INCOME EFFECT OF PARTICIPATION IN AGRICULTURAL PRODUCTION: THE CASE OF SMALLHOLDER MAIZE FARMERS IN TANZANIA

Abstract

Agriculture is an important sector of the Tanzanian economy, contributing about 26.9% to GDP. About 80% of the population depends on agriculture as a source of income. Extant literature shows mixed results regarding the relationship between agricultural participation and income. This study investigated effect of agricultural participation on income in Tanzania. The National Sample Census of Agriculture data 2019/2020 with a sample of 11,812 households was used. The study employed a quasi-experimental design. Propensity score matching was used to analyse the effect of household participation in maize production on income in Tanzania. The findings show that households participate in maize production have a negatively and significantly effect on their household income. Again, the use of fertilizer, off-farm employment, land size, and type of seed used positively and significantly influenced participation in maize production. On the other hand, sex of the household head, membership in cooperative, use of irrigation and herbicides had negative and significant effects on participation in maize production. Consequently, there is a need to provide necessary agricultural inputs such as fertilizer, improved seeds and a more enabling environment for land ownership to be used in maize production among smallholder farmers.

Keywords: Agricultural production; maize; income; smallholder; PSM

Introduction

Agriculture is expected to meet dual objectives which are poverty reduction and ensuring food security (Gassner *et al*., 2019; Omodero, 2021). In Tanzania, agriculture contributes around 26.9% of the gross domestic product (GDP), 85% of all exports, and over 80% of the population's source of income (URT, 2021a, 2021b). However, majority of households earn their living through employment in the agricultural sector (Frederick *et al*., 2020; World Bank, 2019). The statistics show that 80% of people in rural areas of Tanzania derive their livelihood from agriculture (URT, 2019, 2021b). The farming system in the rural areas is characterized by substantial reliance on rain-fed agriculture, small-scale farming, unorganized market, low productivity and thus, low household income and poverty (Osabohien *et al*., 2020, 2021).

Tanzania has been experiencing poverty decline, though the pace has slowed in recent years (World Bank, 2020). The number of people living in poverty declined from 28.2% in 2012 to 26% in 2018 (URT, 2021a). The World Bank, (2019) reports that about 14 million Tanzanians live in absolute poverty and 81% of the most impoverished live in rural areas. However, around 75% of those engaged in agricultural production including production of Maize are poor having low household income (URT, 2019). Reducing poverty requires understanding on the drivers of income among Maize farm households including the effect of participation in Maize production. Various studies (e.g., Abokyi *et al*., 2020; Anang *et al*., 2020; Manda *et al*., 2021; Wang *et al*., 2021; Midamba, 2022; Geffersa *et al*., 2022; Mupaso *et al*., 2023) revealed the diverse household, socio-economic and institutional factors related to participation in agriculture. Nevertheless, limited studies (Osabohien *et al*., 2021; Wang *et al*., 2021; Paul *et al*., 2021; Wu *et al*., 2023) have been conducted on the effect of participation in agricultural production on income. The cited studies overlooked the effect of participation in maize production as well as poverty status on crop income, this study addresses that gap. Thus, this study assesses the effect of participation in Maize production on crop income among smallholder farmers while accounting for selection bias. Specifically, the study firstly examines the determinants of participating in Maize production, and secondly, analyzes the crop income effect of participating in Maize production.

Maize production and poverty reduction in Tanzania

Crop production accounts for 32% of the nation's Gross Domestic Product (GDP) in Tanzania (Volk *et al*., 2021). Amongst crops produced in Tanzania, cereal crops production dominates in terms of food supply (Nassary *et al*., 2020; URT, 2021b). Also, cereal crops production including maize production is necessary for improving food security, household income, poverty reduction, and economic development (URT, 2019).

Tanzania, situated in Sub-Saharan Africa, holds the position of the largest maize producer in the region. It is ranked among the top 25 global maize-producing countries for the last 50 years (Kim *et al*., 2021; Volk *et al*., 2021). In Tanzania, maize is an important staple crop grown and consumed in all the agroecological zones (Frederick *et al*., 2020). About 61% of all cultivated land in Tanzania is dominated by maize, which is planted extensively for subsistence and for profit (URT, 2021b). Maize accounts for 73% of total production and 66% of annual cereal crops production in Tanzania (URT, 2021b). However, about 80% of maize output is produced by smallholder farmers (Frederick *et al*., 2020). The statistics indicates that 65% to 80% of total maize produced in Tanzania is consumed in the household (URT, 2021b; Volk *et al*., 2021). The production of maize has been increasing over the past two decades (Figure 1).

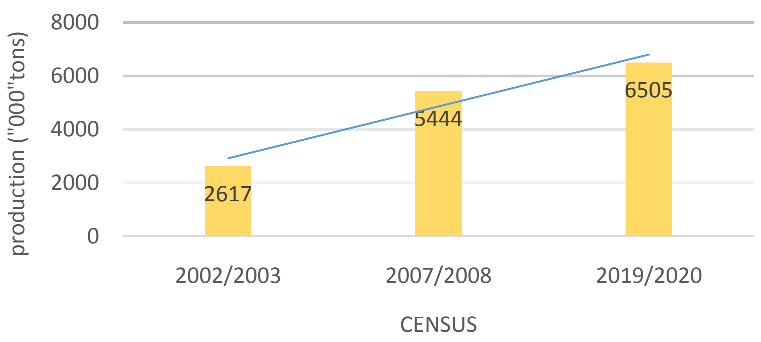

Figure 1. Maize production by smallholder famers for three consecutive agricultural censuses in Tanzania.

