FACTORS INFLUENCE THE ADOPTION OF IMPROVED AGRICULTURAL PRACTICES AMONG SMALLHOLDER FARMERS IN THE RIPAT PROGRAM.

Abstract:
Maize plays a significant role in securing food insecurity mostly in developing countries such as Africa especially in Tanzania where it is a main dietary staple for majority of people national wise. This research assesses the factors that influence corn production level among small scale farmers benefits from RIPAT SUA Project in Morogoro, Tanzania. The project aims to improve maize production and food security through different improved agriculture practices such fertilizer use and intercropping method. A study was carried out using cross-sectional design with 110 smallholder farmers. Information was collected through semi-structured questionnaires and analyzed using descriptive and bivariate probit regression model. Findings reveals that aspect like household income, farm size, farmer experience and training play a crucial role in the adoption of improved agriculture practices. Specifically household income ($p = 0.04$), was found to have a positive effect on fertilizer utilization. Whereas receiving training ($p = 0.007$) was essential for implementing intercropping methods. However, adoption was not significantly impacted by education. The research findings conclude that increase training opportunities, specifically for farmers with minimal education and matching access to credit availability with agricultural investment. This measure will assist small scale in boosting productivity, eventually supporting the sustainable growth of agriculture in Tanzania.
Keywords: Maize productivity, Food security, Smallholder farmers, Agriculture practices, Bivariate Regression.

1. Introduction:

Maize production is significant in securing food for small-scale farmers in sub-Saharan Africa, especially in countries like Tanzania in East Africa (Utonga, 2022; Santpoort, 2020). This

highlights the significance of this corn among crucial agriculture systems and households' food security in Morogoro municipality. Despite being vital, but maize production face numerous challenge like climate, financial constraints, inability to access advanced technologies, and social economic restrictions(Kasoma et al., 2021; Adenle et al., 2018; Farooq et al., 2022).

The Rural Initiatives for Participatory and Agriculture Transformation (RIPAT) SUA Project, was conducted between 2017 to 2021, aimed to oppose these setbacks and enhance maize production output in households in Morogoro Municipality. The project collaborated with Regional Community and Development Associations (RECODA) and Sokoine University of Agriculture (SUA), focused on impacting agriculture practices, increase the availability of agriculture supplies and upgrading the maize farming expertise of farmers.

In a global context maize, provides an estimated 30% of calories is consumed by 4.6 billion people, and is considered to be a staple crop in over 125 developing countries where the majority of producers are smallholder farmers (Nyirenda et al., 2021)**.** Parallel calories are consumed in both Eastern and Southern Africa region (Ekpa et al., 2019)**.** However in Sub – Sahara Africa (SSA), zone the average maize yields remains to be low with production level of 2 tons per hectare which is five times less than the yield potential as determined by climate and soil that prevails in Sub -- Sahara Africa (SSA) producing zone *(*Aramburu-Merlos et al., 2024*)***.** which is contrary with potential standards emphasized with a World Agriculture Production (WFP), average level of 5.8 tons per hectare *(*Dukhnytskyi, 2019**).** This yield gap troubleshoots the urgent need for initiatives such as the RIPAT SUA project to boost maize production and food security at the household level.

East African regions such as Tanzania have pursued different efforts to increase maize production. For instance, The Water Efficient Maize for Africa (WEMA), project has focused on creating maize varieties that can withstand drought and pests in Africa (Daniel Otunge et al., 2010). The Innovation and Inclusion Industrialization project in the Agro-processing Value chain in Maize aims to determine innovation and inclusion and challenges Small and Medium Enterprises (SMEs) participation in agro-processing value chains(Brief, 2020). The Rural Initiatives for Participatory Agriculture Transformation (RIPAT) SUA in Morogoro Municipality is based on these regional initiatives and customizes interventions to accommodate the specific requirements of small-scale farmers in the areas.

