

Determinants of Maize Yields among Small-Scale Farmers at Household Levels in Mbinga District, Tanzania

Abstract

Maize plays an important role in global food security as staple food crop for millions of people. It is considered as the world's most important cereal crop because it is a cheap source of calories as compared to other sources of protein foods. It has the potential of being grown in a variety of agro-ecologies zones with varied yields per hectare. The purpose of the study was to analyse the determinants of maize yields among small-scale farmers at the household levels. This cross-sectional study was conducted in Mbinga District, Ruvuma Tanzania. A multistage sampling technique was used to select 120 farmers in the study area. Semi structured questionnaires and key informant interview were used for data collection. Data was analysed by descriptive statistics and Ordinary Least Square (double log model). The results indicate that farm size, amount of seed, ~~amount of~~ fertilizer and ~~amount of~~ labour were the significant determinants of maize yields among farmers in the district. The study recommends that; the government should ensure access to inputs for farmers, farmers should be capacitated on accessing loans with low interest and reliable markets through formation of farmers' associations, and farmers should be exposed to better farming techniques through effective provision of extension services.

Key words: Maize, Yield, small-scale, farmers, household

1.0 Introduction

The implementation Sustainable Development Goals (SDGs) encounters a significant number of issues, among others, hunger, food insecurity and climate change (Xu et al., 2020; Dicks et al., 2019). In achieving the SDGs that are linked with poverty (Goal 1), hunger (Goal 2), Health (Goal 3) and climate change (Goal 13) requires, among other efforts, to ensure a wider scope and sustainable implementation of agricultural policies and strategies (Xu et al., 2021). One of the strategies has been to ensure a worldwide improvement in agricultural production so as to slow down food insecurity (Dutta et al., 2020). This is backed by Food and Agricultural Organization (FAO) et al., (2018) and the International Food Policy Research Institute (IFPRI) which identified food security as the global concern of the 21st Century. Reducing the global food insecurity requires bridging the variations in yield gaps for small-scale farms as main producers of major cereal crops in developing countries (Krupnik et al., 2015; Godfray et al., 2010). The cereal crops such as maize and wheat are dependable for food security in the world.

Maize plays an important role in global food security as staple food crop for millions of people particularly Africa, Asia and Latin America (Erenstein, 2010). It is rationally considered as a cheap source of calories as compared to fruits, vegetables and animal source of protein foods. It is regarded as the world's most important cereal crop occupying about 14% of the global cropland area (FAO, 2020). On average, the global production of maize reaches 1,127 million tons annually (OECD/FAO, 2019). It has the potential of being grown in a variety of agro-ecologies zones with varied yields per hectare. It has relatively higher yields than other types of cereal crops which make

it potential for farmers even in areas with high population pressure and a limited farm size (Shiferaw et al., 2011).

In the developing world, maize is the most widely grown cereal crop and a dietary staple however it is faced with substantial deficits causing demand for its import (Grote et al., 2021). In the sub-Saharan Africa (SSA) maize is grown on more than 40 million hectares of land. Over half of the SSA countries grow maize as the primary cereal crop and it is one of the top cereals to more than three-quarters of the countries (FAO, 2021). The consumption of the crop per day is beyond 100 grams to more than half of the countries. Prasanna et al., (2021) determined that the population of SSA is projected to double over the next 30 years. The projection raises concerns over an increase in the demand of cereal crops by three-fold (van Ittersum et al., 2016). In the East African Community (EAC) countries, Tanzania is the major producer of maize followed by Kenya and Uganda (Ntabakirabose, 2015). It has the strength of being grown in almost all agro-ecological zones in the country (USAID, 2010). As such, it is grown and consumed staple crop by most of the Tanzanian households. It is the most important cereal crop in the country, contributing for almost 70% of the annual cereal production (GoT, 2018). This makes it as priority staple crop and serves as the best strategy for achieving food security among communities.

In Tanzania, the crop is predominantly produced to 80% by small-scale farmers who grow it mainly for subsistence (Wilson & Lewis, 2015). The production is actually accelerated by its potential in accounting about 31% of total food produced and 70% of entire cereal consumption countrywide with the per capita consumption standing at 128 kilograms annually and 35% of daily calories consumption (Suleiman & Rosentrater, 2015; Baha, et al., 2013; BEFS, 2013; Suleiman et al., 2013 Zorya et al., 2011). For that case the crop is considered as the high priority and the most important strategy for achieving household food security within the country (FAO, 2016; Homann-Kee et al., 2013). Thus, the subsector has the role to play in achieving food security to attaining high-quality livelihood among citizens as advocated in the Tanzania Development Vision (TDV) – 2025.

