietendense in'n gedereguleerde markomgewing in Suid-Afrika. Agrekon. 2000;39(3):292-312.
3. Baiyegunhi L, Sikhosana A. An estimation of import demand function for wheat in South Africa: 1971-2007. African Journal of Agricultural Research. 2012;7(37):5175-80.
4. Sihlobo W. An evaluation of competitiveness of South African maize exports. MSc Agric Thesis Stellenbosch University, Stellenbosch, South Africa; 2016.
5. Ranum P, Peña-Rosas JP, Garcia-Casal MN. Global maize production, utilization, and consumption. Annals of the New York Academy of Sciences. 2014;1312(1):105-12.
6. Shiferaw B, Prasanna BM, Hellin J, Bänziger M. Crops that feed the world 6. Past successes and future challenges to the role played by maize in global food security. Food Security. 2011;3(3):307.
7. Gouse M, Pray CE, Kirsten J, Schimmelpfennig D. A GM subsistence crop in Africa: The case of Bt white maize in South Africa; 2005.
8. Altman M, Hart TG, Jacobs PT. Household food security status in South Africa. Agrekon. 2009;48(4):345-61.
9. Obi A, Ayodeji BT. Determinants of economic farm-size–efficiency relationship in smallholder maize farms in the Eastern

Cape Province of South Africa. Agriculture. 2020;10(4):98.

10. Onuk E, Ogara I, Yahaya H, Nannim N. Economic analysis of maize production in Mangu local government area of Plateau State, Nigeria. PAT Journal. 2010;6(1):1-11.

11. Trostle R. Global agricultural supply and demand: factors contributing to the recent increase in food commodity prices. Rev: Diane Publishing; 2010.

12. Simiyu SW. Factors influencing maize production among small scale farmers in Kenya, A caseof Bungoma Central Sub County; 2014.

13. Greyling JC. Policy, production and productivity: Spatial dynamics in the South African maize industry during the 20th Century; 2019.

14. Du Plessis J. Maize production: Department of Agriculture Pretoria, South Africa; 2003.

15. Van Zyl J, Nel H. The role of the maize industry in the South African economy. Agrekon. 1988;27(2):10-6.

16. Kibirige D, Obi A. Agricultural efficiency of smallholder farmers in Eastern Cape province of South Africa. International Journal of Economics, Commerce and Management. 2015;3(9):269-89.

17. Liebenberg F, Pardey PG. South African agricultural production and productivity patterns. The shifting patterns of agricultural production and productivity worldwide. 2010:383-408.

18. Madyibi Z. The massive food production programme: Does it work? In the Shadow of Policy: Everyday Practices in South Africa Land and Agrarian Reform; 2013.

19. Muchara B, Letty B, Obi A, Masika P, Ortmann G, Wale E, et al. The role of capital assets and institutions in the success and failure of smallholder irrigation schemes in South Africa. Journal of Human Ecology. 2014;48(2):235-47.

20. Greyling JC, Pardey PG. Measuring maize in South Africa: The shifting structure of production during the Twentieth Century, 1904–2015. Agrekon. 2019;58(1):21-41.

21. Sharma G. Pros and cons of different sampling techniques. International Journal of Applied Research. 2017;3(7):749-52.

22. Aigner D, Lovell CK, Schmidt P. Formulation and estimation of stochastic frontier production function models. Journal of Econometrics. 1977;6(1):21-37.

23. Abdulai S, Nkegbe PK, Donkoh SA. Technical efficiency of maize production in Northern Ghana; 2013.

24. Otieno OD. Socio economic drivers influencincing smallholder maize production in Tobacco Growing Zones of Migori County, Kenya.

25. Haiyang T, Jin Z. Changes and influencing factors of maize production pattern in China. Asian Agricultural Research. 2016;8(3).

26. Musokwa M, Mafongoya P, Lorentz S. Evaluation of agroforestry systems for maize (*Zea mays*) productivity in South Africa. South African Journal of Plant and Soil. 2019;36(1):65-7.

27. Jari B, Fraser G. An analysis of institutional and technical factors influencing agricultural marketing amongst smallholder farmers in the Kat River Valley, Eastern Cape Province, South Africa. African Journal of Agricultural Research. 2009;4(11):1129-37.