Economic Analysis of the Production of Root-vegetables by Small-Scale Farmers in Mbulu District

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Abstract

The production of vegetables supports farmer's food security and income generation. This paper seeks to analyse the production of root-vegetables by small-scale farmers in Mbulu District, Tanzania. The paper applied a cross-section design and a two-stage sampling to obtain 120 farmers producing either carrots or Irish potatoes. Results from the Cobb-Douglas production function showed that farm area and inputs cost were significant factors that influenced production of carrots; while farm area, labour, inputs cost, and equipment cost were significant factors that influenced the production of potatoes. Furthermore, results from multiple regression showed that income of root-vegetables growers decreased significantly with the production of potatoes compared to carrots; but increased significantly with farm area. The findings highlight the need for the Ministry responsible for Agriculture to offer agricultural extension services regarding optimal production of root-vegetables for sustainable increased returns to scale in the long-run.

Keywords: production, farm income, regression analysis
JEL Classification D24, C30

1. Introduction

Vegetables are an essential component of people's daily diet, and provide essential vitamins, minerals, and other nutrients (Cheng et al., 2016; Lewis et al., 2012). World vegetables production grew from 446m tonnes in 2000 to 1,128m tonnes in 2020. In Africa, production grew from 44.4m tonnes in 2000 to 85.7m tonnes in 2020; and specifically in Tanzania production grew from 1.2m tonnes in 2000 to 2.8m tonnes in 2020 (FAO, 2022, 2023). Vegetable production is an important source of household income for financial improvement of the lives of rural farmers, and the surrounding communities (Elbert, 2014; Betek & Jumbam, 2015).

During the 2019/2020 agricultural year, 478,452ha were planted with root-vegetables by smallholder farmers in Tanzania. Also, 4,761ha were planted with root-vegetables in Manyara region during the same period (NBS, 2021). However, the level of agriculture production in Manyara region is reported to be low in some areas such as Mbulu District (NBS, 2021; Mbulu DC, 2022). Low agriculture production results into the production of root-vegetables below the thresholds needed (FAO & Ministry of Social Development and Family of Chile, 2021). As vegetable production serves the purpose of helping households along the urban-rural continuum to generate income (Chagomoka, 2015), improving the production of root-vegetables in Mbulu District will also improve the thresholds needed for vegetable production globally.

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 ♦ **https://doi.org/10.56279/ter.v13i1.163**

The theory of production and linear regression model provided a base for analysing factors influencing the production of root-vegetables and income obtained from such production by small-scale farmers in Mbulu District, Tanzania. Msuya and Ashimogo (2005) applied the Cobb-Douglas production function when analysing the production of sugarcane in Mtibwa, Tanzania; while Regasa (2016) applied a regression model when analysing the determinants of income of Irish potato growers in Ethiopia. It is against such a theory and model that this study was undertaken to analyse factors that influenced the production of root-vegetables and income obtained from such production by small-scale farmers in Mbulu District, Tanzania.

The remaining part of the paper is organised as follows. Section 2 discusses theories and empirical findings in relation to studies already undertaken. Section 3 explains the methodology of this study. Section 4 presents the study results; while section 5 gives conclusions and recommendations for policy making.

2. Literature Review

2.1 Theoretical Review

A production function is defined as the maximum amount of output that can be produced (through the use of a given production technology) with a given amount of input (Rasmussen, 2013). It implies that for any given amount of input there should be an output; and if there is no input introduced then there is no output to be produced. If inputs and outputs are treated as two separate categories, the relationship between inputs and outputs can be expressed as $F(x, y) = 0$, where x is a J dimensional non-negative input vector, and y is an M dimensional non-negative output vector. The general formula considered a much more restricted formulation, which for a single output case can be expressed as:

$$F(X_1, X_2, , , , , X_j) \equiv F(x)$$

Where $F(x)$ is the production function, which gives the maximum possible output for a given x; $F(x) = 0$ if there are no any inputs; $F(x) \geq F(x')$ for $x \geq x$ means that the production function increases with increases in inputs; $F(x)$ is continuous and twice differentiable everywhere, meaning that the production has a decreasing efficiency with respect to any factor of production; and if the output is closed and non-empty for any input introduced means that for any input $x > 0$ introduced, the production function will not be zero ($F(x) > 0$) (Kumbhakar et al., 2015).