In the country, the crop's production is mainly undertaken in the Southern Highlands regions (Rukwa, Ruvuma, Mbeya, Njombe and Iringa) which are principally characterized by small-scale farmers. Among the regions, Ruvuma contributes a significant amount of maize in the grain basket countrywide. The area approximately planted into maize constitutes for about 50% of the area occupied with annual crops in the region (2007/08 National Sample Census of Agriculture [NSCA], 2012). Compared to its area for crop plantations, the region has the opportunity to significantly boost its maize yield because of its favourable weather and proximity to the export markets such as Mozambique which turns out to be an important opportunity for export. Within the region, Mbinga district is a potential producer of the crop due to its favourable climate and it occupies the largest area 65,770 hectares which accommodate cereal plantations (NSCA, 2012). This informs that it has a potential role in improving maize yield within the region.

Despite the importance it has both for food security and economic well-being in the country, maize production and productivity among producing households is still low that stands at 1.2 – 1.5 tonnes/ha compared to 1.8 tons/ha for SSA (DTMA, 2014; URT, 2015). In addition to that, its productivity is outlying from that of South Africa (SA) and the World average yields in general standing at 2.7 and 4.3 tonnes/ha correspondingly (Urassa, 2015). Countrywide, there have been instituted diverse sectorial initiatives to address this matter in the course of maize producing households. These initiatives include; the National Strategy for Growth and Reduction of Poverty (NSGRP I and II), introduction of District Agricultural Development Plans (DADPs), Agricultural

Sector Development Programme (ASDP), Japan Policy and Human Development (JPHD), the Eastern Africa Agricultural Productivity Programme (EAAPP), and Southern Agricultural Growth Corridor of Tanzania (SAGCOT). These initiatives aim at, among others, transforming agriculture which promotes yields and economic growth. However, despite these efforts in place, maize production and productivity are still low and unstable for most small-scale producing households (MAFC, 2011; Suri, 2011; URT, 2011; Baha, 2013; MAFAP, 2015; URT, 2015).

Hitherto, considerable studies have been conducted on maize sub sector in country (Barreiro-Hurle, 2012; URT, 2012; Mcharo, 2013; Suleiman and Rosentrater, 2013; Lyimo et al, 2014; Suleiman et al, 2015; Urassa, 2015; Wilson & Lewis, 2015). The attention has been grounded on perception, use of improved maize varieties, production and post-harvest losses, production efficiency, storage, value chain and incentives. Although substantial research has been devoted to the sub sector, the focus has been far from the determinants of the crop yield among farming households. Therefore, the current study aimed at analysing the determinants maize yields among small-scale farmers in Mbinga District, Tanzania. The findings of the study will help to capacitate promotion, improvement and enhancement of various determinants of the yield to raise its production.

The outline of the paper is as follows: Next to this section, materials and methods are presented. Then, results and discussion section is presented. The final section concludes the study and provides substantial recommendations.

2.0 Materials and Methods

The study was conducted in Mbinga district, Ruvuma region, Tanzania. The district is bordered by Njombe region to the north, Songea rural district and Songea Urban district to the East, Mozambique to the south and Nyasa district to the west. The district has an area of 4,839.78 km² with a total of approximately 353,683 people composing a population density of 73.1 inhabitants/km² (National Census, 2012). It is characterised by highlands and low-lying areas featured with temperate tropical climate. It is benefiting from a reliable and sufficient uni-modal rainfall patterns with an average of 1200 mm annual rainfall. Generally, the district's weather condition is favourable for agriculture. The agriculture is predominantly small-scale farming into maize, coffee, beans, and wheat (Komba, 2021). In supporting the initiatives of food security the district is rich in maize production through small-scale farmers.

The study adopted a cross-sectional design which gave a clear print of the overall maize production within the district. This design was convenient for enhancing data collection, inexpensive and sufficient in terms of time. With a multistage sampling technique 120 small-scale farmers were selected for the study. Initially, the district was chosen purposively, then four wards (Kigonsera, Kikolo, Matiri and Mpepai) were chosen randomly from a list of maize producing wards. Finally, the selection of small-scale farmers was conducted proportionally to the wards from a list of maize producing households. Both quantitative and qualitative data were collected from the households by using semi-structured questionnaires that were carefully designed to meet the purpose of the study. The tool based on age, sex, education level, farming experience, farm size, household size, the amount of maize seed planted, the amount of fertilisers used, and the amount of maize yield. A pilot study and training to enumerators were conducted prior to data collection for ensuring validity of the tool.

