UNFOLDING FACTORS INFLUENCING PINEAPPLE PRODUCTION: EMPIRICAL EVIDENCE FROM BAGAMOYO IN TANZANIA

Isaka Kasyupa, Bahati Ilembo
Mzumbe University, Tanzania
kasyupaisaka@gmail.com
bmilembo@mzumbe.ac.tz

Abstract: *This paper examined factors that influence pineapple production in Bagamoyo using cross-sectional data collected during the harvesting season of 2023/2024. A sample of 150 smallholder pineapple farmers was randomly selected using a systematic random sampling procedure. We used the Ordinary Least Squares with a Cobb- Douglas function to estimate the parameters after log- linearize the Cobb- Douglas function. The coefficient of determination* $R^2 = 0.81$ *showed that the explanatory variables were fit for the model as 81% of the variation in the production of pineapples is explained by the selected seven factors. Further results revealed that out of the seven predictors, labour, age and farming experience were statistically significant (p-values: 0.000, 0.003 and 0.000) respectively, all of which the p-value was less than a 5 per cent level of significance. The other variables namely education level, soil quality, technology use and farm size were insignificantly explaining pineapple production. We conclude that labour (family and hired), age and farming experience are positively correlated to the quantity of pineapple production. We recommend that the policy on agriculture should insist on the provision of extension services to be offered timely to ensure quality yield for both local consumption as well as exports. Encouraging exports through promotion to address the challenge of untapped potential for exports of the pineapple which in turn encourages production and lastly, investment in agricultural research would steer up the need for further research into pineapple seed breeding, pest control and post-harvest technology. Such initiatives would promote crop production and thereby improve the livelihood of the smallholder farmers.*

Keywords: Cobb-Douglas, Ordinary Least Square, Pineapple, Bagamoyo
JEL CLASSIFICATION: Q1, O13, M21

1. Introduction

Ananas Comosus is among the cultivated crops in the Sub- Saharan Africa and Tanzania is ranked 18th in the list of top 20 pineapple-producing countries (Worldatlas, 2025). It is a tropical and economic fruit with encouraging market potential in the global market (Shelindina et al. 2023; Jaji, Man and Nawi, 2018; Hemalatha & Anbusehi, 2013). According to Akrong et al. (2022), pineapple is an important horticultural export as well as a cash crop which creates employment opportunities among the rural population. Further, pineapple is one of the most beloved tropical fruits in the world offers significant health benefits and is rich in vitamin C, B vitamins, fibre, and minerals (Firatoiu et al. 2021). In Tanzania, the *ananas comosus* is an important fruit crop (Makaranga et al. 2018) and its production is expanding rapidly with an increasing tendency toward commercial cultivation through the

* Corresponding author: Bahati Ilembo
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expansion of existing farms and the opening of new farms. This trend has been caused by increased demand for pineapple in local and internal markets particularly in the Middle East. The origin of pineapple has been traced back to Brazil and Paraguay in the Amazon basin where the fruit was first domesticated (Collins, 1949). There is evidence that pineapple cultivation provides sustainable livelihood to many smallholder farmers in developing countries (Campıta, Tokuda and Sales, 2022) and has gained global popularity as both a delectable fruit and a versatile ingredient in culinary delights with its vibrant taste and rich nutritional content make it a sought-after delight among consumers worldwide (Shelindina et al., 2023). Commercial production of pineapples in Tanzania is limited due to many challenges such as difficulty in obtaining high-yielding, uniform and disease-free planting materials in large quantities and lack of reliable markets. The low yield is partly due to the slow rate of pineapple multiplication by conventional methods and the lack of high-quality seeds. Pineapple production in the Bagamoyo district still uses traditional farming and no evidence that farmers apply fertilizers or agro-inputs. Consequently, the production volume has not been stable. Even though Tanzania is gifted with enough productive arable land, varied climatic zones and a bounty of water sources all across the country, the production of pineapple and its contribution to the country's economy is still petty. There are several factors for the unstable pineapple production mostly farm size, number of farm labour, seed, fertilizer, and experience in the farming system (Ariani and Tanjung, 2024; Ojeyele, 2021; Ria, Wiludjeng and Mulyatno, 2021; Akhilomen et al. 2014). Also, access to markets, cost of inputs and transportation and cost of labour, influenced the pineapple production (Haji and Babune, 2023).
Despite its economic importance, the production of pineapple in the study area has been low and as such, influences the ability of smallholder farmers to maximize the potential opportunities and enjoyable socio-economic benefits of pineapple farming in the area. Also, existing studies on pineapple production in Tanzania (Magasha, Alex & Mlage, 2025; Haji & Babune, 2023; Makaranga et al. 2018; Bakewell- stone, Lieblein & Francis, 2008) focus on a narrow set of regions, leaving out important pineapple-producing areas like Bagamoyo. As a result, a broader understanding of the regional differences in pineapple cultivation and challenges might be lacking given the significance and the potential of Bagamoyo in the pineapple production. This paper is set to examine the factors influencing pineapple production in Tanzania, using Bagamoyo as a case study. Bagamoyo is chosen due to its predominance in pineapple production as a result of a combination of favourable climatic conditions, market accessibility and agricultural tradition. Thus, the findings will be used to generalize to other areas in the country and subsequently to all other areas with similar characteristics regarding weather, soils, and other climatic conditions. The paper is organized as follows; section 2 is on materials and methods while section 3 is on results and discussion. Section 4 concludes and section 5 gives the policy implications.