In the case of this study, the study opts to use bivariate probit regression model to assess different factor the triggers the use of improved agriculture practices among households in Morogoro municipality, specifically in Magadu, Mlimani, and Kauzeni wards. Through the use of this econometric approach, the researcher focuses on considering possible connections among various adoption choice, allowing for a profound understanding of how specific initiatives impact farmers' decisions and agriculture in general. This approach allows for a classier view by taking into account individual household factors as well as possible influence at the ward level.

Numerous studies have troubleshoot the significance of improved practices in enhancing agriculture methods to boost maize productivity and food security in Tanzania , specifically small

scale farming practices, (Milheiras et al., 2022; Jin et al., 2022, ; Mushi et al., 2022). Nevertheless, the specific influence of agriculture initiatives in project like RIPAT SUA on the adoption of improved practices as well as how they contribute to boost productivity are yet unknown. Therefore, the study focuses on how RIPAT SUA attempts to fill gap by examining how various socio-economic characteristics such education level, Household income, and access to agriculture services, affect the chance of adopting improved practices. This finding will add the knowledge to the literature on how focused interventions might improves agriculture efficiency and food security, with possible implications for similar projects and programs in Tanzania to both rural and urban areas, and across East Africa region.

2.0 Methodology

2.1 Study Area

The study on which this paper is based was conducted in the Morogoro Region, located in the Mid-eastern part of Tanzania specifically in Morogoro Municipality which is located along the slopes of Uluguru Mountain. The district is found at the latitude 6°49'20" S and longitude 37°40'0" E. The agriculture profile of Morogoro Municipality is arable land is 11,844ha out of 4,623,005ha of Morogoro region, The nature of the soil in mountains area is mainly Oxisols which are general in nitrogen and phosphorus, in valley and low land areas are generally characterized by fertile alluvial soils. Morogoro Municipality is famous for producing food and cash crops, especially Maize 6.6%, paddy 5.8%% other crops 11.8%, region peas 16.9%, and sugarcane 59.4%% (URT,2020). Morogoro municipal district was purposively selected because it is one of the districts where the RIPAT SUA project was implemented. The study will focus on Maize farmers since maize is the first step crop produced and consumed because of its high carbohydrate content, maize is a major source of calories. Also, maize is the dominant annual crop grown in the Morogoro region and it had a planted area 1.5 times greater than paddy, despite of increase in area of production but the yield has dropped over the years since 1994/1995 (URT, 2007). The study looks at important factors in Morogoro Municipality's maize production. Age, land size, maize output, income, education, agricultural experience, and marital status are a few of these. These variables included are important for agricultural practices and results as both factors work together to influence farming methods and results, highlighting the complex nature of farming success

