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Demographic Factors Influencing Uptake of Farming Technologies Among Smallholder Maize Farmers in Mvomero District, Tanzania

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Abstract: *Despite of growing recognition of importance of farming technologies in crop production, the adoption of farming technologies at farm level is yet questionable and smallholder farmers continued to have low yield of maize. This simply means smallholder farmers need to adopt technologies if they want to enhance maize production and improve their food security and income generation. This paper evaluated the implication of demographic factors on adoption of farming technologies in maize production in Mvomero district – Tanzania. The study used simple randomly technique to choose 180 smallholder farmers of maize. The questionnaire was employed to collected data while analysis was performed by logit regression. The major finding of the study suggests that age, gender, education and experience of smallholder farmers play vital role in adoption of farming technologies in maize production. The study further reveals that education and experience of smallholders increases the adoption of farming technologies. The study also confirms that increases of age of smallholder farmers are associated with decreases the adoption of farming technologies in maize production. The magnitude of effect of experience on adoption of farming technologies was largely compared to gender and education. The study emphasize that, policy makers and other stakeholders should consider experience, education and gender while planning for dissemination of agricultural technologies. It is also advised that, older people must less given priority in planning for dissemination of farming technologies in maize production.*

Keywords*—Adoption, Farmer, Farming, Food, Maize, Smallholder, Technology*

1.0 INTRODUCTION

Tanzania is one of the developing countries whose majority of its population rely heavily on agriculture as means of surviving. The agriculture is widely practiced all over the country while smallholder farmers are mostly dominant in the sector who cultivating the farm land ranging from 0.5 ha to 2 ha (Mkonda & He, 2016). According to Terry, (2022), agriculture constitutes significantly food and income to rural people, foreign currency to the country through export of agricultural products but also it supply raw material for growing small and medium scale industries. Despite of that, agriculture is generally faced by number of challenges include climate change, inaccessibility of improved seeds, soil infertility, diseases and pests (Chimonyo et al., 2020). Also, poor agronomic practices add important implication to land degradation and deforestation.

In Tanzania, Maize contribute 10% of total value of agricultural products in the country (Mkonda & He, 2016). It is considered as second cereal crop after rice, it widely cultivated in all regions and mostly consumed by Tanzania. Maize is also contributed large share of food security to the households (Suvi et al., 2020). The consumption of maize countrywide is approximately 3,000,000 tons annually. The crop accounts for 31% of the total food production. It also contribute to large share of income to household through labour force on farming operations, sales of maize and sales of by-product from maize (Selejio & Lasway, 2019).

Despite its importance in food security and income generation, maize farming is constraints by climate change, soil infertility and poor seed quality. FAO (2016), about 56% of smallholder farmers used low quality seeds that produced locally and likely to reduce maize production by 30% if smallholder farmers continued to use local seeds. Other constraints associated with maize farming include lack of access to extension services, diseases and pests. The implication of such constraints led to low maize yield, low income and food insecurity (Grote et al., 2021). In order to address them, smallholder farmers need to adopt improved farming practice includes use of improved seeds and fertilizers. In addition, farming technology is considered as the practice that promotes improved farming technologies in crop production. Various scholars opined that the successful uptake of farming technologies by smallholder farmers, it requires involvement of stakeholders inclusive the smallholder farmers. The stakeholders are essentially participate to its roles which is changing over time (Nonga et al., 2011). The need of smallholder farmers and preferences are important when it comes to the issue of uptake of farming technologies (Kinabo et al., 2016). The choice of

farming technology is one of the driving factors that promote the crop production. The decision of smallholder farmers do adopt improved seeds is thought to involve demographic factors. Thus study by Nxumalo et al., (2019) pointed out that age, education and extension service have strong influence on adoption of maize hybrid seeds. In this aspect, increase of uptake for improved farming technology is considered as a critical strategy to maize production which in turn provide assurance of increased income and food security (Mahuku et al., 2015).