2. Materials and Methods

2.1 Data, Sampling and Sample Size

The study used primary data that were collected from 150 pineapple smallholder farmers in Bagamoyo. Precisely, data were collected from the most pineapple-producing area in the district, namely Kiwangwa, having a population of 25,997 according to population and housing census of 2022 (NBS, 2022). The data collected were for the 2024/2025 production season. The pineapple farmers were selected using a systematic random sampling procedure after a list of smallholder pineapple farmers was made available. Farmers were listed in some order to make it possible to randomly select the desired sample size. The area of study is shown in Figure 1 underneath.

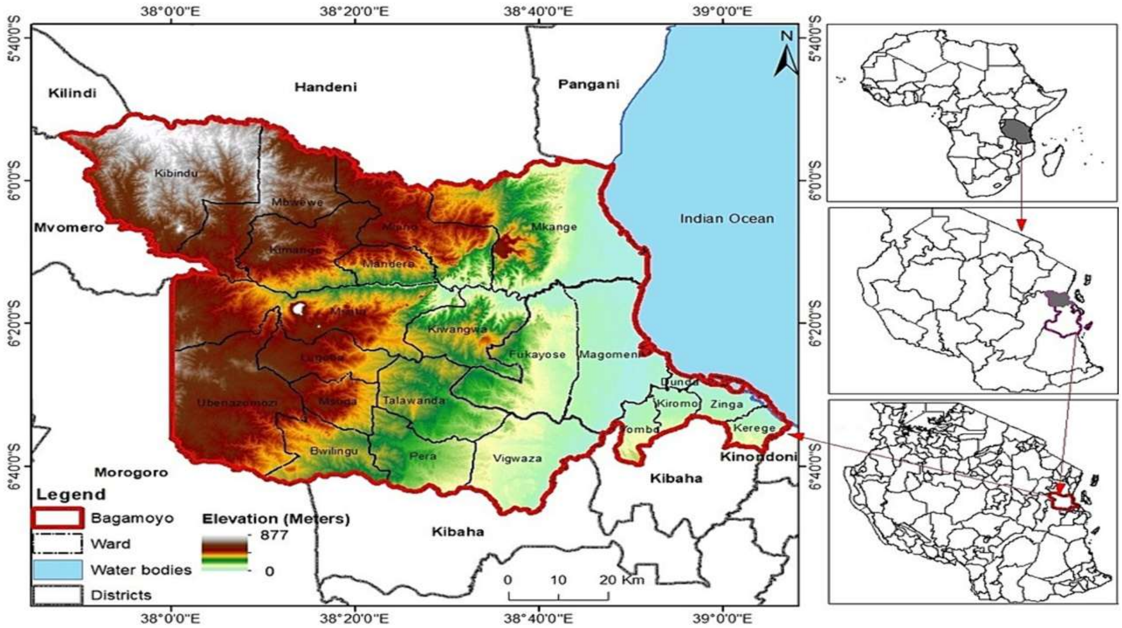

Figure 1: Bagamoyo district map
Souce: Adapted from Mugabe et al. (2024)