Various specific mathematical forms have been put forward for the production function, but the most commonly used is the one developed by Charles Cobb and Paul Douglas in the second quarter of the 20th century:

$$Y = AK^{\beta_1}N^{\beta_2} \text{ , } 0 < \beta_i < 1.$$

Where, Y represents aggregate output; K is the capital input; N is the labour input (capital and labour being the two 'factors of production' in this function); and β_i are the coefficients.

Return to scale refers to a technical property of production that examines changes in output subsequent to a proportional change in all inputs (where all inputs increase by a constant factor). If $\beta_1 + \beta_2 > 1$, then return to scale is increasing; if $\beta_1 + \beta_2 < 1$, then return to scale is decreasing; and if $\beta_1 + \beta_2 = 1$, then return to scale is constant (Cottrell, 2019).

Msuya and Ashimogo (2005) presented the Cobb-Douglas production function with five input variables: land area cultivated (L), family labour utilized (Fl), hired labour utilized (Hl), total variable input (R), and the value of total capital equipment (C); while output (Y) was the maximum attainable output for a given level of all inputs, measured in kg. The function was shown as:

$$LnY_{in} = \beta_{0n} + \beta_{1n} \ln L_{1n} + \beta_{2n} \ln Fl_{1n} + \beta_{3n} \ln Hl_{1n} + \beta_{4n} \ln R_{1n} + \beta_{5n}\, ln\, C_{1n} + \in I$$

Ningsih (2016) applied the Cobb-Douglas production function to analyse factors that affect the production of cabbages, and found that these factors included labour, land, pesticides and seeds. Ali et al. (2019) applied the Cobb-Douglas production function and result revealed that seed rate, tractor hours, labour days and fertilizer were important factors accounting for the increase of tomato production in the study area. Hence, the Cobb-Douglas production function is of great importance towards analysing farm production as it explains the type of returns to scale demonstrated given the inputs used.

2.2 Empirical Review

2.2.1 Factors of Production

There are a number of existing empirical studies that have investigated the production of root-vegetables such as Irish potatoes, cocoyams, onions, or carrots by smallholder farmers. Studies by Dung et al. (2010), Nwakor et al. (2016), Bukul (2018), Ahmed et al. (2018), and Kaka et al. (2022) have pointed out that farm area or land as a factor that affects the production of root-vegetables. These studies suggested that production increases with farm area. However, Omari (2015) found that farm size influenced production negatively. This implies that if farm area is an important factor of production, therefore smallholder farmers ought to increase farm income based on farm area (Bassa et al., 2017). Furthermore, empirical studies by Ahmed et al. (2018), Sapkota and Bajracharya (2018), Mengui et al. (2019), Fikadu et al. (2022) applied the Cobb-Douglas production function, and found that labour was a factor that positively influenced the output of root-vegetables. Also, they found that scarcity of labour in production limits output of root-vegetables such as carrots and cocoyams (Ahmad et al., 2005; Serem et al., 2008).

Moreover, Akamin et al. (2017) and Mengui et al. (2019) pointed out that the production of root-vegetables depends on capital and equipment utilized in a farm. Mengui et al. (ibid.) found that capital influenced positively total output of Irish potatoes in Cameroon, and that smallholder farmers need to promote productivity and output growth.

Also, the production of root of root-vegetables depends on material inputs. Studies by Omari (2015), Dung et al. (2010), Nwakor et al. (2016), Akamin et al. (2017), Sapkota and Bajracharya (2018), and Fikadu et al. (2022) indicated that the use of agro-chemicals, fertilizer, farm yard manure, and seed and seedling influenced positively the production of root-vegetables. On the other hand, some studies indicated non-economic factors such as the availability of extension services (Serem et al., 2008), diseases and pests (Muthoni & Nyamongo, 2009), and sex (Bukul, 2018) affect the production of root-vegetables. In general, these studies have indicated that the production theory is of great importance when analysing the relationship between inputs and outputs of farms. Also, the theory provides a base for understanding the productivity of farms.

