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Gender Differences in Banana Productivity in Tanzania

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Abstract: Banana is one of the key crops produced by farmers in Tanzania. The productivity of bananas among smallholder farmers is very low. One of the core reasons for this lower agricultural productivity in Tanzania is gender inequality in production. This study aimed to establish gender productivity differences in banana production in Tanzania. The study used panel data and a correlated random effects (CRE) model to determine these differences. It finds a 19% difference in banana productivity in favour of male managers, highlighting their (plot managers') characteristics, input use, and banana plot characteristics. The area of banana cultivation by zones, namely Lake, Northern, Southern Highlands, and Eastern zones, was found to increase banana productivity. The use of organic fertiliser and receiving government extension services have a positive influence on banana productivity. On the other hand, being a female manager, an increase in banana plot area, and an increase in the usage of pesticides have a detrimental effect on banana productivity. The findings of this study suggest the need for proper banana plot management, farmer training on skills such as the timing and amount of inputs that can be applied to banana plots sustainably, and the availability of extension services to all plot managers, regardless of their gender. Additionally, the study advocates for the sustainable use of pesticides by adopting good agricultural practices like Integrated Pest Management (IPM) and using appropriate planting materials that are disease-resistant.

Keywords: Gender differences, banana, productivity differences, panel data, correlated random effect.

1. Introduction

Bananas are an important staple food for many people around the world. They, along with plantains, rank among the top ten crops globally, positioned behind maize, rice, wheat, cassava, and potatoes, but ahead of sorghum, millet, and sweet potatoes. The crop serves as a source of income, food supply, and dietary diversity for millions of rural and urban households (Calberto et al., 2015). In developing countries, bananas are the fourth most important crop in terms of production, following rice, wheat, and maize (Sipen et al., 2011). Bananas are also a major export crop for countries like Ecuador and Costa Rica, generating income and employment for millions of households in those regions (Ferreira et al., 2018).

In 2018, approximately 155 million metric tons of bananas and plantains were produced worldwide, with 27% sourced from Sub-Saharan Africa (SSA) (FAOSTAT, 2020). The majority of this production in SSA comes from small plots and backyard gardens (Marimo et al., 2020). The highest per capita consumption of bananas in the world occurs in the East African highlands, where one-third of the population depends on this crop as a staple food. In this region, bananas occupy between 20% to 30% of the acreage under cultivation (Karamura et al., 2012). In Tanzania, around 60% of the total banana output is consumed at households, either cooked or ripened as dessert, while the remaining 40% is sold or given to friends and relatives as handouts (Kilimo Trust, 2015). It is reported that over 60%

of bananas are grown in the Kagera and Kilimanjaro regions, where this crop is a staple food for 75-95% of the population (Kilimo Trust, 2012).

The demand for bananas in Tanzania is increasing in markets as well as at the household consumption level due to a growing population, urbanisation, and changing consumer habits. The rise in banana demand is also linked to the crop's status as a staple food for a large portion of the population. As a perennial crop, bananas are capable of yielding fruit year-round, making them a reliable staple food source across seasons for many people. Most bananas produced in Tanzania are consumed at home, as the majority of smallholder banana farmers primarily focus on household consumption, i.e., subsistence (Bezu & Villanger, 2019). With the growing domestic demand for bananas, the crop is frequently exported to countries such as Zambia, Malawi, Germany, Switzerland, and Austria from Tanzania (OEC, 2020).

Despite the market potential demonstrated by banana production and its role as a main staple food for a larger population, the productivity of the crop remains very low. In Tanzania, the yield for smallholder farmers is reported to be around 6.25 tonnes per hectare, compared to the required 80 tonnes per hectare (FAO, 2012; Lucas & Jomanga, 2021). Another study reported that the total banana production in Tanzania is less than 10% of the required potential of over 60-70 tonnes per hectare per annum (Shell Foundation, 2023). The low productivity of bananas can be attributed to factors such as poor crop management, coupled with production challenges like low soil fertility, persistent drought, the occurrence of pests and diseases, a low genetic base, and numerous social and economic factors (Chabi et al., 2018; FAO, 2012). The lack of credit for smallholder banana farmers and the unavailability of agricultural technologies and extension services limit the efficient production of bananas (Mgbenka & Mbah, 2016). Furthermore, gender differences in agricultural production negatively impact banana productivity, affecting the total crop output per area for smallholder farmers (Agarwal, 2012). The inability of women farmers to access resources and opportunities on an equal footing with men restricts their capacity to improve agricultural productivity, which would increase the overall income of the household.