Figure 1 shows the Bagamoyo district and its location. It is one of eight administrative districts of the Coastal Region in Tanzania. The district covers an area of 945 km^2. The district is surrounded by the Chalinze District to the north and west, the Zanzibar Channel to the east, the Kibaha District to the south, and the Kinondoni District to the southeast in the Dar es Salaam Region. The district is comparable in size to the land area of Turks and Caicos Islands. As of 2022, the population of Bagamoyo district is 205,478. The area has potential for pineapple production. The area is characterized by a warm and humid tropical climate, which is ideal for growing pineapples. The fruit thrives in regions with temperatures between 20°C and 30°C (68°F - 86°F), which is characteristic of many coastal areas in Tanzania, including Bagamoyo. Also, having well-drained soils provides a conducive environment for pineapple cultivation. The region's soils are generally rich in nutrients and can support the growth of pineapples without significant irrigation.

2.2 Production Theory

Production is the process of transforming inputs into outputs (Jehle and Reny, 2011). The fundamental reality that must be contended with in this process is technological feasibility. The state of technology determines and restricts what is possible in combining inputs to produce output, and there are several ways this constraint can be represented. According to Jehle and Reny (2011), the most general way is to think of the production unit as having a production possibility set, where each vector is a production plan whose component indicates the amounts of the various inputs and outputs. The advantage of the production possibility set is by far the most general way to characterize any production unit’s technology because it allows for multiple inputs and multiple outputs. In our case, we consider a farm producing only a single output from many inputs. For this reason, we describe the farm’s technology in our case in terms of a production function.

Let a production technology utilize a vector of inputs denoted by $X = (X_1, ..., X_n) \in \Re_+^n$ to produce a non-negative vector of outputs denoted by $y = (y_1, ..., y_m) \in \Re_+^m$. The production possibility set of a given production unit is a subset of Z of the space $\Re_+^{m+n}$. A production unit may select any input-output configuration $(x, y) \in Z$ as its production plan. The production possibility set is the collection of all feasible input and output vectors and it is represented as $Z = \{(y, x) : x \ \ can \ produce \ \ y\} \subset \Re_+^{m+n}$ Eq1

Furthermore, according to Fare et al (1994) production possibility set can be represented by an input requirement set $F(y)$ or output producible set $G(x)$. The input requirement set represents the collection of all input vectors $x = (x_1, x_2, ..., x_n) \in \Re_+^n$ that yield at least output vectors $y = (y_1, y_2, ..., y_m) \in \Re_+^m$ which can be represented as;

$$F(y) = \{x : (x, y) \ is \ \ feasible\} \qquad \text{Eq. 2}$$

The output producible set is the collection of all output vectors $y = (y_1, y_2, ..., y_m) \in \Re_+^m$ that are produced from the given input vector $x = (x_1, x_2, ..., x_n) \in \Re_+^n$, which can also be represented as; $G(x) = \{y : (x, y) \ is \ \ feasible\}$ Eq. 3