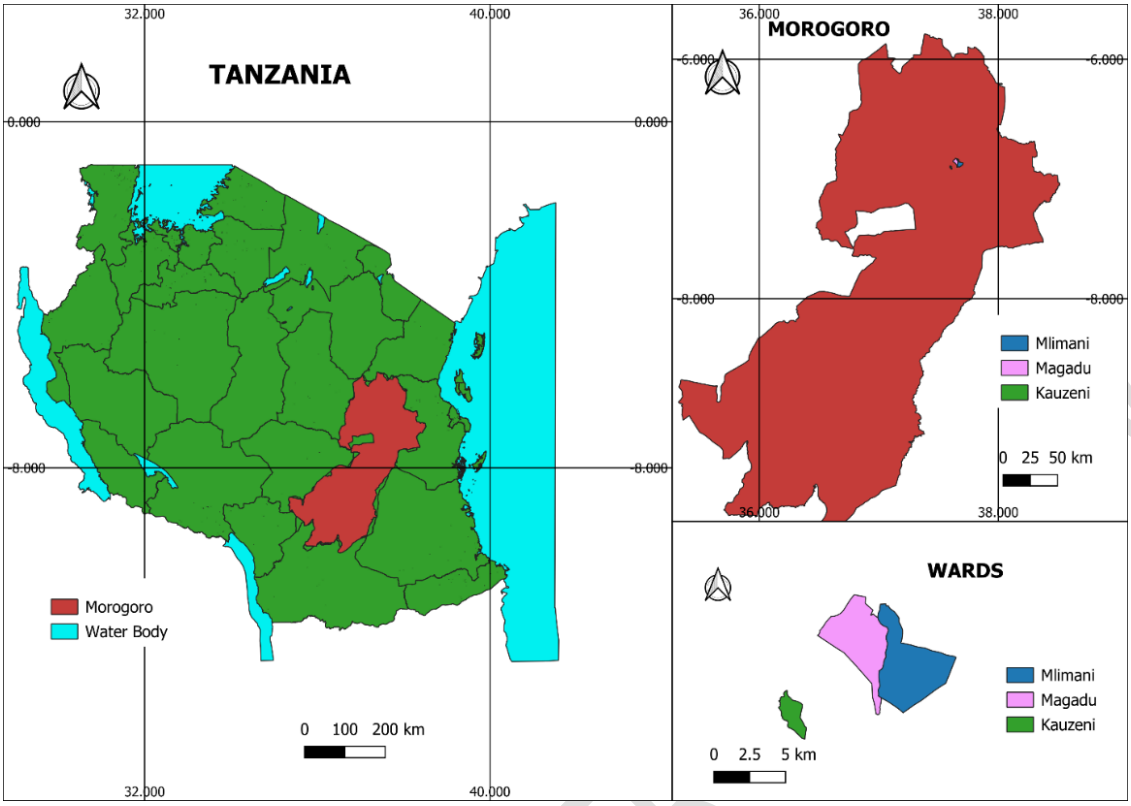

Figure 1. Showing the study area.

2.2 Research Design

The study adopted a cross-sectional design. (Setia, 2018) states that the design is associated with the benefits of its use in that the researcher's measure involves collecting particular information at a given time from respondents, and also allows the researcher to check how someone is exposed to a certain thing and what happens as a result. The design provides a snapshot of ideas, opinions, and information on activities performed by the RIPAT-SUA project, factors affecting the performance of the RIPAT-SUA project, and the effects of the project intervention on food security. However, the limitation of this design is the inability to establish causality between variables since data is collected at once. Hence to tackle this limitation the study performs a strong statistical analysis to investigate correlations among variables and identify potential confounding factors.

2.3 Sampling Procedure and Sample Size.

A purposive selection procedure was used to select 110 farmers who are beneficiaries of the RIPAT-SUA project because targeted farmers received interventions from the RIPAT SUA Project. According to the human population census of 2022, Morogoro municipality has a total population of 471 409 while the project was implemented in two districts Morogoro municipality and Mvomero. The project was implemented for 250 farmers in Morogoro municipality which will also be taken as the study population.

Sample size.

The study used Yamane's formula of 1967 to determine its sample size. The precision level used is 7% statistically for the objectives of the study, this degree of precision guarantees that the projected sample size is reliable and statistically significant.(Stadtländer, 2009).

$$n = \frac{N}{1 + N(e^2)}$$

Where:

n = Sample size**,**

N = Population size (250), and

e = Level of precision (7%)

$$\boldsymbol{n} = \frac{250}{1 + (250\, x(0.07)^2)}$$

n = 112.3595505617 ~ 113

2.4 Data Collection

A structured Questionnaire with both open-ended and close-ended questions was used to collect Quantitative data from the beneficiaries of the RIPAT SUA Project. The types of data to be collected include the contribution of the RIPAT project on food security, farmers' participation in the project, challenges faced during project implementations, and way forward in addressing challenges facing the implementations of agriculturally based projects.

The data that were collected using a questionnaire were analyzed using (STATA MP Version 17) software. Data cleaning was done to ensure the quality of the data. Descriptive statistics were used to analyze quantitative data; frequencies and percentages were generated to quantify the information. Moreover (Cameron, 2007;Li et al., 2019) the Bivariate probit model is utilized to compute two binary outputs which can be mathematically described as two unobserved continuous latent variables. In this case study, smallholder farmers' adoption of fertilizer user measure is represented by Y_1^*, and their application of the intercropping system is represented by Y^*_2. The two latent variables that are not observed can be represented by equations (1) and (2).