Source: National Bureau of Statistics (2021)

The Tanzanian government has been working to promote and enhance the environment for participation in agricultural production including maize production in order to improve productivity, income and reduce poverty (URT, 2019, 2021b). Still, households participation in agriculture including participation in Maize production is low (URT, 2021a). The low participation is associated with a number of factors such as risk in production, low return to factors of production i.e., low land productivity on average for maize which stands at 1.5t/ha (URT, 2021b). Improving crops productivity and crop income particularly of maize crop have been priorities of the Tanzanian government as reflected in its various agricultural development policies and implementation initiatives such as National Agriculture policy of 2013, National Strategy for Growth and Poverty Reduction (NSGRP), Five Year Development Plan, Building Better Tomorrow (BBT) initiative, Agricultural Sector Development Strategies (ASDS I & II) (URT, 2021a, 2022). However, majority of smallholder maize farmers are still having low income (URT, 2021a)

Review of literature and conceptualization of research problem

Maize production is a critical component of food security and economic development in many African countries. However, smallholder farmers' participation in maize production remains low, which limits the potential benefits of this crop for household welfare and national development. This literature review presents the studies on the factors that affect smallholder farmers' participation in maize production in Africa.

Studies of (e.g., Abokyi *et al*. (2020); Alabi *et al*. (2021); Anang *et al*. (2020); Geffersa *et al*. (2022); Manda *et al*. (2021); Midamba, (2022); Mupaso *et al*. (2023); wang *et al*. (2021) on drivers of participation in agricultural production revealed different households' characteristics, socio-economic as well as production factors, and institutional factors which influence participation. These include age of the household head and level of education which have been found to influence smallholder farmers' participation in maize production. Older household heads tend to have more experience and knowledge in agriculture, which enhances their productivity and income (Abokyi *et al*., 2020; Anang *et al*., 2020). Similarly, higher levels of education have been shown to increase households' knowledge and skills in agriculture, leading to higher productivity and income (Akudugu *et al*., 2021; Osabohien *et al*., 2021). Lastly, the sex of the household heads also affects smallholder farmers' participation in maize production, as women often have limited access to productive resources and face gender-based discrimination (Abokyi *et al*., 2020; Midamba, 2022).

Also, cooperative membership has been found to positively influence smallholder farmers' participation in maize production (Wang e*t a*l., 2021; Zhang *et al*., 2021). Cooperatives provide access to credit, extension services, and marketing opportunities, which enhance farmers' productivity and income. Off-farm employment has been found to have both positive and negative effects on smallholder farmers' participation in maize production. On the one hand, off-farm employment provides additional income and reduces households' dependence on agriculture (Alabi *et al*., 2021), On the other hand, it limits farmers' time and resources for maize production (Addai *et al*., 2022; Anang *et al*., 2020; Anang and Ayambila, 2020). Poverty status is a significant factor that affects smallholder farmers' participation in maize production, as poor households are more likely to engage in maize production for food and income (Alabi *et al*., 2021; Olayemi *et al*., 2021).

The type of seed used also affects smallholder farmers' participation in maize production, as improved varieties have been shown to increase yields and income (Abdoulaye *et al*., 2018; Geffersa *et al*., 2022). Fertilizer use is another critical factor that influences maize participation, as it improves soil fertility and crop yields (Kinyondo and Magashi, 2017; Mather *et al*., 2016). Herbicides and pesticides use has been found to positively affect smallholder farmers' participation in maize production, as they control weeds and pests, which improves crop yields and income (Biswas *et al*., 2023; Santpoort, 2020). Irrigation use also enhances smallholder farmers' participation in maize production, as it reduces the dependence on rain-fed agriculture and increases yields (Akudugu *et al*., 2021; Mupaso *et al*., 2023). Unlike previous studies, this study accounted for the effect of poverty status on crop income among Maize farmers in Tanzania.

Few studies have been conducted on the effect of participation in crop production on income. These include study by Wu *et al.* (2023). The authors assessed the effect of participation in farm cooperatives on family farms' operating income (including total and per capita income) in China among 769 planting family farms using the endogenous switching regression model and revealed participation in cooperatives improves family farms' income. Osabohien *et al*. (2021) analyzed data from 683 households in Nigeria to investigate the impact of youth participation in agriculture as a primary occupation on household income and poverty. The findings showed that youth participation in agriculture had a significant positive effect on per capita household income. However, Wang *et al*. (2021) in China found 475 farmers participating in agricultural value chain significantly increases the yield per acre and net income per acre. Paul *et al*. (2021) using 216 farmers and Heckman two-stage treatment effect model, revealed positive and significant effect of participation in pineapple market on farm income. However, these studies did not study the relationship between participation in maize production and crop income using secondary data specifically country level data involving large sample size. Such a gap of knowledge is addressed in this study. Therefore, unlike other studies this paper uses the latest National Sample Census of Agriculture (NSCA) data of 2019/2020 in Tanzania and PSM approach in investigating crop income effect of participating in Maize production in Tanzania.