Gender inequality in agriculture hinders households from achieving high agricultural productivity. It also prompts households to utilise their farm resources inefficiently in production. For the past 50 years, there has been a debate about the contributions of women to agriculture, especially in Africa. This debate began when the United Nations Economic Commission for Africa (UNECA) (1972) reported that 60-80% of the agricultural labour supply in Africa comes from women. Another finding reported that women comprise 70% to 90% of the agricultural labour force in Sub-Saharan African countries (Food and Agricultural Organization (FAO), 1984). In later years, the FAO (1995) reported that women contribute about 60-80% of the labour used in the production of food crops for household consumption and for sale in Sub-Saharan Africa (SSA).

Women living in rural areas in Asia and Sub-Saharan Africa (SSA) are more likely to be employed in the agricultural sector than in other production sectors, with up to 70% of women employed in Southern Asia and over 60% of women in SSA working in agriculture (FAO, 2011). Recent studies find that the contribution of women to the agricultural labour force, in terms of hours worked, is between 40% and 50%, which is nearly half of the 60% to 80% that is usually quoted (FAO, 2011; Palacios-Lopez et al., 2017). This percentage specifically refers to labour force hour contributions to crop production only. Nonetheless, Doss (2015) advises caution in interpreting findings regarding the percentage of women and their labour force contributions in agriculture, as the authors defined labour force in terms of crop production and actual labour used on plots. The studies did not provide sufficient explanation concerning the wide range of agricultural household activities, such as livestock husbandry, marketing of outputs, acquiring inputs, seed collection, crop drying, storage, and post-harvest activities like processing, as well as non-farm activities such as caring for children and the sick (Doss, 2015).

However, despite their significant contributions to agriculture, women farmers are consistently found to be less productive than their male counterparts. The gender gap in agricultural productivity, measured by the value of agricultural produce (including bananas) per unit of cultivated land, ranges from 4% to 25% in favour of male farmers, depending on the country and the crop (O'Sullivan et al., 2014). Several other studies have reported the existence of a gender productivity gap in agriculture (Kilic et al., 2015; Mukasa & Salami, 2015; Slavchevska, 2015). Clearly, women farmers face several setbacks that affect their farm productivity. These setbacks include limited access to training, lack of skills and access to new technology, and insufficient economic resources such as land, capacity, and knowledge of new agricultural practices (Croppenstedt et al., 2013; Quisumbing, 1995; Sheahan & Barrett, 2014). Women are also disadvantaged in terms of access to and ownership of land, extension services, and finance or credit (Croppenstedt et al., 2013; Gebre et al., 2021). The objective of this study is to assess gender productivity differences in banana production in Tanzania.

1.1 Theoretical and conceptual framework

In Africa, farmers who are members of the same household may cultivate the same crop on different plots during one agricultural season (Udry et al., 1995). This situation marks the agricultural household as a particularly interesting unit of analysis for agricultural-related research studies, as it can be examined as a unit of production, breeding, and consumption.

Household economics is linked to the concept of household production behaviour, which is founded on the then-new theory of consumer choice developed by Becker (1965). This theory views households as production and consumption units in which market goods and household resources (mainly time) are integrated with household technology to produce intermediate non-market goods, referred to as "Z goods," which are then consumed in combinations that generate maximum welfare (utility) for the households (Becker, 1965). The model assumes that household members have the same preferences (unitary). However, due to the methodological shortcomings of the unitary model, an alternative model of household behaviour, namely the collective model, was proposed by Chiappori (1992) and Browning & Chiappori (1998). In the collective model, individuals may bargain over household allocation while achieving Pareto efficiency. The two key assumptions of the collective model are that each person in the household has their own preferences and that collective decisions are Pareto efficient. This study will adopt a collective household framework to explain how gender inequalities affect banana productivity. The collective household model is selected because it addresses the significant shortcomings of the unitary model by treating household preferences individually.

The conceptual framework for modelling gender differences in banana productivity for this study is based on a production function that describes the expected output produced from a set of inputs (Peterman et al., 2011). The production of plot manager i in household j in year t is given by:

$$Y_{ijt} = f\left(V_{ijt}, X_{ijt}, Z_{ijt}, G_{ij}\right) \qquad (1)$$

Where Y_{ijt} is a measure of productivity of plot *i*, planted in year *t* by a member of household *j*, *V* is a vector of inputs used by the plot manager (including land, labour, and capital); *X* is a vector of individual attributes; and *Z* are household and community level variables. G_{ij} represents time-invariant variables like gender, which are included in the estimation model.