Model specification

In the Bivariate Probit model, two equations are estimated jointly, each corresponding to one of the binary decisions:

$Y_1^* = X_1\beta_1 + €_1$ ---------- (1),

$Y^*_2 = X_2\beta_2 + €_2$ ---------- (2).

Where:

Y_1^* represents the latent variable for fertilizer use

Y_2^* represents the latent variable for intercropping practices

X_1 and X_2 are vectors of the explanatory variables for fertilizer use and Intercropping practices respectively

$€_1$ and $€_2$ are the error terms, used to follow a bivariate normal distribution with zero means, unit variance, and correlation *p.*

The collective distribution of both ($€_1, €_2$) errors has a variance of 1 and mean of 0. A vector of the independent variables with estimators β common to both outcomes is called variable x1. Equations (3) and (4).

$Y_1 = 1$ if $y^*_1 > 0$, otherwise $Y_1 = 0$ ---------- (3)
$Y_2 = 1$ if $y^*_2 > 0$, otherwise $Y_2 = 0$ ---------- (4).

3.0 Results and Discussion

3.1 Social Demographic Information of the Respondents.

The information displays participants' demographics in the RIPAT SUA Project, which aims to increase smallholder farmers' food security by encouraging appropriate agriculture inputs.

Table 1: Demographic information of the respondents (n= 110)

Respondents' characteristics	Category	Frequency	Percent (%)
Age	20 – 35	39	34.8
	36 – 45	17	15.2
	46 – 55	25	22.3
	55+	29	25.9
Gender	Male	42	38.2
	Female	68	61.8
Marital status	Married	89	80.9
	Single	5	4.5
	Divorced	11	10.0
	Separated	5	4.5
Household size	1-3	43	39.1
	4-6	59	53.6
	7+	8	7.3
Education level	Primary education	99	90.0

	Secondary education	10	9.1
	Collage/University Education	1	0.9

Age of respondents:

Results show that the majority of household heads were youth (34.8%) ranging from 20 to 35 remaining groups. The finding is consistent with Assenga and Kayunze, (2020) who found that the population was characterized by a young population. A few (15.2%) of the heads were in the age range of 36 to 45. The lower percentage of mature youth in a sample may be attributed to the tendency of matured populations to face the transition phase of their lives to migrate to urban to secure employment and low wages. These challenges can be addressed by improving access to education and employment opportunities can help to mitigate the challenges faced by youth.

Gender and Martial status of respondents:

Results show that the majority of respondents are female (61.8%). According to Assenga and Kayunze, (2020), gender plays an important role in household food security for both men and women with the implication that women contribute to agriculture through cultivators, and entrepreneurs in rural production. This is also, supported by Oduniyi and Tekana, (2020), who stated that rural females can engage in different agricultural activities such as gathering food, trading, and processing small agricultural produce which generate income. Concerning marital status (80.9%) of the households' heads were married; the rest had various marital statuses as seen in Table 1 according to Assenga and Kayunze, (2020) married people are more likely to be food secure than single, divorced, and separated.

Education level of respondents

Results show that the majority of respondents fall under primary education (90%), compared to the rest of secondary education with 9.1% and college education with 0.9% the overall results imply that the majority of rural households in Tanzania is inhibited by people with low education levels. This result is supported by the study by (Kingu, 2020, Isaya et al., 2018) who found that the majority of rural people have low education which might affect food security negatively with the implication that education is vital in rural people as it fosters development in rural development as it is a key factor in rural people community.

Household size of respondents:

Results show that the majority of respondents fall under 4-6 members (53.6%). This household size is within the country's average household size of 4.7 members (URT, 2023). According to Mwalukasa, (2018) who stated that household size is important which implies that some agricultures activities can be done by other members and enhance production. This is also supported by Ntwalle, (2019) who argues that large household sizes are more likely to diversify due to an increase in labor availability.

3.2 Bivariate probit Analysis of Adoption of improved Agricultural Practices: Factors influencing Fertilizer Use and Intercropping.