2.2.2 Determinants of Farm Income and Welfare

Regassa (2016) applied a multiple regression analysis to determine factors influencing the income of potato production, and found that seed cost, level of commercialization, number of oxen owned, frequency of extension contact and farming experience positively and significantly affected farmers' income; while total land owned, and ages of household head correlated negatively and significantly affected potato income. Fadipe et al. (2014) applied a multiple regression analysis to evaluate the determinants of income among rural households in Nigeria. The result showed that farm income is the most important source of income for rural households by making up to 57.9% of total household income. In addition, level of education of the household head, farm size, access to electricity, and gender of the household head were identified as the major determinant of household income in the area.

Katepan et al. (2017) applied a multiple regression analysis to identify factors influencing okra farm income in Nakhon Pathom Province, Thailand. The results revealed that the number of schooling years had a significant negative effect on okra farm income. Yusuf et al. (2018) applied a multiple regression analysis to identify the determinants of farm income in Northern Nigeria, and found that livestock keeping, access to credit, farm power, proximity to market, marital status, gender and climate: all influenced farm income. In addition, variation in factors due to differences in agro-ecological zones significantly affected revenue. In general, regression analysis enhanced the analysis of household income by showing different factors that affected income positively or negatively among farmers. Analysis of income among small-scale farmers brings an understanding of the role of crop production towards household consumption.

Tekana and Oladele (2011) applied a multiple regression analysis to examine household welfare among farmers and found that the determinants of household welfare amongst farmers were age, gender, educational level, household head type, access to natural capital and socio-economic status. Biyase and Zwane (2018) applied the fixed effect and random effect probit models to determine factors that influenced poverty and household welfare in South Africa. The results indicated that level of education, residence, race, dependency ratio, gender, employment status, and marital status of the household head were significant determinants of household welfare.

Although there are a number of studies on root-vegetables production in many countries, studies addressing factors influencing production of root-vegetables and income in Mbulu District are scanty. The empirical study conducted in Mbulu and Babati districts by Omari (2015) did neither involve carrots, nor did it take into consideration the application of the Cobb-Douglass production function theory. Furthermore, the study did not apply the OLS to determine factors that influence income obtained through root-vegetables production. This paper contributes to a greater understanding of factors that influence the production of root-vegetables and income obtained from production in Mbulu District, Tanzania.

2.3 Conceptual Framework
The conceptual framework in Figure 1 shows how household income of root-vegetable growers relates to farm production. The productivity of a farm is determined by factors such as land area, labour, other inputs/physical materials, and equipment.

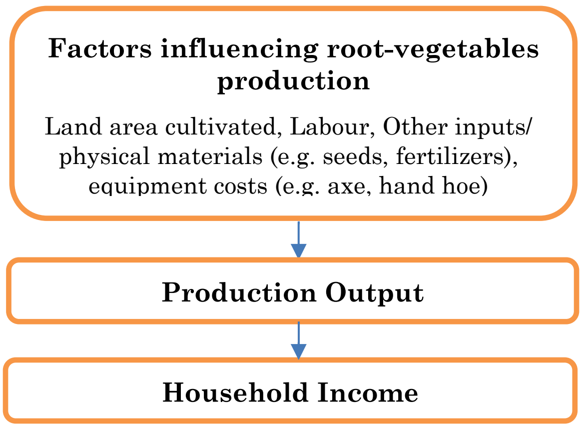

Figure 1: Conceptual Framework
Source: Authors' creation (2020).

3. Methodology
3.1 Research Design
The study was a quantitative one and it used a cross-sectional research design. Cross-sectional research studies allow taking a cross-section of a population so as to obtain an overall 'picture' as it stands at the time of a study (Kumbhakar, 2011).