Conceptual framework

The conceptual framework presented in (Figure 2) illustrates the relationship between explanatory variables and dependent variables such as smallholders' participation in Maize production and crop income. The framework highlights the clusters of factors that affect participation in maize production, namely, demographic features, socioeconomic conditions, and institutional factors. Additionally, the framework includes the relationship between participation in maize production and poverty status of the smallholder farmers.

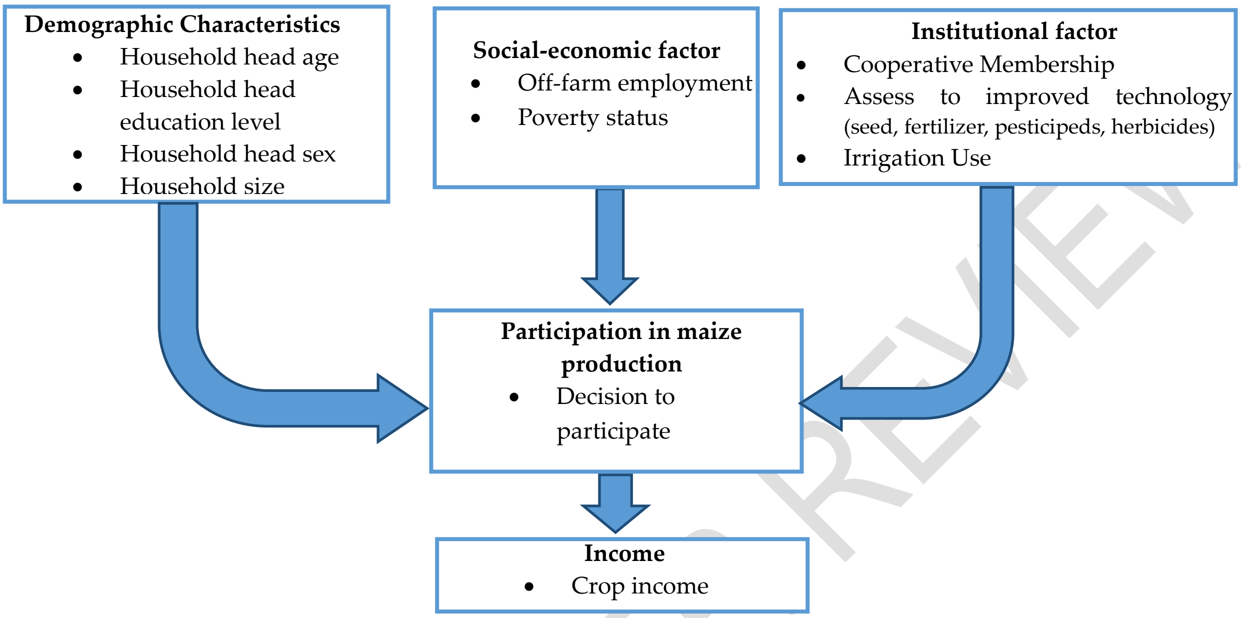

Figure 2. Conceptual framework on the effect of participation in maize production on income

Methodology

Study Area

The study was conducted in high maize-producing regions shown in (figure 3): Ruvuma, Manyara, Tanga, Tabora, Songwe, Rukwa, Singida, and Dodoma in Tanzania. The regions are selected because maize is highly produced compared to other regions in Tanzania. According to NSCA data of 2019/2020, those regions account for about 3,224,191 tones (60.85%) of maize production (URT, 2021b). Moreover the "QGIS 3" software was employed for map creation.

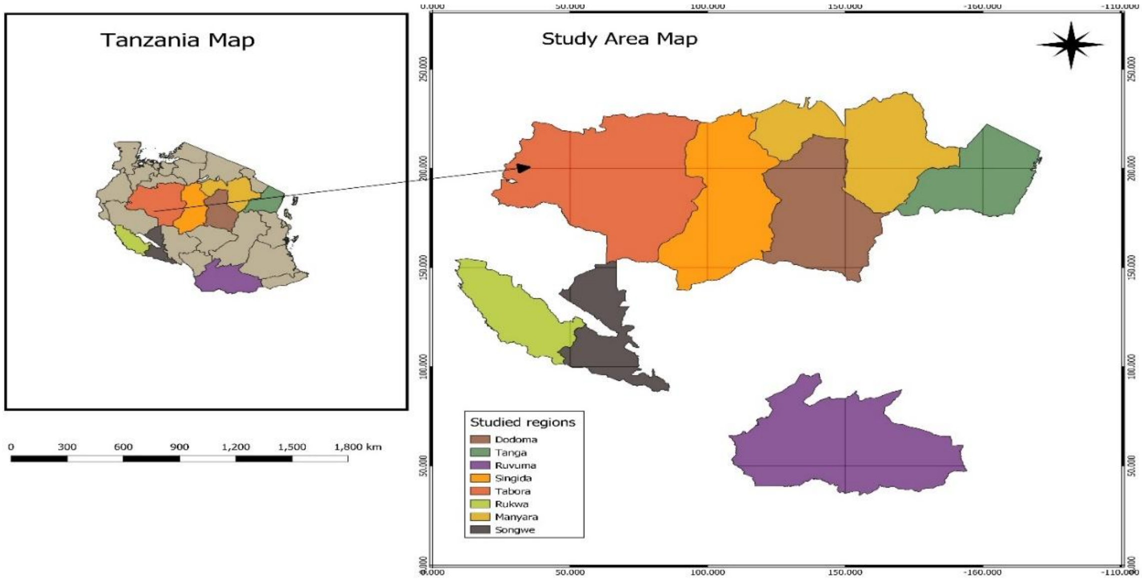

Figure 3. Map showing the study area dealing with production of maize in Tanzania.