2.3 The model

This study used the Ordinary Least Squares with a Cobb- Douglas function to estimate the parameters after log- linearize the Cobb- Douglas function. The mathematical form of the Cobb-Douglas production function is given by $Q = AL^{\alpha}K^{\beta}$, whereby Q is the output, A is the technology used in the production of the output, L is the labour input and K is the capital input. The parameters α and β are elasticities. There are several functional forms for estimating the physical relationship between inputs and outputs. However, if there are three or more explanatory variables in the model, the Cobb- Douglas functional form is still preferred (Hanley and Spash, 1993). In his paper while arguing a case for Cobb-Douglas production function, Murthy (2002) found that apart from its capability to handle multiple inputs in its generalized form, the function does not even introduce distortions of its own in the face of imperfections in the market. The production function of any farmer is determined by the resource availability of a farmer. A basic form of a production function is given by $Q = f(L_d, K, L)$, where Q is the production output, which is a function of land (L_d), the capital, $K$and labour force (L), used for the production of the same output. In our case, the output is pineapple production while the inputs becomes labour, farm size, farming experience, farming technology, age, soil quality and education, the factors which are hypothesized to influence pineapple production. Other merit of the Cobb- Douglas function is its capability in handling various econometric estimation problems such as serial correlation, heteroscedasticity and multicollinearity in an easy and adequate manner. It is further argued that the Cobb-Douglas function facilitates computations and has the properties of explicit representability, uniformity and flexibility. Also, the elasticities of individual inputs can be easily obtained, read and interpreted. Thus, to determine the factors that influence the production of pineapple, the following functional relationship was specified and empirically, the linearized Cobb – Douglas model of unknown parameters is presented as follows:

$$In\,Y = In\beta_0 + In\beta_1 x_1 + In\beta_2 x_2 + In\beta_3 x_3 + In\beta_4 x_4 + In\beta_5 x_5 + In\beta_6 x_6 + In\beta_7 x_7 + \varepsilon_i$$

Where:
Y = Pineapple output in kgs
x_1 = labour; x_2 = farm size (ha); x_3 = farming experience; x_4 = farming technology

x_5 = Age; x_6 = soil quality; x_7 = education; ε_i = Error term
ln = natural logarithm
$\beta_1 to\ \beta_7$ are Coefficient parameters to be estimated

Table 1: Variables in the model and their description

Variable	Description	Expected sign
Pineapple output (kgs)	The amount of pineapple harvested in the 2017/2018 season	
Labour (family and hired)	The number of family members and hired workers who are involved in all of the pineapple farming activities.	+
Farm size	The size in acres of the pineapple farm	+
Farming experience	The number of years (s) in the pineapple production	+
Technology used	Dummy variable for the type of technology used by a farmer (1= if modern technology; 0= if otherwise)	+
Age	The age (in years) of the pineapple farmer	+
Soil quality	Dummy variable on the influence of soil quality on pineapple production (1=if yes; 0=if otherwise)	+
Education level	Dummy variable for education level of pineapple farmer (1= no formal education, 2= primary education, 3= secondary education and 4= tertiary education)	+

Source: Created by author (s)

3. Results and discussion

3.1 Pineapple Production in Tanzania

December is the season for pineapple harvest in Tanzania. The pineapple took a total of 18 months from planting to harvest and between this season, there is a weeding eight times. One acre that is well-kept yields an average of 20,000 pineapples equivalent to 50 tons. Over the ten years (2014- 2023), pineapple production has not been stable to establish a significant change. However, in general, the production has been insignificantly increased throughout the years as shown in Figure 2. For example from 2014 to 2018, there was no significant change in the production until 2019 when it started to increase towards 2022. In 2023 there was a declining production though not significant.