The challenge of estimating such a production function in Equation 1 is that the inputs (V_{ijt}) are selected by firms. Therefore, there might be an unobservable variable ω_{it} which is observed or partially observed by the firm before selecting V_{ijt}, the selections will likely depend on ω_{it}, this generates a correlation between V_{ijt} and ω_{it}, and make OLS estimates inconsistent. This is classical endogeneity problem which dates back to Marschak & Andrews (1944). The endogeneity problem in production functions can be addressed by the use of fixed effects and instrumental variables, among other approaches. The fixed effect approach involves assumption that $\omega_{it}=\omega_i$, where the fixed effect ω_i is observed by the firm before it selects its inputs (Ackerberg et al., 2015).

1.2 Literature review

Measuring gender differences (the gender gap) in agricultural productivity has been of interest to researchers in developing countries. In Sub-Saharan Africa (SSA), women have little control over household resources, lower control over farm production, are inclined to use traditional inputs and technology, and are deprived of both human and physical capital in terms of quantity and quality (Mukasa & Salami, 2015). These gender-based differences weaken women's capacity to fully contribute to economic growth, impact intra-household resource allocation, affect resource productivity, and ultimately hinder household welfare. The gender productivity gap in agriculture varies across SSA, averaging around 20 to 30% (Croppenstedt et al., 2013; Kilic et al., 2015).

Several studies have reported gender differences in agricultural productivity. For instance, Slavchevska (2015) found weak evidence of mean differences in productivity between male- and female-owned plots in Tanzania. By considering plot managers' characteristics, plot characteristics, inputs used, and the type of crop being studied, female-managed plots were consistently found to be less productive than those managed by males. Udry (1996) discovered that plots controlled by women have significantly lower yields than similar plots within the household that are controlled by men. Akresh (2005) found that gender differences in agricultural productivity are evident in regions close to those reported earlier by Udry (1996), which exhibit Pareto-inefficient intra-household allocations, while other areas showed no evidence of Pareto inefficiencies.

According to the World Bank (2022), gender differences in agricultural productivity in Tanzania range from 20% to 30%, with approximately 97% of the difference attributed to reduced access to male family labour. The remaining 3% is due to limited access to key agricultural inputs such as land, improved seeds, fertiliser, and pesticides. If Tanzania can successfully close the existing gender gap, the country could boost its annual GDP by up to 0.86%, thereby improving human capital and household welfare (World Bank, 2022). Another study by Peterman et al. (2011) investigated gender differences in agricultural productivity in various areas and found consistently lower productivity on female-owned plots and in households headed by females.

Mukasa and Salami (2015) found that, on average, female-managed plots are 27.4% less productive than those managed by males in Tanzania. Sources of gender productivity differences were identified as land size, land quality, labour inputs, and household characteristics. Curbing gender productivity differentials in agriculture is reported to improve harvests by 8.1%, raise monthly household consumption by 1.4%, and lift up to 4.9% of households with female-managed lands out of poverty in Tanzania. Kilic et al. (2015) found that female-managed plots are, on average, 25% less productive compared to male-managed plots. They also determined that the gender productivity gap is attributed to variations in the type and value of crops cultivated and levels of household adult male labour inputs by 82%.

The current study uses three waves of panel data to model gender productivity differences among banana growers in Tanzania. The dataset used is nationally representative, which has advantages over other datasets that are usually limited to specific districts or regions of a particular country and are mostly cross-sectional in nature. The data provide an edge in controlling for household time-invariant characteristics, such as ability, soil quality, and responses to unobservable shocks like drought. Using this data, for example, makes it easier for the current study to estimate indicators of gender productivity and their effects among banana growers. Unlike other studies, this study contributes to the ongoing literature by focusing on a single perennial crop—bananas—which can be harvested throughout the year, and by establishing the status of gender productivity differences.

Additionally, this study methodologically contributes to the literature by using a correlated random effects (CRE) model to estimate the banana production function.