The question of uptake or adoption of farming technologies has importance in Tanzania because recognizing the demographic factors are essential to address uptake of farming technologies. Noting that if smallholders continued to have low uptake of farming technologies, maize yield could decline and if such persist it will led to food insecurity which later affect children through malnutrition. In this aspect, encourage smallholder farmers to adopt farming technologies particularly improved maize yield could have increases maize production. Adoption or uptakes of farming technologies have clearly associated with demographic factors. For instance, in India old farmers were considered most adopter of improved rice seeds while in Malaysia married farmers were linked to adoption of hybrid seeds. In addition, smallholder farmers who were of high income wer active in adoption of agricultural technologies than those with low income. Due to that scenario, examining the implication of demographic factors to adoption of farming technologies is of importance, since the youth in Tanzania is occupied more than 50% of Tanzania population unlike in previous years. This call for further studies is needed to go beyond the known factors which have been studied in many of the previous studies and explore new one. The variable age, education, marital status, household and income themselves are not new but smallholder farmer experience and its effect on uptake behaviour of farming technologies is limited. The study however evaluates the demographic factors influencing the uptake of farming technologies under smallholder maize production which have limited studies.

2.0 LITERATURE REVIEW

This section divided into two, theoretical framework which underlines theories related to adoption of farming innovation. In this study, theory of utility is more applicable to analyse underlying factors influencing the adoption of technologies on crop production. The rest part of this section devoted on empirical literature reviews of previous studies related to crop production. It examined the existence of knowledge or information related to what is known about underlying factors affecting the adoption of farming technologies on crop production.

Theory of Utility

The theory was developed and specifically was applied to the market for the consumer behaviour. Principally it assumes that the individual choice rely on utility that individual derived from taking it. From there, several studies applied the theory to assess the underlying factors for choice of agricultural technologies. The adoption of farming technologies in economic perspective, it relates to rationality in decision making. This means smallholder farmers make choice among alternatives while hoping that, expected utility derived from it will be maximized. In other word, smallholder farmers make choice of farming technologies where profit or output from maize production will be maximum (Jha et al., 2021; Dimoso & Katabi, 2021). The smallholder farmers assumed that utility or yield obtained from improved farming technologies is higher than those derived from what is commonly practiced or local farming technologies practiced for long time. While utility is not physically observed, the practice of economics by smallholder farmers are observed through choices where they make on the farm (Nxumalo et al., 2019). The expected utility is assumed as

$Uij=\beta jxi+\varepsilon j$ ' and $Uik=\beta kx\ I+\varepsilon\ k$ ' …… (1)

Uij and Uik are utilities derived from the uptake of farming technologies by smallholder farmer I selected technology j and k, Xi is a vector of independent variable that affect directly the perceived utilities. While βj and βk are coefficients, εj and εk represent the error terms and they are identically and independently distributed.

Assuming that smallholder farmer *i* choose category j in opposite to k, in other word, smallholder farmer select the item that perceived to high utilities than item with low utilities. Thus Uij> Uik, k ≠ j…..……...……..…. (2)

The utility obtained from a particular choice of farming technology may not be seen. However what is perceived is the discrete choice of the farming technologies that it relates to unobservable and continuous variable.

$Yi=1$ *if* $Uij> Uik$
$\Rightarrow\ Uij-Uik>0$
$\Rightarrow(\beta\ j\ x\ i+\varepsilon\ j)-(\beta\ k\ x\ I\ +\varepsilon\ k\ )>\ 0$
$\Rightarrow Y\ I=1$ *if* $(\beta\ j\ -\beta\ k)\ x\ i+(\varepsilon j-\varepsilon k)\ >0$ ' ' and $Y\ i=0$ *if* $(\beta\ j-\beta\ k\ )\ x\ i+(\varepsilon\ j-\varepsilon\ k\ )\leq\ 0$……...……...……..(3)

Specifically choice model considers logit, when smallholder farmers faces more than one choices, it principally becomes the probability of choice where 1 for success and 0 for failure (Liao et al., 2019). The logit model has been used to study factors associated with choice (Fadina & Barjolle, 2018). The logit is based on assumption of logistically distributed and its function is cumulative distributed (Anugwa et al., 2020). The estimation of logit model is typically probability based and mathematically is as follows;

$$P=\frac{e^{\beta\times}}{1+e^{\beta\times}} \qquad (4)$$

$$1-P=1-\frac{e^{\beta\times}}{1+e^{\beta\times}}=\frac{1}{1+e^{\beta\times}} \qquad (5)$$

$\frac{P}{1-P}$ as probability of $Y = 1$ relative to the probabilities which is zero.