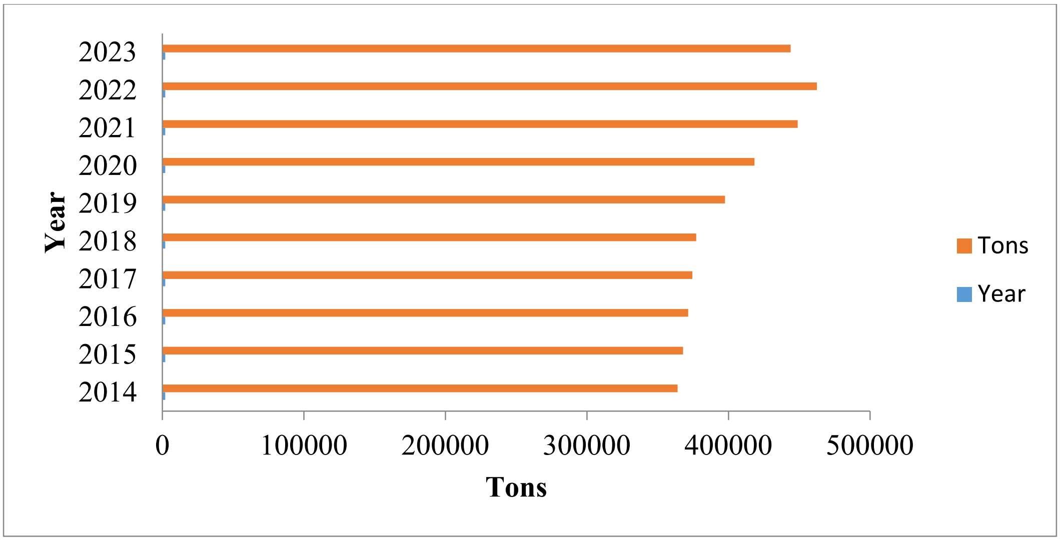

Figure 2: Trend of pineapple production (2014- 2023)
Source: Extracted from FAOSTAT (2025)

Further, both the production, area harvested and yield (kg/ha) show an increasing trend but at a slow pace and suggest that there is hope for sustainable growth in crop production in the future years, if measures are taken to address the production challenge. Table 2 shows the annual changes in production, area harvested and yields.

Table 2: Production, harvested areas and average yield in Tanzania

Year	Production	Area harvested(ha)	Yield (kg/ha)
2014	364178.88	15500	23495.4
2015	367927.39	14845	24784.3
2016	371483.7	15242	24372.8
2017	374543.39	15619	23979.4
2018	377257.3	15939	23668.2
2019	397658.04	17014	23372.2
2020	418498.21	17212	24313.7
2021	448885	18476	24295.8
2022	462512.51	18969	24383
2023	443910.5	18136	24477.2

Source: Extracted from FAOSTAT, 2025

It is evident from Table 2 that the production, though increasing over the years, the pace is too slow than expected, given the available production opportunities in the area. It is for that reason this study is set to examine the factors influencing the pineapple production in the area.

We begin the analysis by providing the technical considerations that paved the leeway to perform the econometric model analysis. In all the families of regression models, it is inappropriate to enter into the same regression model predictors which are highly correlated with each other. It also makes modest sense to include independent variables in the model that are highly correlated, as they would not be making an exceptional contribution to the regression model. This is because of the danger that they will mask each other's effects. If the variables are highly correlated among themselves, the predictive power of the predictors will obscure the predictive power of the response variable. While we recognize that there is a possibility of having very high multicollinearity (sometimes perfect multicollinearity) even if the coefficients of correlation between all pairs of variables are not very high, it was important to check for the presence of multicollinearity before embarking on modelling so that to have a prior determination of the behavior of explanatory variables to be included in the model. The dependent variable used was the quantity (in kgs) of the pineapples produced in the 2023/2024 harvest season, while the independent variables were age, education, farm size, soil quality, farming experience, technology use and labor. Table 3 shows the results of the diagnosis checks of the multicollinearity using a correlation matrix.

Ta**ble 3:** Correlation analysis for multicollinearity test

Variables	Pearson correlation coefficient	Sign.
Labor		
(a) Farm size	0.843**	0.000
(b) Experience	0.129	0.114
(c) Technology used	0.104	0.205
(d) Quantity of fertilizer used	0.858**	0.000
(e) Age	0.373**	0.000
(f) Soil quality	0.009	0.914
(g) Educational level	0.027	0.739
Farm size		
(a) Experience	0.283**	0.000
(b) Technology used	0.103	0.212
(c) Quantity of fertilizer used	0.965**	0.000
(d) Age	0.538**	0.000
(e) Soil quality	-0.002	0.980
(f) Educational level	-0.091	0.266
Experience		
(a) Technology used	-0.057	0.489
(b) Quantity of fertilizer used	0.318**	0.000
(c) Age	0.367**	0.000
(d) Soil quality	-0.005	0.949
(e) Educational level	0.153	0.062
Technology used		
(a) Quantity of fertilizer used	0.107	0.192
(b) Age	0.036	0.660
(c) Soil quality	0.010	0.908
(d) Educational level	0.018	0.824
Quantity of fertilizer used		
(a) Age	0.521**	0.000
(b) Soil quality	-0.004	0.958
(c) Educational level	-0.038	0.642
Age		
(a) Soil quality	-0.013	0.871
(b) Educational level	-0.298**	0.000
Soil quality		
(a) Educational level	0.068	0.409