2. Methodology

2.1 Econometric specification

The exposition of econometric model in this study followed Barrett et al. (2010) where the dependent variable Y_{iht} is the banana output on plot *i* cultivated by member of household *h* in time *t*, and suppose that X_{iht} is a vector of explanatory variables that the researcher observes, that is, inputs and household characteristics that might affect banana production. Because this study is specifically interested in gender productivity difference, let G_{ih} represent time invariant variables like the gender of the plot manager, ω_h captures the household fixed effects, and ε_{iht} is the error term. X_{iht} includes the usual non-land production inputs (e.g., labour and capital).

$$lnY_{iht} = \beta_0 + \beta_1 X_{iht} + \beta_2 G_{ih} + \omega_h + \varepsilon_{iht} \quad (2)$$

Assuming constant returns to scale, all inputs related variables can be converted into per acre terms, with y_{iht} denoting banana yield (i.e., output per acre), and x_{iht} denoting the input application rate per unit area (Barrett et al., 2010; Helfand & Taylor, 2021; Yao & Hamori, 2019). Input application rate per unit area is used to ensure analysis that controls for the intensity with which other factors of production are used (Helfand & Taylor, 2021). The production function can then be specified as

$$lny_{iht} = \beta_0 + \beta_1 x_{iht} + \beta_2 G_{ih} + \omega_h + \varepsilon_{iht} \quad (3)$$

Equation 3 was estimated using a correlated random effects (CRE) model, which includes the means of all time-varying variables as controls for the level two variables. The primary focus of this study is to determine the existence of gender productivity differences in banana growing among farmers in Tanzania. Therefore, gender is a key variable of interest. Using a fixed effects model to estimate the production function removes all time-invariant variables, such as gender or distance, if included in the model. Fixed effects models allow for the consistent estimation of the effects of time-varying variables, even in the presence of unobserved heterogeneity in time-invariant or level two variables (Schunck & Perales, 2017). A good alternative to standard fixed effects and random effects models is the Correlated Random Effects model (CRE) developed by Mundlak (1978). The correlated random effects model is capable of separating within-cluster and between-cluster effects, allowing for the consistent estimation of both time-varying and time-invariant variable effects (Schunck & Perales, 2017). The CRE model was specified as

$$lny_{iht} = \beta_0 + \beta_1 x_{iht} + \beta_2 G_{ih} + \pi \bar{x}_i + \omega_h + \varepsilon_{iht} \quad (4)$$

x_i bar represents the means of all time varying variables included in the model. The estimation of effects of level two variables like gender assumes that there is no correlation between level two variables and level two error (Schunck & Perales, 2017). The cluster mean $\bar{x_i}$ absorbs any correlation between x_{it} variables and the level two error (Schunck, 2013). By including the cluster mean ($\bar{x_i}$) of level one variable in a random effects model the process is therefore an alternative to cluster mean centering (Halaby, 2003). Consequently, β_1 is the fixed-effects estimate (Mundlak, 1978; Wooldridge, 2010). The estimated effect of $\bar{x_i}$ which is π, is the difference of the within and between effects (Mundlak, 1978), it is represented as $\pi=\beta_B-\beta_W$, and allows for testing the augmented regression test or Mundlak test with null hypothesis that $\pi=0$ (Schunck & Perales, 2017). If the within and between effects are not statistically significantly different from each other $\beta_B=\beta_W$, then the standard random effects model's assumption of a zero correlation between level two error and level one covariates holds (Schunck & Perales, 2017).

The interpretation of the difference of the within and between effects (π) is thought to be less meaningful as it is confounded with the level two error (Schunck, 2013). The correlated random effects model is sometimes called the Mundlak model (Mundlak, 1978; Wooldridge, 2010). The approach has become increasingly popular in panel data analyses and has been applied in different studies (Karl et al., 2013; Otten, 2020). The production function specified might have some number of explanatory variables for which a significant number of observations have zero values. Inputs like organic fertilizer, pesticides, and hired labour have observations with zero values as they are applied in a few banana plots. The plots with zero quantities of inputs will be dropped from the sample when the variables are log-transformed. Adding one or an arbitrarily small number to adjust the zero values is not independent of the units of measurement of the variable concerned (Battese, 1997).

This study emulates Battese (1997), Battese et al. (1996), and Battese (1993) by using a dummy variable equal to one for farmers that report zeroes for some inputs of interest (*Q;* physical or labour). In order to take care of inputs with zeroes Equation 4 is re-specified as:

$$lny_{iht} = \beta_0 + \beta_1 x_{iht} + \beta_2 G_{ih} + \beta_3 D_{iht} + \beta_4 lnQ^*_{iht} + \pi \bar{x}_i + \omega_h + \varepsilon_{iht} \qquad (5)$$

where D is a dummy variable for inputs with zero values ($D_{iht}=1$ if $Q_{iht}=0$ and $D_{iht}=0$ if $Q_{iht}>0$). Time varying variables means $\bar{x_i}$ still include the means D_{iht} and Q^*_{iht} variables. Physical or labor inputs with zeroes are expressed by $Q^*_{iht}=max(Q^*_{iht}, 1-D_{iht})$, this expression takes explicit account of the fact that some farmers apply no inputs (fertilizer, pesticides and hired labour) in some years. Using this approach, the full data set is employed and the obtained estimates are efficient and unbiased (Battese, 1997).