3.2 Population and Sampling Technique
The study population was agricultural households engaged in the production of root-vegetables in Mbulu District Council, in the Manyara region of Tanzania. Root-vegetables are high in carbohydrates, calcium, and vitamin C; and account for roughly 40% of the food eaten by half of the population of sub-Saharan Africa (SSA) (FAO, 2023). The Manyara region has five districts, including Mbulu, a district reported to have low level of agriculture production (PORALG, 2022; Mbulu DC,

2022). Manyara region has 4,566 agricultural households engaged in the production of carrots and Irish potatoes (NBS, 2021). Furthermore, the region ranked second in carrot yield (2.4 tons/ha), and fourth in potatoes yield (5.5 tons/ha), in the 2019/20 agricultural year in Tanzania (NBS, 2021).

When a population size is about 5000 units, a sample size of 357 units can be selected with respect to 95% confidence interval and 5% margin error in a sample size (Research Advisors, 2006). The study adopted a two-stage sampling technique to obtain the respondents required. First, a cluster of wards with growers of either carrots or round potatoes were formed in Mbulu District. Bashay, Tumati and Yaeda Ampa wards were selected since these wards had valleys with natural springs for irrigation and other purposes in the district (URT, 2020). Thereafter, 120 agricultural households engaged in the production of either carrots or Irish potatoes were selected from the cluster to provide the required information.

3.3 Data Sources

A primary data collection method was employed to source data. Questionnaires were distributed to sampled agricultural households engaged in the production of carrots and round potatoes to obtain the required information.

3.4 Empirical Model Specification

3.4.1 Regression Analysis

Regression analysis was applied to model the Cobb-Douglas production function. Regression analysis is one of the most widely used techniques for analysing multi-factor data because its broad appeal and usefulness result from the conceptually logical process of using an equation to express the relationship between a variable of interest (the response), and a set of related predictor variables (Montgomery et al., 2012). The general regression model is specified as follows:

$$Y_i = \beta_0 + \beta_i X_i + \varepsilon_i \qquad (1)$$

Whereby:

Y_i is the variable of interest (the response)
β_0 is the intercept
β_i is the coefficient of Y for a unit increase in X_i
ε_i is the error term

According to Msuya and Ashimogo (2005), the Cobb-Douglas regression model for farm production should include output, farm area, inputs, and equipment. Therefore, the regression model for each root-vegetable was estimated as follows:

$$lnY_i = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i} + \beta_4 lnX_{4i} + \varepsilon_i \qquad (2)$$

Whereby:

ln = Natural logarithms
Y_i = Output of vegetables produced (in kg per hectares)
X_{1i} = Farm area cultivated (in hectares)

X_{2i} = Labour, family and/or hired (in man days)
X_{3i} = Input costs (like seeds, fertilizer, pesticides) (in TZS)
X_{4i} = Equipment costs for items such as hand hoe, machete, axe, forked hoe, sickle, can and generator in TZS
β_i = Coefficients to be estimated
ε_i = Error term.

Also, according to Regasa (2016) and Fadipe et al. (2014), a regression model for analysing factors influencing income obtained through root-vegetables production was estimated as follows:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \varepsilon_i \quad (3)$$

Whereby:

Y_i = Income (TZS/hectare)
X_{1i} = Type of vegetables (carrot/potato)
X_{2i} = Experience (year)
X_{3i} = Farm area (hectare)
β_i = Intercepts
ε_i = Error term.

4 Results and Discussions

4.1 Descriptive Statistics

The results presented in Tables 1 show that about 62.5% of root-vegetables growers produced carrots, while about 37.5% produced potatoes. This corresponds to 75 carrot growers, and 45 potato growers. Here, the majority of farmers grew carrots. This could have been due to the fact that carrots had good yields per hectare in the region. In Manyara region, the yield per hectare for carrots was 12.4 units; while for potatoes the yield per hectare was 5.5 units during the long rainy season in the 2019/20 agricultural year in Tanzania (NBS, 2021).

Table 1: Frequency Distribution Table Showing Type of Root-vegetables

Type of root-vegetables	Frequency	Percent
Carrots	75	62.5
Potatoes	45	37.5
Total	**120**	**100**

Source: Field data (2020)

Furthermore, Table 2 shows that about 88.33% of the farmers engaged in root-vegetables growing were males, while about 11.67% were females. This corresponds to 106 male root-vegetables growers, and 14 female root-vegetables growers. In a study on vegetable production in Cameroon, Akamin et al. (2017) found similar results: that 83% of the farmers who engaged in vegetables growing were male, while about 17% were female.