** means the correlation is significant at 0.01 level (2-tailed)
Source: Created by author (s)

It was imperative to check whether the independent variables used in the model were highly correlated among themselves so that they would not create an endogeneity problem. According to Foster et al. (2006), multicollinearity is shown by low tolerance; a tolerance of 1 indicates that a variable is not correlated with others, and a tolerance value of 0 shows a perfect correlation. Also, another index that can be used is the Variance Inflation Factor (VIF) a value of 2 for VIF shows a close correlation, and a value of 1 shows little correlation. Both the tolerance and VIF should be in the region of 1. The multicollinearity test suggested that two variables (farm size and quantity of fertilizer used) should be dropped from the analysis as shown in Table 4 since they have the VIF beyond the accepted range.

Table 4: Collinearity statistics (Tolerance and VIF)

Independent Variable	**Tolerance**	**VIF**
Age	0.571	1.752
Education level	0.780	1.282
Soil quality	0.994	1.006
Experience	0.701	1.426
Technology type	0.977	1.023
Labour (family and hired)	0.230	1.355
Farm size	0.063	15.798

Variance Inflation Factor (VIF) was high and more than 10 for the variables farm size and quantity of fertilizer causing multicollinearity between the two. In the presence of multicollinearity, the variables concerned may not reveal their significant influence as they mask the effect of each other, hence leading to imprecise estimates that affect the predictive power of the model. According to Gujarati (2014), the solution to the problem is to drop them, even though when the multicollinearity is moderate it can be tolerated. The decision applied to solving the multicollinearity problem is to look at the value of VIF if exceeding 10 and at the same time, the Tolerance value is closer to zero. (Gujarati, 2014: pp.362-363, 372).

3.2 The model estimations

Overall, the goodness-of-fit test revealed that the model fits the data (F- value =101.364, p-value= 0.000) at a 5% level of significance, implying that the explanatory variables are determinants of the response variable and can thus be used to explain the influence of the predictors to the response variable. Also, the coefficient of determination was 0.810 (81%) indicating that 81 per cent of the variation in the production of pineapple, is explained by the selected factors. It can be concluded that the explanatory power of the multiple linear regression model is satisfactory and thus the model can be used to explain the factors that affect pineapple production. The variables that were included in the model are; age, labor, farming experience, education level, soil quality, and technology used. The estimated coefficients are presented in Table 5.

Table 5: Estimated Coefficients for Multiple Regression Model

Variables	Unstandardized Coefficients β	Std Error	Standardized Coefficient Beta	t	Sig.
Constant	-589.504	8470.818		-0.070	0.945
Age	451.793	105.900	0.197	4.266	0.000*
Education level	-2062.473	1249.202	-0.067	-1.651	0.101
Soil quality	-2564.562	6995.978	-0.013	-0.367	0.714

Farming experience	352.982	118.516	0.123	2.978	0.003*
Technology used	1929.346	4996.041	0.014	0.386	0.700
Labour	2671.912	139.107	0.769	19.208	0.000*

Note: (*) Indicates Significant at 5% level.
R = 0.900 R^2 = 0.810 Adjusted R^2 = 0.802 F = 101.364 statistically significant at $p<0.05$
Source: Created by author (s)