2.2 Data type and source

The data for this study comes from the Tanzania National Panel Survey (NPS) conducted from 2008 to 2013. The NPS data were part of the Living Standards Measurement Studies (LSMS) collected by the World Bank and the Tanzania National Bureau of Statistics (NBS). The first wave was carried out between October 2008 and September 2009, the second wave from October 2010 to September 2011, and the third wave from October 2012 to September 2013. The writing of this paper began in 2019 when we had only four waves of NPS data. This study opted against using wave four (2015) because it was highly refreshed. Due to the significant refreshment of the sample in the fourth wave, identifying the attrition rate for the entire wave three of the NPS in relation to wave four was not possible (NBS, 2016). Using extended panel households, the attrition rate was found to be 8%.

In this study, the NPS data were customised by selecting households that grow bananas. Households were defined by their heads, who were censored at 18 years of age or above to be included in the analysis. This selection resulted in 237 observations in 2008, 179 observations in 2010, and 190 observations in 2012. The total number of observations across all waves was 606 in Tanzania (Mainland and Zanzibar), leading to an unbalanced panel dataset. When the panel dataset is unbalanced, Stata software applies listwise deletion, removing all observations with at least one missing value. Stata commands can be applied to unbalanced panels without causing inconsistency of the estimators, especially when the data is missing at random (Baltagi, 2005).

It is imperative to understand who manages the plots or makes decisions about when to plant, procure inputs, and use outputs, rather than who owns the plot (Doss et al., 2015). In this study, we focus on the decision-maker or plot manager in describing differences in banana production along gender lines. The LSMS dataset captures information about the decision-maker at the plot level. The decision-maker, or plot manager, as referred to in this context, is the person who decides what to plant on the plot and manages all activities pertaining to the banana plot. Table 1 summarises the priori expectations of the study.

Table 1: *Description of variables used in the study*

Variable	Description of variable	Sign
Banana productivity	This is a dependent variable signifying banana output per acre	+
Gender_manager2	1 if the plot manager is a female	-
Area	Plot size, a continuous variable (Acres)	+/-
D3_Fmandays_weeding	1 if family labor was used-man days	+/-
Lnmax3_Weeding_ID1_Days	Family labor-man days	+/-
D4_Fwomandays_weeding	1 if family labor was used-woman days	+
Lnmax4_Weeding_ID2_Days	Family labor-woman days	+
D5_pesticides_qnty	1 if pesticides was applied	+
Lnmax5_pesticides_qnty	Quantity of pesticides applied (Milliliter)	+/-
D6_organic_fertilizer_qnty	1 if organic fertilizer was applied	+
Lnmax6_organic_fertilizer_qty	Quantity of organic fertilizer applied (Kg)	+/-
Lake_zone	1 if the zone in question is Lake zone	+
Northen_zone	1 if the zone in question is Northern zone	+
Southern_highlands	1 if the zone in question is Southern highlands	+
Eastern_zone	1 if the zone in question is Eastern zone	+/-
Western_zone	1 if the zone in question is Western zone	+/-
Southern_zone	1 if the zone in question is Southern zone	+/-
Age	Age in years, continuous variable	+/-
Land_free_used	1 if land is used for free	+
Land_rented	1 if land is rented	+/-
Extension1	1 if have access to government extension	+

3. Results and Discussion

3.1 Descriptive statistics

Descriptive statistics for this study are shown in Table 2. The table indicates that women make up 27.6% of all plot managers. The average productivity of bananas is 673.59 kg per acre per year, and the average land area (plot) used for banana cultivation is 2.4 acres. Banana growers utilise about 72% of family labour from men (man-days) for an average of 8.3 days per year for weeding activities. The descriptive statistics also show that farmers use family labour from women for about 61% of weeding, with an average of 6.66 (approximately 7) days per year.