Source: Own Design (2023)

Research Design and Data

The study employed a quasi-experimental research design in identification of participants and non-participants in maize production as the researcher did not random assign participants into groups. Also, the study utilized a sample size of 11,812 smallholder cereal crop farmers, with a specific focus on maize farmers. This sample size is used because 90% of farmers are dealing with Maize production (URT, 2021b). Table 1 shows the distribution of farmers and member of farmers in the study areas presented by regions. Also, the selected farmers were used by NBS to collect NSCA data from August 2019 to October 2020. Thus, in this study the data collected are secondary data of 2019/2020. Data collected includes household characteristics, farm characteristics, production of cereal crops and poverty.

Table 1: Show the distribution of the farmers and number of farmers by regions.

Region	Frequency	Percentage
Dodoma	943	7.98
Tanga	2038	17.25
Ruvuma	2732	23.13
Singida	692	5.89
Tabora	1772	15.00
Rukwa	2227	18.85
Manyara	673	5.7
Songwe	731	6.19
Total	11,812	100.0

Data Analysis

This section presents the method of data analysis for the drivers of participation in Maize production as well as the effect of participating in maize production on crop income. The study applied the independent sample t-test in descriptive analysis, Probit model in analyzing the drivers of participation in maize and PSM Method by Rosenbaum and Rubin, (1983) in analyzing the crop income effect of participation in Maize production. Moreover the "STATA 17" software was utilized for data analysis.

Probit model for the analysis of the drivers of participation in Maize production

This study used the probit model following (Osabohien *et al*., 2019). This study considers the assumption that the respondents were risk neutral (Osabohien *et al*., 2019). The probit model used in examining the drivers of participation in maize production among farmers is specified as follows:

$$D_i^* = X_i^{'}\beta_i + \mu_i \quad (1)$$

$$P(D_i{=}1/X_i) \quad (2)$$

$$D_i = \begin{cases} 1 = \text{If household grows maize as the main crop} \\ 0 = \text{Otherwise} \end{cases} \quad (3)$$

Where D* is a latent variable denoting the difference between the utility of participating in maize production (U_{iA}) and the utility of not participating in Maize production (U_{iN}). As stated in the theoretical modelling of this study, the farmer participates in maize production expected to gain higher utility than otherwise ($D_i^* = U_{iA} - U_{iN} > 0$). However, the participation in maize production D_i is expressed by latent variable D_i^* which is a function of farm households as well as socioeconomic characteristics (X_i) as explanatory factors (See Table 2). Whereas μ_i is an error term follow the standardized normal distribution with mean of zero and constant variance (∂^2). The nature of dependent variable, that is participation in maize production is binary or dichotomous which motivates the application of probit model. Also, applying this model in our analysis considered the application of same model by previous studies in analysis of participation in crop production (Example (Osabohien *et al*., 2021)).

Propensity Score Matching Method for analysis of crop income effect of participation in Maize production.

In estimating the effect of participation in maize production on crop income, different methods such as endogenous switching regression model and two stage Heckman sample selection model and PSM have been used. The study analyzed the impact of participating in maize production on crop income using the PSM method and the Average Treatment Effect (ATE) model based on Osabohien *et al*. (2021) and Zhao *et al.* (2021). PSM served as both the identification strategy and estimation method for evaluating the effect of maize production participation on crop income. The PSM helped to establish the counterfactual situation i.e., situation of participants before engaging in maize production and addressing selection-on-observables bias (overt bias). Therefore, for household i, (where i=1…K and K denotes the population of households), the reason for estimating the effect of participation in maize production($D_i = K$) on income ($Y_i D_i$) is to know the difference of crop income effect between participants ($D_i = 1$) and non-participants ($D_i = 0$) on maize production which is known as a counterfactual scenario.

This study used PSM, since PSM does not require any functional form assumptions when defining the link between outcomes and predictors of outcomes, and does not suffer from distributional assumptions (Becerril and Abdulai, 2010). In this study all the relevant variables were accommodated and all assumptions of PSM were met. However, the PSM only accounts for self-selection bias based on an observed trait (Austin, 2012). The PSM method started with the probit model specified in equation (1) and then, estimate the propensity score (P(x)) in equation (4) above and finally, estimate the average treatment effect model. Yet, PSM allows the matching problem to be of a single dimension, the propensity score (P(x)) is the probability of a household participating in maize production as their main crop and can be given as:

$$\Pr(X) = \Pr(D = 1/X = x) \quad (4)$$

Where D is the household participation in maize production and X is the observable or covariates characteristics of households. The propensity score can be obtained using formula from equation (5) to get the probability of household participation in maize production. Can be given as following.