Table 2: Frequency Distribution Table Showing Sex of Root-vegetables Growers

Sex	Frequency	Percent
Female	14	11.67
Male	106	88.33
Total	**120**	**100**

Source: Field data (2020).

The results in Table 3 show that about 41.67% of root-vegetables growers were from Tumati and Yaeda Ampa wards; while 16.67% were from Bashay ward. This corresponds to 50 root-vegetables growers from Tumati, 50 root-vegetables growers from Yaeda Ampa, and 20 root-vegetables growers from Bashay.

Table 3: Frequency Distribution Table Showing Residence Ward of Root-vegetable Growers

Ward	Frequency	Percent
Bashay	20	16.67
Tumati	50	41.67
Yaeda Ampa	50	41.67
Total	**120**	**100**

Source: Field data (2020)

Again, Table 4 shows that about 19.17% of root-vegetables growers had no formal education; while about 53.3% had primary school education; and 27.5% growers had secondary school level education or higher. This corresponds to 23 root-vegetables growers who had no education, 64 root-vegetables growers who had primary school education, and 33 root-vegetables growers who had secondary school education or higher. In a study on the determinants of rural income in Tanzania, Aikaeli (2010) found that 16.2% of household heads in rural areas had no formal education, 69.5% had primary school education, and 14.3% had secondary school education or higher.

Table 4: Frequency Distribution Table Showing Education Level of Root-vegetable Growers

Education	Frequency	Percent
No Education	23	19.17
Primary education	64	53.33
Secondary education or higher	33	27.5
Total	**120**	**100**

Source: Field data (2020)

Moreover, Table 5 shows that about 78.3% of root-vegetables growers were using bicycles as means of transport, while 21.61% were using motor vehicles. This corresponds to 94 root-vegetables growers who used bicycles, and 26 who used motor vehicles. According to the NBS (2021), about 41.8% of agricultural households in Tanzania own a bicycle as an asset, compared to 2.6% agricultural households, which own a vehicle as an asset during the 2019/20 agricultural year.

Table 5: Frequency Distribution Table Showing Transport Facility of Root-vegetable Growers

Transport Facility	Frequency	Percent
Bicycle	94	78.33
Motor vehicle	26	21.67
Total	**120**	**100**

Source: Field data (2020)

The results in Table 6 shows the mean experience of a root-vegetables growers was 4.49 years; and lies between 2–11 years. The mean farm area was 0.15ha; with a maximum of 0.41ha, and minimum of 0.02ha. Also, the mean labour time was 124.38 man-days; with a maximum of 258 man-days, and a minimum of 81 man-days. The mean input cost used was TZS165,062.50; with a maximum of TZS525,000, and a minimum of TZS44,000. Also, the mean equipment cost used was TZS143,633.30; with a maximum of TZS643,000, and a minimum of TZS22,000.

Ali et al. (2019) found that the average labour time for tomato growers in Peshawar district was 54.8 man-days, ranging from 51–58 manual days. Katepan et al. (2017) established that the man-time required in okra production in Nakhon Pathom province, Thailand, was between 1 year and 15 years. On their part, Akamin et al. (2017) observed that, on average, farmers spent about 131 man-days on their vegetable farms (0.53 ha on average), and each farmer used approximately 37,000 CFA Francs worth of equipment during the farming period under consideration.

Table 6: Summary of Statistics for the Quantitative Data Variables

Variable	Mean	Std. Dev.	Min	Max
Experience	4.49	1.67	2	11
Farm area	0.15	0.11	0.02	0.41
Labour	124.38	37.11	81	258
Input cost	165,062.50	891,46.93	44,000	525,000
Equipment cost	154,383.30	157,616.70	22,000	643,000

Source: Field data (2020)

Likewise, the results presented in Table 7 show the mean sales of root-vegetables in the study area was TZS1,565,367; with a maximum of TZS4,510,000, and a minimum of TZS247,500 for carrots. For potatoes, Table 7 show the mean sale by root-vegetables growers was TZS942,000; with a maximum of TZS2,820,000, and a minimum of TZS150,000.