Only 11% of farmers applied pesticides to their banana plots, with the average quantity of pesticides applied being 15.43 litres. Additionally, 25% of farmers applied organic fertiliser to their banana plots, with an average of 242.86 kg per year. The percentage of observations represented by each agricultural zone is as follows: Lake Zone 17.5%, Northern Zone 23.4%, Southern Highlands 26.6%, Eastern Zone 16.7%, Zanzibar 7.6%, Western Zone 4.9%, and Southern Zone 3.3%. The average age of the respondents was 51 years, which falls within the category of economically active age. About 6.6% of the banana plots were used for free, and only 1.2% were rented. Farmers who received government extension services accounted for 16.5% of the total observations.

Table 2: *Descriptive statistics*

Variable	Obs	Mean	Std	Min	Max
Gender_manager2	606	0.2756	1783.80	0	1
Productivity	606	673.59	3587.59	50	22400
Area	606	2.40	1.24	0.12	9

D3_Fmandays_weeding	606	0.72	0.44	0	1
Max3_Weeding_ID1_Days	606	8.30	9.19	1	60
D4_Fwomandays_weeding	606	0.61	0.49	0	1
Max4_Weeding_ID2_Days	606	6.66	8.33	1	60
D5_pesticides_qnty	606	0.11	0.31	0	1
Max5_pesticides_qnty	606	15.43	79.28	0.2	1050
D6_organic_fertilizer_qnty	606	0.25	0.43	0	1
Max6_organic_fertilizer_qnty	606	242.86	897.15	20	10000
Lake_zone	606	0.1749	0.38	0	1
Northen_zone	606	0.2343	0.424	0	1
Southern_highlands	606	0.2657	0.442	0	1
Eastern_zone	606	0.1667	0.373	0	1
Zanzibar	606	.07590	0.265	0	1
Western_zone	606	0.0495	0.2171	0	1
Southern_zone	606	0.033	0.1788	0	1
Age	606	50.87	15.10	20	91
Land_free_used	606	0.066	0.25	0	1
Land_rented	606	0.012	0.11	0	1
Extension1	606	0.1650	0.37	0	1

Source: Authors calculation based on NPS data

3.2 Gender differences in banana productivity

The Hausman specification test (Hausman, 1978) was conducted to ensure that the appropriate model was estimated. The results of the Hausman test rejected the random effects (RE) model assumptions (Prob > chi2 = 0.0001). A correlated random effects (CRE) model was then estimated. This model was significant (Prob > chi2 = 0.0000), implying that the specified variables collectively explain the variation in the productivity of plot managers.

The results obtained are presented in Table 3. In the results table, R stands for random effects, W stands for within-cluster effects, and D stands for the difference between the between-cluster and within-cluster effects. The difference between the within and between effects (π) is not important as it is confounded with the level two error (Schunck, 2013). Therefore, the results of the between coefficients (represented by D) are not discussed, as they are not meaningful. As expected, the coefficient for the gender of the plot manager is negative and significant at the 10% level. This indicates that banana plots managed by female managers have lower productivity—19% less—compared to plots managed by male managers. The lower productivity of female managers may be explained by their inefficient use of inputs such as organic fertiliser, lower technical knowledge, and fewer extension visits compared to their male counterparts. Women may also be allocated lower-quality land compared to men. Additionally, women are often responsible for most of the unpaid household tasks, such as caring for children and the sick, fetching water, and managing domestic energy needs. These responsibilities may create an opportunity cost of time for female managers, resulting in less time allocated to banana farming.

If both plot managers (females and males) were assumed to have the same production function, then equal banana productivity could be expected within a particular household, regardless of who (gender) manages the banana plot. This would require that households allocate factors of production efficiently, leading to Pareto efficiency. However, the results found refute the assertion of the same production function and suggest the presence of Pareto inefficiencies in intra-household resource allocations among banana-growing households in Tanzania. The results are consistent with the findings of Akresh (2005), Kilic et al. (2015), Mukasa & Salami (2015), and Palacios-Lopez et al. (2017).