$$P(x_i) = \Pr[D = 1/X_i] = \frac{\exp(\delta x_i)}{1+\exp(\delta x_i)} \quad (5)$$

After estimating the propensity score for households participating in maize production, the study drive Average Treated on Treated (ATT) through a kernel-based matching approach (KBM) and nearest-neighbor matching (NNM). To match the treated group near the propensity score is the most used approach for matching the participants and non-participants in Maize production. The nearest neighbor matching approach (NNM) involved comparing each treated subject to the control subject with the closest propensity score (Wang *et al.*, 2021) was used. Generally, it serves as a substitute in control units. The next step involved determining the variances between paired units, and their average was used to calculate ATT. In the KBM, treated individuals were matched with a weighted average of controls. The weights in KBM were based on the difference in propensity scores between participants and non-participants. The estimators (Heckman & Todd, 1998, 1997; Olounlade *et al.*, 2020; Osabohien *et al.*, 2021) are shown as:

$$ATT = \frac{1}{n^1}\Sigma_1\left\{\left(\frac{Y_{1i}}{D_i}=1\right) - \Sigma_j r_{1,0}\left(\frac{Y_{0i}}{D_i}=0\right)\right\} \quad (6)$$

Whereby n^1 is the number of treatment cases and r is the set of weight scales of the gap between the participants and non-participants of Maize production. ATT is estimated by averaging the within-match differences in the outcome of a variable between the participants and non-participants in maize production within the same propensity (Heckman and Todd, 1998; Osabohien et al., 2021). The Average Treatment Effect (ATE) can be specified as:

$$Y = [Y_i|D_i = 1] - E[Y_i|\,D_i = 0\,] \quad (7)$$

$$\mathrm{E}(Y_1 - Y_0/\mathrm{D}=1) = \mathrm{E}[\mathrm{E}(Y_1 - Y_0/\mathrm{D}=1, \mathrm{P}(\mathrm{x}))] = E[E(Y_1/D=1, P(x)) - E\left(\frac{Y_0}{D}=0, P(X)\right] \quad (8)$$

The variable of interest is the coefficient α in equation (9) which is average treatment effect of participating in Maize production. The ATE model can be specified as:

$$Y_i = X_i^{'}\delta + \alpha D_i + \varepsilon_i \quad (9)$$

Where Y_i is the crop income, ε_i is a normal random disturbance term and D_i is a dummy variable for participation in Maize production; $D_i = 1$ if the household produces maize as their main crop and $D_i = 0$ if otherwise. Nevertheless, the treatment variable D_i is not randomly assigned among households participating in Maize production, which means is endogenous to Y. The vector X_i represents the vector of control variables. The variables used in the analysis are presented in Table 2:

Table 2: Study variables and their measurements.

Variable	Variable description	Expected Sign
Agriculture participation	Dummy Participation (1= maize production)	
Household head Education	Level of education in numbers of years	+
Fertilizer use	Dummy for use of fertilizer (Yes=1)	+
Pesticide use	Dummy for use of pesticides (Yes=1)	+
Herbicides use	Dummy for use of Herbicides (Yes=1)	+
Off farm employment	Dummy for off farm employment (Yes=1)	+/-
Irrigation use	Dummy for use of Irrigation (Yes=1)	+
Cooperative	Dummy if is member of cooperative (Yes=1)	+
Land size	Land size used in Acres	+
Seed used	Dummy for Seed used (1=local)	-/+
Household head age	Age of household head in years	-/+
Household head sex	Dummy of sex of household head (1=Male)	+/-
Household head size	Total number of households	+
Household Income	Average monthly crop income in Tsh	+
Poverty Status	Poverty status (1= poor)	+/-

The study also examined the validity of assumptions used in evaluating treatment effects. Normally, PSM is underlined by three assumptions, when estimating treatment effects and these are as mentioned herein. The first is a Conditional Independence Assumption (CIA), which controls the observable covariate that could affect the decision of the household to participate in maize production, assuming that observed explanatory variables of the household (X), the outcome is independent of participating in maize production which may be written as: $Y_0, Y_1 \perp D/X$. The second assumption is common support which ensures the probability of households who participate in Maize production are in a strict interval to allow overlap in attributes between participants and non-participants. To ensure enough matching, meaning that household with the same X values have a positive probability $(0 < [Pr(X) = P(D = 1/X)] < 1)$ of being both participants and non-participants (Becerril and Abdulai, 2010). The third assumption is the balanced assumption. This study conducted a balance test to ensure that households with similar propensity scores share similar unobservable attributes irrespective of their participation in Maize production (Wang *et al*., 2021; Zhao *et al*., 2021), which can be written as; $D \perp X/Pr(X)$. Given the analysis's reliance on propensity scores rather than conditioning on all covariates, it was essential to assess whether the matching procedure successfully balanced the distribution of relevant variables in both the control and treatment groups (Austin, 2012; Olounlade *et al*., 2020). This involved creating "blocks" or groups of households (participants and non-participants in maize production) with identical propensity scores, aligning with the assumptions of balanced scores (Becerril and Abdulai, 2010).