The study utilizes a Bivariate Probit Regression model to evaluate the factors that influence smallholder farmers' decision to adopt improved agricultural practices, such as using fertilizer and intercropping. The study consists of seven key important factors. The model underscores the connection between adoption decisions and demonstrates the notable impact of factors such as access to credit, household income, extension services, and training on the likelihood of adoption. The Wald chi-square of 23.371, with a p-value of 0.054, indicates a strong fit for the data.

Household income in Table 2 highlights has a positive impact on fertilizer consumption, indicated by (a coefficient of 0.398 and a p-value of 0.04) at the 5% level. This entails that farmer with higher income levels were more likely to use fertilizer compared to farmers with lower income level. The possible reason is that farmer with higher income level is able to pay for the expenses related to the fertilizer use, which enhance household output. This result is in agree with Varma & Wadatkar, (2024) who, argued that richer farmers often implement sustainable techniques by combining mineral and organic fertilizer to improve soil fertility and crop yields while lowering reliance on pricey chemical fertilizers. Similar, to Akol et al., (2023), who argued that Africa farmers opt for suitable agriculture methods such as the use of organic manure which offer better health of production and soil health over the chemical fertilizer which destroy the land fertility

Farm Size in Table 2 highlights has positive impact on intercropping practices indicated by (a coefficient of 0.348, $p = 0.077$) at the 10% level. This entails those farmers with larger farmer size were more likely to engage in intercropping than those with smaller plots, because large farms offer flexibility, permitting farmers to undergo diverse cropping patterns, which can attribute productivity and land use efficiency. In keeping with these findings of with Werf, (2023) who, argued that greater biodiversity and natural pest management are made possible by larger land area, which also make crop variety and intercropping easier to execute. Similar to Bene et al., (2022) who, argued that larger farm size can successfully support the simultaneous cultivation of various species, intercropping improves agriculture diversification and sustainability while optimizing resources use and ecological advantage.

Results reveal that farming experience has a favorable and statistically significant effect on intercropping adoption at the 10% level (coefficient; 0.972, p-value: 0.077). This suggests that compared to farmers with less experience, more experienced farmers are more motivated to use intercropping, demonstrating the need for knowledge in handling intricate farming systems. Findings show that experienced farmers can perfectly manage complex intercropping practices, leading to increased resilience and productivity, helping to minimize risk and maximize land utilization. This finding is consistent with Dugassa, (2023), who suggested that experienced farmers can enhance production and resilience through intercropping by mitigating risk associated with pests, and optimizing resource allocation. Just like Huss et al., (2022), who suggested that having skills in agriculture can help farmers make the most out of their land, increase productivity, and enhance resilience in intercropping methods, thus reducing the chance of scarcity of resources and crop failure.

Concerning Training from the project; the results reveal that training has benefits and a greatly important effect on the adoption of intercropping at the 1% significance level (coefficient: 0.847, p-value: 0.007). This entails that trained farmers have a much higher chance of embracing intercropping. This highlights the important function of farmers' training programs in advancing sustainable agriculture practices which offer necessary skills and knowledge. As observed by Mosonsieyiri et al., (2021), providing training to farmers gives them the technical know-how needed to implement intercropping systems, leading to increased crop yields and greater sustainability on the farm. Similar training enhances the adoption and upkeep of Sustainable Land Management technologies, to encourage the adoption of Sustainable Land Management among a variety of smallholder farmers, training might provide an affordable solution.

Table 2. Factors that influence Fertilizer use and Intercropping Adoption among Smallholder Farmers: A Bivariate Probit Regression: (N=110).