Table 3: *Gender differences in banana productivity*

Lnproductivity (Dependent variable)	CRE	Robust Std. Err.
R__Gender_manager2	-0.190*	0.108
R__Lake_zone	0.878***	0.204
R__Northen_zone	1.153***	0.223
R__Southern_highlands	0.640***	0.178
R__Eastern_zone	0.660***	0.182
R__Western_zone	0.356	0.235
R__Southern_zone	0.079	0.295
W__lnarea2	-0.872***	0.079
W__D3_Fmandays_weeding	0.155	0.264
W__lnmax3_Weeding_ID1_Days	0.019	0.089
W__D4_Fwomandays_weeding	-0.064	0.186
W__lnmax4_Weeding_ID2_DaysR	-0.015	0.012
W__D5_pesticides_qnty	0.364	0.249
W__lnmax5_pesticides_qntyR	-0.042***	0.009
W__D6_organic_fertilizer_qnty	-0.045	0.158
W__lnmax6_org_fert_qntyR	0.012**	0.005
W__age	0.007	0.017
W__Land_free_used	0.369	0.229
W__Land_rented	-0.510	0.537
W__extension1	0.445***	0.148
D__lnarea2	0.545***	0.118
D__D3_Fmandays_weeding	-0.207	0.394
D__lnmax3_Weeding_ID1_Days	0.041	0.123
D__D4_Fwomandays_weeding	0.114	0.286
D__lnmax4_Weeding_ID2_DaysR	-0.0005	0.012
D__D5_pesticides_qnty	-0.097	0.343
D__lnmax5_pesticides_qntyR	0.037***	0.013
D__D6_organic_fertilizer_qnty	-0.004	0.274
D__lnmax6_org_fert_qntyR	-0.009	0.010
D__age	-0.0037	0.017
D__Land_free_used	-0.249	0.352
D__Land_rented	-0.085	0.592
D__extension1	-0.485**	0.235
Constant	4.810***	0.218
Observations	606	
Number of groups	299	

*** , ** ; *: Significant at the 1%, 5%; 10% respectively.
Source: Authors calculation based on NPS data

The variation in climatic and agro-ecological environments, in addition to the existence of differences in gender norms and culture across the country, can influence banana productivity differences between male and female farms in various regions. Hence, this study controlled for agro-ecological zones to assess their effects on banana productivity. The findings show that, in the Lake zone, banana productivity increases by 87.8% at a 1% level of significance compared to Zanzibar. This may be because the zone contains the Kagera region, which is the largest producer of bananas in the country. The increase may further be explained by the existence of favourable annual temperatures and rainfall, coupled with good soil fertility and better crop management in the Kagera region. In the Northern zone, banana productivity increases by 115.3% at the 1% significance level compared to Zanzibar. This zone contains the second largest producer of bananas (Kilimanjaro) in Tanzania, after Kagera. In Kilimanjaro, farmers are nowadays concentrating on banana production as their main cash crop after abandoning coffee, which was the main cash crop in a large area of the zone. Also, the weather conditions in this zone favour the production of bananas, as it is situated at the foot of the largest mountains (Kilimanjaro and Meru) in Tanzania.

In the Southern Highlands zone, banana productivity increases by 64% at the 1% significance level compared to Zanzibar. This may be explained by the fact that the zone has the third highest producer of bananas in Tanzania, which is the Mbeya region. Both rainfall and temperature across the regions that make up the Southern Highlands zone are favourable for banana production. Banana productivity increases in the Eastern zone by 66% compared to Zanzibar at the 1% significance level. This zone comprises parts of the Morogoro, Tanga, and Pwani regions, which are rich in banana production. Areas like Lushoto and Matombo have favourable rainfall and temperature for banana production, which may influence the increase in banana productivity in this zone. The findings of this study on the relationship between banana productivity and agro-ecological zones match those of Akresh (2005) and Slavchevska (2015).

The total area of banana production has a negative coefficient and is significant at the 1% level. The results suggest that an increase in banana plot area by one acre reduces productivity by about 87.2%. The findings depict the presence of an inverse relationship between banana plot size and productivity. The inverse relationship between farm size and productivity explains the fact that small farms have higher yields per acre than large farms. From the literature, there are several possible explanations for the inverse relationship between farm size and productivity. Some of the explanations are risk aversion, biases due to omitted variables such as soil quality, agronomic-related matters, and measurement error due to farmers' self-reported production. This result is in line with the findings by Lokina (2011) and Muyanga & Jayne (2019).

Application of pesticides to banana plots was found to be negatively correlated to banana productivity at the 1% significance level. The findings show that a unit increase in pesticide application on banana plots reduces banana productivity by about 4.2%. This may be because banana plants are prone to infestations as they are grown in tropical areas that favour insect and pest attacks. Continuous application of pesticides to banana plots to foil pest attacks may lead to pest resistance, which may increase banana disease outbreaks. Furthermore, the application of pesticides may distort the quality of land, which in turn leads to a reduction in banana productivity. Pesticide application may also impact farmers' health and put their surrounding environment at risk of a reduction in net banana productivity growth and welfare in both the short and long run. Similar results were reported by Sheahan et al. (2016).