Results and Discussion

Descriptive Statistics Results

This section presents results of the descriptive statistics for farmers who participated in maize production and farmers who did not participate in maize production shown in (Table 3). The results indicate that on average, there is a statistically significant difference at 5% level between farmers participating in maize production and those farmers who did not participate in the maize production in terms of education, use of pesticides, use of fertilizer, use of irrigation, land size, seed used, household head sex and household income, poverty status. The results imply that participants in maize production are on average, have many years of education, larger land size, used fertilizer, pesticides and local seeds highly. Also, they were more employed in off-farm, and from female headed-households with low irrigation use and poor than non-participants in Maize production.

Table 3: Descriptive results for participants and non-participants in maize production

Variable	All means	Participant	Non-participants	P-Value
Household head education	6.294	6.465	6.055	0.000
Fertilizer use	0.353	0.461	0.2	0.000
Pesticide use	0.125	0.155	0.083	0.000
Herbicides use	0.065	0.065	0.066	0.846
Off-farm employment	0.427	0.449	0.396	0.000
Irrigation use	0.0114	0.019	0.006	0.000
Cooperative membership	0.146	0.141	0.153	0.08
Land size	2.2	2.5	1.8	0.000
Seed used	0.757	0.636	0.926	0.000
Household head age	45.335	45.234	45.478	0.373
Household head sex	0.827	0.819	0.838	0.0075
Household size	6	6	5	0.9124
Household Income	208845	193256	230724	0.000
Poverty status	0.372	0.334	0.399	0.000

Results and Discussion on factors influencing smallholders farmers' participation in maize production.

Table 4 presents the results of the probit model, our model fitted the data reasonably well [Chi-squared = 2519, P= 0.000)]. The results reveal that out of thirteen explanatory variables considered, nine variables were found to significantly influence maize participation among smallholder Maize farmers. The log-likelihood estimates of the probit regression model indicate that fertilizer use, off-farm income, land size use and type of seed used were positive and significant while on the other hand, sex of the household head, cooperative membership, irrigation use and herbicides use were found to negatively and significantly affect the participation in maize.

Also, farmers participating in off-farm employment were found to have a higher probability of participating in maize production by 3%. This implies that the farmers who participate in off-farm employment are more likely to participate in maize production than those who do not participate in off-farm employment. The plausible reason is that, with limited capital outlay which is a dominant feature among smallholder farmers in Tanzania, participation in off-farm employment helps farmers to have access to necessary inputs, technology, and markets needed in production process and hence act as motivator for participation. The findings are similar to those of Alabi *et al*. (2021), Anang *et al*. (2020) and Addai *et al*. (2022)

Fertilizer use was found positively and significantly related to the participation in Maize production. The result indicates that the probability of participating in maize production is higher by 26% among farmers who use fertilizer in production of maize. This implies that the farmer who uses fertilizer has a higher probability of participating in maize production than their counterparts. Furthermore, access and fertilizer use enable rural households to increase productivity in maize production. Whereas the results are similar to the study of Thompson *et al*. (2019), they are also contrary to the study of Sarkar *et al.* (2021) and (Kinyondo & Magashi, 2017). This suggests that the high cost of fertilizers, coupled with limited access and knowledge, can deter smallholders from using them, leading to lower yields and decreased participation.

Land used was found to be positive and statistically significant influencing the probability of household participation in maize production. Accordingly, the land size used in agricultural production increases the likelihood of households to participate in maize production. The model outcome indicated that as the size of land used increased by one acre the probability of households participating in maize production increased by 7.4%. A similar relationship was reported by Midamba, (2022) and Anang & Ayambila, (2020).

Regarding type of seed used, the probit model results revealed that type of seed used positively and significantly affects the decision of households to participate in maize production at 5% level. The farmer who uses local seed in production has a 32.8% higher probability of participation in maize production than those who use improved seeds. This shows that household farmers who use local seeds in agriculture are likely to participate in maize production. The results are contrary to the study of Geffersa *et al.* (2022) and Abdoulaye *et al.* (2018) who found positive and significant effect of improved maize seeds on participation in maize production. The contrary results are due to the high cost of improved seeds, coupled with limited access and knowledge, can deter smallholders from using them, leading to lower yields and decreased participation (Biswas *et al*., 2023).

Poverty status is found to positively and significantly affect the probability of household participation in maize production. Specifically, the results reveal that a poor farmer is more likely to participate in maize production than a non-poor farmer by 20.2%. This relationship is statistically significant at the 1% level. These findings are consistent with our hypothesis as well as previous research of Dwi Yennie *et al.* (2021) and Balogun *et al.* (2021). This is because maize is a subsistence crop that provides both food and income to households, making it an essential part of their livelihood strategies. Poor households are more dependent on maize for their food and income needs, and thus, they are more likely to engage in its production.