Variables	Coef.	St.Err.	t-value	p-value	Sig
Education	-0.346	0.398	-0.87	0.384	
Experience	-0.79	0.583	-1.36	0.175	
Access to Credit	-0.072	0.452	-0.16	0.874	
Farm Size	-0.203	0.136	-1.49	0.137	
Household Income	0.398	0.193	2.06	0.04	**
Extension Service	0.253	0.312	0.81	0.418	
Training	-0.267	0.251	-1.06	0.288	
Constant	-3.084	2.43	-1.27	0.204	
Inter Cropping					
Education	0.191	0.544	0.35	0.726	
Experience	0.972	0.551	1.77	0.077	*
Access to Credit	0.941	0.59	1.6	0.111	
Farm Size	0.348	0.197	1.77	0.077	*
Household Income	0.343	0.251	1.37	0.171	
Extension Services	0.051	0.364	0.14	0.889	
Training	0.847	0.312	2.72	0.007	***
Constant	-5.547	3.355	-1.65	0.098	*
athrho	-0.039	0.19	-0.21	0.836	
Mean dependent var	0.8		SD dependent var		0.402
Number of obs	110		Chi-square		23.371
Prob > chi2	0.054		Akaike crit. (AIC)		267.285

**** p<.01, ** p<.05, * p<.1*

3.3. Marginal Effect of Bivariate Probit Model on factors that influence agriculture practices.
By utilizing the bivariate probit model, table 3, below reveals the marginal effect of different factors on the adoption of agriculture practices. The study investigates how education, credit access, Land size, experience, extension services, household income, and training affect the likelihood of smallholder farmers' adopting certain practices. The findings insist on the importance of having access to credit.

Table 3. Marginal Effect of Bivariate Probit Model on Factors that Influence Agriculture Practices

variable	dy/dx	Std. err	z	P>z
Education	-0.093	0.143	-0.65	0.517
Experience	-0.024	0.185	-0.13	0.895
Access to Credit	0.07	0.161	0.43	0.664
Land Size	-0.028	0.05	-0.56	0.575
Household Income	0.169	0.07	2.43	0.015
Extension services	0.089	0.11	0.81	0.419
Training	0.009	0.088	0.1	0.918

Based on the marginal effects findings in Table 3, reveals that household's income has a statistically significant positive impact (P =0.015), with a marginal effect of 16.9%. This suggests Household with high income are more likely to adopt agriculture practices under study. This highlights that financial capability directly supports farmers ability to invest in improved farming techniques, which aligns with research by Kurgat et al., (2020), indicating that having access to financial resources may boost agriculture investment by adopting specific practices that may not always result from them unless other factors such as awareness or training, are taken into consideration. Similarly, smallholder farmers' freedom in resource allocation may be restricted by responsibilities associated with financial resources, as indicated by research from Lazaro & Alexis, (2021)

4.0 Conclusion and Recommendation:

The findings display that the age, gender, marital status, education level, and household size of smallholder farmers are vital factors influencing agriculture practices and food security results. The majority of participants were youthful, women, married, and had elementary schooling, mirroring, the demographic of rural areas in Tanzania. Limited educational attainment and extensive family sizes, point to the available workforce for farming, underscoring the importance of education and empowerment initiatives in enhancing food security.

The analysis of the adoption of improved agriculture techniques using a bivariate probit model reveals that, household income, farming experience, farm size and training significantly influence farmers' choices to adopt fertilizer use and intercropping. Interesting, increased household income was found to have impact on fertilizer usage suggesting that farmers with money are more likely to spend on fertilizer to enhance productivity. On the other hand, intercropping was significantly influenced by farm size and training, emphasizing the importance of large farms and agriculture education in promoting varied cropping methods. Additionally, farmers with experience were more motivated to incorporate intercropping, emphasizing the significance of hands-on experience in handing intricate agriculture practices.

Despite the efforts made by the RIPAT SUA Project to encourage smallholder farmers to adopt improved agriculture practices, such as fertilizer and intercropping, the findings entail further improvements are needed to increase efficiency and productivity. The project should prioritize expanding its training programs, especially targeting farmers with limited education, to enhance their technical capabilities. Furthermore, it is very crucial to coordinate credit programs with agriculture investments, ensuring that financial resources are directed towards agriculture inputs. By focusing on these important areas, the RIPAT SUA Project can better assist smallholder farmers in adopting practices that lead to higher productivity and food security.

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