Table 7: Summary Statistics for Income Obtained by Sales of Carrot and Potato

Variable	Unit	Obs.	Mean	Std. Dev.	Min	Max
Sales of carrots	TZS	75	1,565,367	1,215,926	247,500	4,510,000
Sales of potatoes	TZS	45	942,000	627,214.6	150,000	2,820,000

Source: Field data (2020)

4.2 Factors Influencing Production of Root-vegetables

4.2.1 Factors Influencing the Production of Carrots

Table 8 presents OLS estimates for parameters of the Cobb-Douglas production function for carrots. The results show that farm area and input cost were significant factors influencing the production of carrots; with p-values of 1% and 10% levels, respectively.

In addition, the results show that the model was highly significant in estimating the factors influencing the production of carrots. Again, the Cobb-Douglas production function for carrots showed that the value of multiple determinations (R^2) was 0.9909. This implies that 99.09% of the total variation in the dependent variable (output) is explained by variation in the independent variables included in the model**.**

Also, the results in Table 8 show that the coefficient value for farm area was 0.91, which is positive and significant at a p-value of 0.01. It means that for every 1% increase in farm area, production output will increase by 91%. This implies that the area was fertile, and also conditions allowed for good production since the area had running water from rivers that was used for irrigation throughout the year. Similarly, land has a significant contribution to production output (Chisasa, 2014).

Table 8: OLS Estimates for Parameters of the Cobb-Douglas Production Function for Carrot

Lnoutput	Parameter	Coefficient	Std. Err.	t
Lnfarmarea	$\beta 1$	0.91***	0.03	34.31
Lnlabour	$\beta 2$	-0.05	0.06	-0.93
Lninputcost	$\beta 3$	0.14*	0.05	2.84
Lnequipmentcost	$\beta 4$	0.01	0.03	0.46
Constant	$\beta 0$	8.11***	0.59	13.75

Note: Significance levels of 1%, 5%, and 10% are indicated by ***, **, and * respectively. R^2 = 0.9909; Adjusted R^2 = 0.9904

Source: Field data (2020)

Also, the results in Table 8 show that the coefficient of input cost was 0.14, which was positive and significant at p-value of 0.1. This implies that for every 1% increase in input cost, the production output increased by 14%. But this increase could be due to efficient usage of inputs (that is seed, fertilizers and pesticides). Most of the studies conducted had used variables like seed, fertilizers and pesticides separately as inputs. Ningsih (2016) found that seed and pesticide were statistically significant, while fertilizer was not statistically significant.

Return to scale gives the value of 1.01, indicating increasing returns to scale. This suggests that, doubling inputs (farm area, labour, input cost and equipment cost) will more than double outputs. This implies that root-vegetables growers should efficiently use inputs to increase outputs.

4.2.2 Factors Influencing Production of Potatoes

Table 9 presents the OLS estimates for parameters of the Cobb-Douglas production function for potatoes. The results showed that the estimated coefficients of the variables of the production function were all statistically significant. Farm area and equipment cost were statistically significant at 1% level, input cost was statistically significant at 5% and labour at 10% levels.

Table 9: OLS Estimates for Parameters of the Cobb-Douglas Production Function for Potato

Lnoutput	*Parameter*	Coefficient	Std. Err.	t
Lnfarmarea	β_1	0.91***	0.05	18.68
Lnlabour	β_2	0.16*	0.10	1.72
Lninputcost	β_3	0.18**	0.08	2.31
Lnequipmentcost	β_4	-0.04***	0.01	-3.22
Constant	β_0	6.62***	1.09	6.05

Note: Significance levels of 1%, 5%, and 10% are indicated by ***, **, and * respectively. R^2 =0.9878; Adjusted R^2 = 0.9866

Source: Field data (2020)

Also, results showed that the model was highly significant in estimating factors influencing the production of potatoes. Also, the coefficient of multiple determinations (R^2) is 0.9878. This implies that 98.78% of the total variation in the dependent variable (output) is explained by variation in the independent variables included in the model. This implies that the model was fit for the data.