On the other hand, the sex of the household head was found negative and significant associated with the probability of household participation in maize production at 1% level. A male headed household had 10.3% lower probability to participate in maize production compared to the female headed household. The result concurs with our theoretical predictions and hypothesis that being male, or female does not real matter in production of maize. Similar results were found by Midamba, (2022) and Abokyi *et al.* (2020)

Cooperative membership found negative and significant related to participation in maize production at 1% level. This means that the probability of participating in maize production is lower by 9.5% for the smallholder maize farmers with a membership in cooperative than those without membership in a cooperative. This reveals that households who are members of a cooperative are less likely to participate in maize production than households that do not belong to the cooperative. The result is surprising and inconsistent to the previous studies (Hu *et al.*, 2021; Wang *et al.*, 2021; Zhang *et al.*, 2021) which found positive and significant association between membership in cooperative and participation of agricultural production. The reason for inconsistent results is perhaps high membership fees, lack of trust in the cooperative leadership, and unequal distribution of benefits can discourage smallholders from joining and participating in cooperatives (Ahmed & Melesse, 2018).

The use of irrigation farming was found to be negatively and significantly at 1% level related to the participation in Maize production. This means the probability of participating in maize production is lower by 34.8% for the farmers who use irrigation farming than farmers who do not use irrigation farming, which is contrary to our hypothesis. This shows that small-scale farmers using irrigation are less likely to participate in maize production than those who are not using the irrigation system. The reason for this result is fact that large proportion of maize farmers in Tanzania are involved in rainfed agriculture and only 2.5 percent of cultivated area in Tanzania is under irrigation including maize area (National Bureau of Statistics, 2021). Also, the result confirms the descriptive results in Table.4 that only 0.1% of the smallholder famers are using irrigation farming. This result is consistent with that of Zhang *et al.* (2021) in Tanzania.

Use of Herbicides revealed negatively and significantly at 1% level related to the participation in Maize production. This means farmers who use herbicides have 22.3% lower probability of participating in maize production than those who do not use herbicide. This implies that farmers who use herbicides in agriculture production are less likely to participate in maize production than those who do not use herbicide. On this study probability of participation in maize and using local seeds was 33% higher than those who used improved seeds. This result is consistent with those of Santpoort, (2020).

Table 4: The estimated results of the Probit model on determinants of participation in maize production

	Coef.	Robust Std. Err.	Marginal Effects	Std. Error
Household head sex	-0.278	0.034	-0.103***	0.012
Household head Age	-0.001	0.001	-0.000	0.000
Household head Education	-0.001	0.004	-0.000	0.001
Household size	-0.009	0.004	-0.003	0.002
Cooperative Membership	-0.243	0.038	-0.095***	0.015
Off-farm employment	0.08	0.026	0.030***	0.010
Land Size	0.192	0.009	0.074***	0.003
Irrigation	-0.913	0.125	-0.348***	0.041
Seed use	0.858	0.032	0.328***	0.012
Fertilizer use	0.716	0.03	0.260***	0.010
Herbicides use	-0.568	0.057	-0.223***	0.022
Pesticides use	-0.008	0.043	-0.003	0.016
Poverty status	0.549	0.028	0.2025***	0.01
Constant	-1.067	0.087		
Mean dependent var		0.584		
Pseudo r-squared		0.157		
Chi-square		2519.097		
Observation		11812		
Prob>chi2		0.000		

*** *p<.01*, ** *p<.05*, * *p<.1* significant at the 1, 5 and 10 percent probability levels, respectively

Results on the effect of household participation in Maize production on Income

Table 5 displays the outcomes of the average treatment effect on the treated (ATT) using two different matching methods. The findings suggest that engagement in maize production leads to a decrease in income for smallholder farmers. Specifically, the results obtained through the nearest neighbor matching method demonstrate a statistically significant reduction in crop income at a 5% significance level when participating in maize production. The reduction of income on average is about 69,569 TZS for smallholder farmers participating in maize production. On the other hand, the estimated result from kernel-based matching method revealed a negative and significant effect of participation in maize production on crop income. On average, participation in maize production decreases the crop income by 78,601 TZS. The results further show that if the household produced maize as their main crop, they would have obtained a decrease in crop income of between 60980.738 TZS –64228.087 TZS (Table:5). The result is consistent with study of Wanjala and Muradian (2013). Differently, the result is inconsistent to the study of Osabohien *et al.* (2021) who found participation in agriculture is positive related to crop income among youth in Nigeria. The difference in results is associated with fact that this study included only maize in studying about 11,812 smallholder farmers while, Osabohien *et al*. (2021) included agricultural crops with a sample of only about 300 smallholder farmers in Nigeria.

Table 5: The PSM results on the effect of participation in maize production on crop income.

Variable	Sample	Treated	Control	difference	Std. Err	T-Stat
			NNM			
Household Income	**Unmatched**	**96627.9802**	**115361.954**	**-18733.973**	**3302.35654**	**-5.67*****
	ATT	**95922.8071**	**165491.948**	**-69569.141**	**10448.6569**	**-6.66*****
	ATU	**115389.753**	**51161.666**	**-64228.087**		
	ATE			**67339.982**		
			KBM			
Household Income	**Unmatched**	**96627.9802**	**115361.954**	**-18733.973**	**3302.35654**	**-5.67*****
	ATT	**95922.8071**	**174524.111**	**-78601.303**	**5280.25465**	**-14.89*****
	ATU	**115389.753**	**54409.015**	**-60980.738**		
	ATE			**-71247.129**		

Note: *** p<.01, ** p<.05, * p<.1 respectively.