Data management was performed by using Statistical Package for Social Sciences (SPSS). Clean data set was then analysed by using descriptive statistics and Ordinary Least Square (OLS) regression

technique. These techniques were used to describe small-scale farmers' characteristics and analyse the relationship between maize yield and its determinants. The Cobb-Douglas production function was adopted in analysing the linear relationship between farm inputs and output. To find out the determinants of maize yield, a double log model was appropriate for its convenience in best fitting the data (Haq et al., 2002; Sarkar et al., 2010; Adhikari, 2013). The Cobb-Douglas production function was presented as in (1):

The Cobb-Douglas production function can be presented as:-

$$Q = F(K, L) = A L^{\alpha} K^{\beta} \dots\dots\dots (1)$$

Where,

Q	Output
K	Capital
L	Labor
A,	Positive constants
α, β	Elasticities of labor and capital respectively

This can be estimated by regression analysis through linearization by transforming the equation into a double log form so that it could be estimated by the least square method. The transformed model becomes (2)

$$\ln Q = \ln A + \alpha \ln L + \beta \ln K \dots\dots\dots (2)$$

This can further be extended to accommodate more than two inputs that a farmer employed in maize production process. The appropriate model for the study was now transformed into (3)

$$\ln Y = \beta_0 + \beta_1 \ln A + \beta_2 \ln Fe + \beta_3 \ln Fas + \beta_4 \ln Ed + \beta_5 \ln L + \beta_6 \ln Fs + \beta_7 \ln F + \beta_8 \ln F + \epsilon_i \dots\dots\dots (3)$$

Where,

Y	Amount of maize yield in kilograms,
A	Age of a farmer in years,
Fe	Maize farming experience,
Fas	Family size,
Ed	Education level of the farmer (highest level reached in years),
Fs	Farm size in hectares,
L	Amount of Labour in number of workers,
S	Amount of seed in kilograms,
F	Amount of fertilizers in kilograms,
ln	Natural logarithm,
β_0	Constant term (Intercept),
β_i	Regression coefficient of i^{th} independent variable (Where $i = 1, 2, 3 \dots n$)
ϵ_i	Error term

After the specification of the model, Microsoft Excel and STATA-13 software packages were used to reach to the main findings of the study. Before jumping into the data analysis the testing for the satisfaction of OLS assumptions before the estimation of statistical results was conducted. This is

because the violation of the OLS assumptions could make the estimates unreliable and biased. The problematic issues were remedied and the analysis was ultimately conducted.

3.0 Results and Discussion

3.1 Demographics

Gender: Table 1 indicates that the sample was composed of 94 Males and 26 females which is 78.3% and 21.7% respectively. This implies majority of the farmers were predominantly married while the minority represented their husbands (household heads) who were not available at times of data collection.

Age: Results in Table 1 show the dominance of the age between 15 and 59 years in the sample by 97%. It ~~shows~~ shows maize production was mainly performed by farmers in a productive age in the study area. The results relate with Onuk et al., (2010) who identified age as an important aspect in influencing yields.

Marital status: It is shown from Table 1 that 86% of the sample was occupied by married respondents. This coincides with Amaza et al., (2006) who determined that married couples have the capability of providing access to labour. This is influenced by their capacity to coordinate and organize family plans.

Level of education: The results show that all respondents were possessing formal education which enables individuals follow instructions from the experts. The results align with Ahmed et al., (2013) and Onojah et al., (2013) who determined dominance of formal education to majority of small-scale farmers and that it was an important aspect to support farming.

Years of experience in maize farming: The findings from Table 1 show that farmers had enough experience in the farming activities. Oyewole (2012) noted that output was directly proportional to the years of farming experience. The experience helped farmers in improving the production techniques.

Farm size: Results from Table 1 show that 91.7% of farms were of the size less than 2.9 hectares. This show that maize farming was predominantly undertaken by small-scale farmers. The findings were similar to Olayide (2013) who asserted that majority of farms were relatively small not more than 5.99 hectares.

Table 1. Demographics of small-scale maize farmers

Variables	Frequency (%)
Gender	
Male	026 (21.70)
Female	094 (78.30)
Age Group	
15 - 29	021 (17.50)
30 - 44	049 (40.80)
45 - 59	047 (39.20)
60 - 74	003 (02.50)
Marital Status	
Single	006 (05.00)
Married	104 (86.00)
Separated	003 (03.00)
Widowed	007 (06.00)
Level of education	
Primary education	105 (87.50)
Secondary education	013 (10.80)
Tertially education	002 (01.70)
Farming experience (years)	
00 - 09	039 (32.50)
10 - 19	020 (06.70)
20 – 29	040 (33.30)
30 - 39	021 (07.50)
Farm size (Hectare)	
<1.00	006 (05.00)
1.10 – 1.99	081 (67.50)
2.00 – 2.98	023 (19.20)
>2.99	010 (08.30)
Total	100

Source: Survey data, 2017

3.2 OLS analysis of the determinants of maize yields in the study area

3.2.1 Regression analysis

To analyse the determinants of maize yields in the study area, the regression analysis through double log model examined the relationship between the output (yields) and the inputs used by farmers in the production process. The regression output is shown in Table 2.