Application of organic fertiliser on banana plots was found to correlate positively with banana productivity. The study found that a unit increase in the application of organic fertiliser increases banana productivity by 1.2% at the 5% level of significance. This may be because the application of organic fertilisers to banana plots is cheap and can improve plot soil in both textural and structural forms. Application of organic fertiliser to banana plots can also facilitate the ability of soil to retain water and promote strong banana plant development. In addition, organic fertilisers are readily available to farmers as they are generated from materials that are commonly used or consumed at home; these material sources include animal remains, sewage sludge, and plant remains. The findings of this study are in line with those found by Cen et al. (2020).

The contribution of government extension to banana productivity was found to be positive and significant at the 1% level. Farm managers who receive government extension services increase banana productivity by about 44.5% compared to those who do not receive government extension services. This may be explained by the role extension services play in the transfer of agricultural technology, enhancing smallholder adults' learning, acting as a conduit for farmers' problem-solving, and orienting farmers to the agricultural production knowledge and information system. The findings match those of Danso-Abbeam et al. (2018).

4. Conclusion

Low crop productivity has been linked to gender inequality in agriculture. Low banana productivity is also linked to gender inequality in its production. Gender productivity differences in agriculture have been a topic of interest for policymakers, academia, and women's empowerment advocacy groups. Several schools of thought attribute gender productivity differences to observed factors, such as unequal access to key agricultural inputs, or unobserved factors, such as individual farmers' farm management skills. Other perspectives attribute the productivity differences to the initial endowment of resources, while some argue that the differences cannot be explained by the observed factors.

Using rich panel data, this study contributes to the existing debate by examining the gender differences in banana productivity in Tanzania. The study finds a difference in banana productivity of 19% in favour of male managers, highlighting their (plot managers') characteristics, input use, and banana plot characteristics. The banana cultivation area was located in zones such as the Lake, Northern, Southern Highlands, and Eastern zones, which were found to increase banana productivity. The use of organic fertiliser and receiving government extension services have a positive influence on banana productivity. Conversely, being a female manager, an increase in the banana plot area and an increase in the usage of pesticides have a detrimental effect on banana productivity.

5. Recommendations

The findings of this study show that there is a gender productivity difference of 19% in banana productivity in favour of men. This difference is attributed to observable factors, such as poor access to physical resources for women, and unobservable factors, such as a lack of proper banana production skills. Policies aimed at enhancing female managers' (women's) access to factor inputs, such as capital, labour, and land, will help to narrow the existing gender productivity gap in banana production in Tanzania. While equal access to inputs may be a necessary condition for reducing the gender productivity difference, it may not be sufficient, as there may still be differences in banana harvests stemming from the same factors of production used. This could be due to unobservable circumstances, such as the plot manager's ability, timing of planting dates, and soil quality, which may exacerbate the gender productivity difference in banana cultivation.

The findings suggest that training should be provided for farmers on banana growing skills, including adequate planting times, the timing and appropriate amounts of fertiliser to apply to plots, and effective management of banana plots, particularly for female managers. In addition, extension services should be made available to all plot managers, regardless of gender. Furthermore, the findings recommend identifying agricultural zones that can excel in banana production and where efforts should be directed to enhance banana productivity. Additionally, the study suggests that farmers should reduce the use of pesticides by adopting good agricultural practices, such as Integrated Pest Management (IPM). They should choose pesticides with the lowest risks to human health and the environment, receive proper training on the use and handling of pesticides, and observe appropriate waste management practices.

Future research focusing on banana gender productivity differences, using various types of data and methodologies, and concentrating on banana-rich producing zones and regions in Tanzania can be conducted to confirm the existence of the productivity gap. This will contribute to a more extensive understanding of the gender productivity difference in banana production and provide further evidence-based policy measures to alleviate the gap.

5. Declarations

Authors contributions: Conceptualisation (H.L.M., R.B.L. & O.S.); Literature review (H.L.M., R.B.L. & O.S.); methodology (H.L.M., R.B.L. & O.S.); software (N/A); validation (H.L.M., R.B.L. & O.S.); formal analysis (H.L.M., R.B.L. & O.S.); investigation (H.L.M., R.B.L. & O.S.); data curation (H.L.M., R.B.L. & O.S.) drafting and preparation (H.L.M., R.B.L. & O.S.); review and editing (H.L.M.); supervision (R.B.L. & O.S.); project administration (H.L.M.); funding acquisition (N/A). All authors have read and approved the published version of the article.

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