Figure 4 visually represents the propensity score distributions of the treated and control groups. The upper half of the graph pertains to the treatment group, while the bottom half represents the control group. The y-axis represents the density of estimated propensity scores, and the x-axis represents the propensity score values. To ensure comparability, a common support condition is enforced, requiring the propensity score distribution of both groups to overlap. The estimated propensity scores range from 0.15341 to 0.982538 (mean = 0.567974) for the treatment group, and from 0.049252 to 0.982538 (mean = 0.515895) for the control group. Consequently, the common support region is bounded between 0.174374 and 0.982538. Any samples falling outside this range were excluded from the analysis conducted to estimate the average treatment effect on the treated (ATT) in both groups. As a result, approximately 91 percent of the treated and control groups were within the common support area, indicating substantial overlap between the two groups.

Figure 4. Distribution of estimated propensity scores for participants and non-participants in maize production

Table 6 displays the results of the balancing tests conducted on each matching algorithm before and after the matching process. The findings demonstrate a notable reduction in mean standardized bias from 22.2 percent (pre-matching) to 4.2 to 5.6 percent (post-matching). Moreover, the Pseudo-R^2 value experiences a substantial decline, decreasing from 15.7 percent to 0.6 percent. Prior to matching, the likelihood ratio tests reveal the joint significance of all covariates at a probability level below 1 percent. However, after matching, these tests no longer indicate significant joint significance. Additionally, the matching process leads to a significant decrease in total bias, ranging from 58 to 66. These outcomes provide clear evidence that the matching procedure effectively balances the observed characteristics between the treated and control groups.

Table 6: Covariate balancing tests before and after matching.

Matching algorithm	**Pseudo-R²**		**LR χ2 (P-value)**		**Mean standardized. bias**		**Total bias reduction %**
	Before	After	Before	After	before	after	
MNM	0.157	0.006	2515.30 (0.000)	75.65 (0.247)	22.6	4.2	66
KBM	0.157	0.006	2515.30 (0.000)	122.29 (0.15)	22.6	5.6	58

From Figure 5, the nearly identical density plots for the matched sample indicate that matching the predicted propensity score balanced the covariates. Therefore, plots derived from the matched data appear to be balanced.

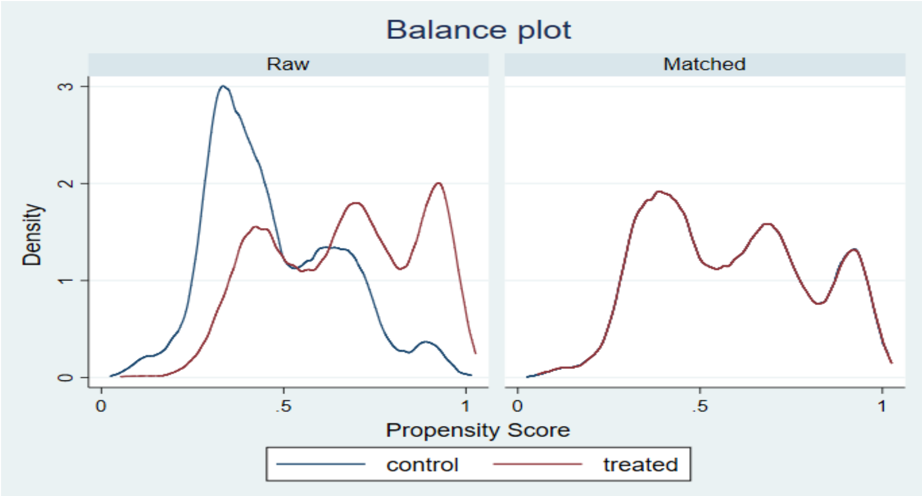

Figure 5. Kernel density plots for checking the covariate balance before and after matching.

Conclusions and recommendation

This paper analyzed specifically two specific objectives. Firstly, the drivers of participation in maize production and then, the effect of participation in maize production on crop income among smallholder farmers. From the study, fertilizer use, off-farm income, land size used, and seed used were important drivers of participation in maize production. The findings imply that there is a need for promotion and support on use of improved inputs particularly fertilizer for the farmers to participate in maize production. Furthermore, the study emphasizes the need to create more favorable environment for availability of improved seed as well as for increasing land ownership to be used in production of Maize. In addition, government can provide favorable conditions that will easy land rights occupancy in rural areas among small-scale maize farmers to increase their maize cultivated area.

Moreover, participation in maize production does not necessarily make smallholder farmers better off in terms of crop income. This finding is associated with the fact that on average, the majority of smallholders participate in maize production while using local maize seeds which results into low yields and thus, low crop income. Therefore, to improve crop income particularly of maize, the government and other stakeholders need to promote the participation in maize production by considering support of necessary agricultural inputs including improved maize seeds and fertilizer.

The study's limitation is its quasi-experimental research approach, which limits the ability to establish correlations and develop a thorough grasp of long-term trends. A longitudinal or experimental research design would be more effective in understanding how dynamics evolve over time. For a future study, examining the effects of climate-resilient farming techniques and sustainable agricultural approaches on maize output and income for Tanzanian smallholder farmers is crucial, especially regarding changing climate conditions. A comparison analysis of the income implications of participating in maize production compared to other crops would also highlight relative profitability and prospective diversification options for these farmers.

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