Table 2. Determinants of maize yields; Regression estimates

Variables	Coefficient	Robust Standard Error	t	P> t
Ln_A	-.0877170	.2359027	-0.37	0.711
Ln_Ed	-.1435423	.1202760	-1.19	0.235
Ln_Fas	.0560127	.1312948	0.43	0.670
Ln_Fe	-.0330458	.0870573	-0.38	0.705
Ln_Fs	.8933541	.1522154	5.87	0.000*
Ln_S	.2039806	.0822531	2.48	0.015**
Ln_F	.1481990	.0535858	2.77	0.007*
Ln_L	.2361729	.1107317	2.13	0.035**
Constant	1.586657	.6839152	2.32	0.022**
Number of observations(120), F(8, 111)= 15.63, Prob>F = 0.0000, R-squared = 0.5673				

Source: Stata output, 2022

Note: * is significant at 1%, ** is significant at 5%

3.2.2 Regression model results

The computed R-square of the model is 0.5673. It indicates that 56.73% of the variations in maize yields was explained by the farm inputs in the production process. The F-test value 0.0000 is highly significant showing that the farm inputs were vitally explaining the variations of the maize yield. This denotes the best fit of data.

3.2.3 The input-output relationship of maize farming in the study area

Farm size: The farm size coefficient is positive (0.8934) and significant at 1%, which indicates a 01% increase in the farm size would improve the maize yield by 0.89%, at ceteris paribus. The findings are in line with Liu et al., (2021); Key, (2019); Rada & Fuglie, (2019); Wu et al., (2018); Kimhi (2003); Dorward (1999) who identified a positive contribution of the farm size on maize yield. Importantly, the study notes that a proper utilization of the extra farms (plots) could result into increased maize yield in the study area.

Amount of seed: The coefficient of regression for the amount of seed is positive (0.2040) and significant at 5% indicating 01% increase in the amount of seed would increase the maize yields by 0.20%, at ceteris paribus. The findings are similar with Fang and Belton, 2020 asserted that an increase in the amount of seed affect maize yields positively. The results imply that improvement in extension services is required especially on the provision of trainings in seeds spacing on the farms. This signifies that proper spacing could result into improved maize yield in the study area.

Amount of fertiliser: The coefficient for the variable of the amount of fertiliser is positive (0.1482) and significant at 1% showing 01% increase in the amount of fertiliser could result into 0.15% increase in the maize yields, provided that other inputs are fixed. The results concur with Liu et al., (2021); Urassa, (2015) who identified that the use of fertilisers boosts the yields. This implies that access to affordable technology (fertiliser) was important determinant for sustainable production among small-scale farmers. The optimal use of fertiliser was required to reach the ideal production capacity of small-scale farms in the study area.

Amount of labour: The coefficient for the amount of labour is positive (0.2361) and significant at 5%. This indicates that 01% increase in amount of labour could increase 0.24% of maize yield, at

ceteris paribus. The findings relate with Fang and Belton, 2020; Olujenyo (2008) who noted an increase in the amount of labour determines the maize output positively. This positive relationship between labour and yield was important in ensuring sustainable maize production in the study area. Thus, reasonable addition in units of labour could increase in maize yield.

4.0 Conclusion and recommendations

This paper analysed the determinants of maize yields among small-scale farmers in Mbinga district. The study employed a cross-sectional research design and a multistage sampling technique to gather data from 120 small-scale farmers. Data were collected at Kigonsera, Kikolo, Matiri and Mpepai wards. Semi-structured questionnaires administered at the maize farming households whereas interview guides were administered on gathering data from the District Agricultural Officer and Ward Executive Officers. The results from the double log model indicate that farm size, amount of seed, ~~amount of~~ fertiliser and ~~amount of (avoid repeation)~~ labour were the significant determinants of maize yields among small-scale farmers in the district. The study concludes that farmers should ensure an increase and proper utilization of farm inputs (farm size, seeds, labor and fertilizers) in the production process so as to boost the yields.

The study recommends the following for the sustainability of the crop yields. First, the government should ensure access to inputs for farmers. These are such as fertilisers and seeds which have an important role in improving the yields. Second, farmers should be capacitated to financial inclusion to access loans with low interest and reliable markets through formation of farmers' associations. Third, farmers should be exposed to better farming techniques such as the rational application of inputs through provision of effective extension services. Finally, the study recommends researches on the livelihood analysis and value chain in the crop's production process.

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