The results presented in Table 9 further show that the coefficient value for farm area was 0.91, which was positive and significant at a p-value of 0.01. This implies that for every 1% increase in farm area, the production output increases by 91%. This could be due to the area being fertile, and other conditions allowing for good production. This result is in line with a previous study by Ahmed et al. (2018), which found that farm size was a significant determinant of production levels.

Also, the results in Table 9 show that the coefficient value of labour was 0.16, which is positive and significant at a p-value of 0.1. This implies that for every 1% increase in labour man-day, production output increases by 16%. This could mean that root-vegetables growers were utilizing labour efficiently. This result also conforms with the study conducted by Ali et al. (ibid.), which found that labour significantly affects tomato yield.

Furthermore, the coefficient of input cost was 0.18, which was positive and significant at a p-value of 0.05. Therefore, for every 1% increase in input cost, the production output increases by 18%. However, this increase could be due to the efficient usage of inputs. Most of the studies conducted used variables like seed, fertilizer and pesticides separately as inputs. Ogunmodede and Awotide (2020), for example, found that seeds and pesticides were significant factors, while fertilizer was not a factor to explain farm production.

Again, the coefficient value of equipment cost was -0.04, which was negative and significant. This implies that for every 1% increase in equipment cost, production output decreases by 4%. However, Akamin et al. (2017) found that equipment cost positively influenced vegetable production. Hence, potato growers need to plan for optimal utilization of equipment.

Return to scale gives the p-value of 1.21, indicating increasing returns to scale. This suggested that doubling inputs (farm area, labour, input cost and equipment cost) will more than double outputs. It means that root-vegetables growers should efficiently use inputs to increase outputs.

4.2.3 Factors Influencing Income Obtained Through Production of Root-vegetables
Results in Table 10 indicates that the income of root-vegetables growers decreased significantly with the production of potatoes compared to the production of carrots (p-value = 0.01). This implies that farmers need to plan for profitable crop production so as to generate income for household expenditure, and for savings. Poon and Weersink (2011) found that potatoes significantly influence farm income. Also, the results in Table 10 show that with a unit increase in farm area, the income of a root-vegetables grower increases by 9,294,759 units, hence farm area was a significant factor that positively influenced the income of root-vegetables growers, with a p-value of 0.01. This implies that there is a need to optimize the utilization of farm area to improve income. Studies by Bassa et al. (2017), Fadipe et al. (2014), Regassa (2016) and Qasim and Knerr (2013) found that farm area was a significant factor that influenced the income of vegetables growers.

Table 10: Factors Influencing Income Obtained Through Root-vegetables Production

Dependent variable: Income	Coefficient	Std. Err.	t
Potatoes	- 622,660.6***	42,580.4	-14.62
Experience	-6285.32	13,513.59	-0.47
Farm area	9,294,759***	207,066.3	44.89
Constant	189,523***	62,567.94	3.03

Note: Significance levels of 1%, 5%, and 10% are indicated by ***, **, and * respectively. R^2 = 0.9572; R = 0.9784; Adjusted R^2= 0.9561.
Source: Field data (2020)

5. Conclusions and Policy Implications

This study examined factors that influenced the production of root-vegetables and income obtained from production in Mbulu District. The study used cross-sectional data, and employed the Cobb-Douglas production function and regression model. The findings showed that farm area and inputs cost were significant factors that influenced the production of carrots; while farm area, labour, input cost, and equipment cost were significant factors that influenced the production of potatoes. On the other hand, the findings showed that income of root-vegetables growers decreased significantly with the production of potatoes; compared to the production of carrots. Also, the findings revealed that the income of growers of root-vegetables increased significantly with farm area. Therefore, the government of Tanzania, through the Ministry responsible for agriculture, needs to offer agricultural extension services regarding optimal utilization of farm area, labour, material inputs, and equipment to broaden farmers' understanding and practices towards optimal production of root-vegetables.

Acknowledgement
The authors acknowledges the support from Prof. M. Mbonile, Prof. G. Nyamubi, Advocate W.S. Ntiro, and the staff at the Eastern Africa Statistical Training Centre for their valuable comments.

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