Table 5 shows that the coefficients for variables age, farming experience and labour were all positive and significant. The positive sign implies the positive relationship between each of these variables with the pineapple production., any unit increase of either of the variables will result in an increased pineapple production by some amount. Being significantly influencing the production of the pineapple means there is a close causal-effect relationship with the dependent variable which is pineapple production. The significance is shown by the p- values 0.000, 0.000 and 0.003 for age, farming experience and labour respectively all of which are less than the 5% level of significance. The coefficients for the other variables, namely education level and soil quality were negatively related to pineapple production meaning that when each of these increases, pineapple production decreases and vice versa though were all insignificant. Similarly, the technology used was insignificant even if having a positive sign. The insignificance of the other variables might have been attributed to a lack of variation in the data collected. For example, if education levels are uniformly high or low in the study area, the variability needed to establish a relationship with pineapple production may not be present. Similarly, if all the soil in the region is of similar quality, the variable soil quality would not show significant variation to explain production differences. The insignificance of soil quality is contrary to Verhulst et.al (2010) who contended that high soil quality equates to the ability of the soil to maintain high productivity. Similarly, regarding education, the literature suggests that education is important and significantly increases production (Ninh, 2021; Eric, Prince & Elfreda, 2014), helps manage the farms and combine inputs in a better way. Unfortunately, this is contrary to the findings in this study. Further, age is positively influencing pineapple production indicating that a year increase in age of a pineapple farmer would increase production by 452kgs times, ceteris paribus. The finding is consistent with Mamuye (2016) who concluded that younger farmers are less productive than older farmers. This result is also consistent with the findings by Anigbogu et. al. (2015) in that age is among the socioeconomic factors influencing agricultural production among cooperative farmers in Nigeria.

Labour is one of the most important factors of production. The study revealed that the amount of labour used in pineapple production had a statistically significant influence on pineapple production. The positive coefficient means when all other factors are held constant, an increase in the number of labourers hired or family labour would increase pineapple production by 2671.912 Kgs which is consistent with Ojeleye (2021) and Akhilomen et al. (2014) in their studies on profitability assessment of pineapple production and economic efficiency analysis in pineapple production respectively.

The experience that the farmer has in farming activities is a determinant of increased agricultural output. In this study, we found that farming experience has a significant influence on pineapple production. The positive sign coefficient means that, under *ceteris paribus*, an additional year in the farming experience increases the amount of pineapple production by 352.982 Kg. This result is consistent with Ria, Wiludjeng & Mulyatno (2021); and Abdulai et al. (2013) who found that the experience that the farmer has, positively determines crop production. Further, Abdulai et. al. (2013) stressed that farmers with many years of experience were more technically efficient than those with few years of experience.

4. Conclusion

This study examined factors influencing pineapple production in Tanzania using estimated results from the Cobb- Douglas function. The results show that out of seven predictor variables used, three were statistically significantly influencing pineapple production and are namely, age, labour and farming experience while four variables namely farm size, soil quality, farming technology and education level of the farmer were statistically insignificant. Despite available literature on factors affecting horticulture crop production, little has been documented specifically in the pineapple production of which this study tried to fill this gap. This opens up another investigation avenue to further include variables other than the ones used in this study in examining factors influencing pineapple production in other areas not covered by the present study.

5. Policy Implications

There are various policy interventions given the state of the art of pineapple production in the study area and that can be generalized to other production places. It is also evident from the statistics that the production of pineapple, even though shows a non-decreasing trend, but the increase over time is too slow. To stimulate production, the agricultural policy may provide incentive packages to smallholder farmers in the area to better access inputs such as seeds, fertilizer, as well as extension services to improve their production, productivity and profitability. The policy could also insist on the provision of extension services to be offered timely to ensure quality yield for both local consumption as well as exports. Encouraging exports through promotion to address the challenge of untapped potential for exports of the pineapple which in turn encourages production. Lastly, investment in agricultural research would steer up the need for further research into pineapple seed breeding, pest control and post-harvest technology. Such initiatives would promote crop production and thereby improve the livelihood of the smallholder farmers.

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Bio-note

Bahati Ilembo is a lecturer in the Department of Mathematics and Statistics Studies and teaches mainly statistics and quantitative techniques. He holds both a Bachelor's and Master's degrees in Statistics and a PhD in the areas of agricultural economics. His areas of research have been mainly statistical applications to agriculture, development economics and social science in its broad sense. He has published in the areas of applied statistics and agricultural economics in both journal articles and book chapters.

Isaka Kasyupa is a former master’s student supervised by Dr. Ilembo in the area of Applied Economics and Business. He graduated from the Department of Business Studies and currently working as a banker in the Corporate Rural Development Bank PLC in Tanzania.