Where, P = probability of success, 1-P = Probability of failure, e = natural logarithms ≈ 2.718, Xi = independent variables, β = Coefficients and i = 1, 2, 3….

Empirical Studies

Improving production and yield of crops require smallholder farmers to adopt the agronomic practices and techniques to improve production and yield of crops. Adoption of improved farming technologies is a critically important in order to enhance yield of crop. Mwalongo et al., (2020) examined the influential factors on choice of improved seeds of groundnuts in Tanzania. The primary data collected from 300 groundnut producers and probit model applied to analyse the underlying drivers for adoption. The result suggests that, age, gender, group membership, access to seeds and cost of seed were strongly affecting the adoption of crop production.

The study by Selejio & Lasway, (2019) who assessed the economic drivers of adoption of hybrid maize and industrial fertilisers in Tanzania. Primary data was collected from 1551 farming households and probit regression was opted to estimate the economic analysis of adoption of organic fertilizers and hybrid maize seed. It found that adoption of hybrid maize seeds and industrial fertilisers were as low as 28% and 21% respectively. The major finding further reveals that extension service contact was significant influencing adoption of industrial fertilizer and improved seeds. It is also noted that, education was strongly influencing the adoption of improved maize seeds.

Another study conducted by Mogaka et al., (2021) who valuated the effect Socioeconomic characteristics affecting the choice of improved soil practices under smallholder farmers, located in western Kenya. The evaluated the effect of socioeconomic factors on choice of improved soil practices under smallholder farmers. The major finding indicates that farmer's socioeconomic characteristics increases the uptake of climatic smart soil practice. The study also reveals that adoption of climate smart soil practices improve crop yield and contribute to suitable climate condition. However, the study had not clearly indicated sample size of respondents and specific socioeconomic factors influencing the adoption of improved soil practices.

Socioeconomic factors have strong role on adoption of various innovations for improving crop production and yield at farm level. Sanya et al., (2020) attempted to evaluate the role of different attributes for uptake of hybrid bananas producers in rural central Uganda. About 242 banana producers were randomly selected in Nakaseke and Luwero district. The probit regression was employed to estimate the influence of factors (Socioeconomic) and other drivers on adoption of hybrid seeds among banana smallholder farmers. The study suggests that socio-economic factors that influence the adoption of banana producers showed that education, farmer's experience, household size were significant influential on adoption of hybrid seeds of banana. The study recommends that establishment of platforms for stakeholders that bring together various actors to share information that necessary to promote the widely adoption of hybrid seeds of banana crop.

The age, education, gender, household size and income are considered as important socioeconomic factors that affect adoption of agricultural technology. The study by Alexis et al., (2021) who analysed demographic factors driving the adoption of organic farming in Rwanda. About 182 respondents were selected as a sample of smallholder farmers who participated in coffee production. The analysis of socioeconomic factors influencing the adoption of farming technology was merely by descriptive statistics and logit regression. The study indicated that about 60.4% of coffee producers were male. The major finding of the study confirmed that education, gender and farming experience were positive and significant affecting the adoption of organic farming. The study is advising that youngest farmers of coffee must be supported to participate in the sector they were more adopter of farming technologies.

3.0 MATERIAL AND METHODS

This study was done in Mvomero district, Morogoro – Tanzania. The location was chosen based its potential in grain production particularly maize production. It situated in location where it receives rainfall in a period of September to June of each year with most rainy month in April of each year. the average annual rainfall stood at 296mm which favour maize production while average temperature is normally fractuate between 27^0C to 29.4^0C.

The study considered the cross-sectional design, kind of research design where data collected in a single point at place at once. This was actually reduced cost and time but also it captures the perception of the smallholder farmers related to adoption of farming technologies in maize production.

Sampling Technique and Sample Size

In this study, simple randomly probability sampling was employed to select 180 respondents from smallholder farmers of maize in the study area. According Coolican (2018), simple randomly probability sampling reduces the biasness in selecting the individuals in the study. While purposive non-probability sampling was employed to select the area of the study with the view of the area to be favourable for maize production. The sample size of this study was determined through sample determination formula and justified by several studies proposed applicable sample (Taherdoost, 2017; Boddy, 2016).

Data Collection and Data Type

The questionnaire employed to collected data from the field where identified respondents from selected area where given questionnaire to fill. Since the data was collected from the field, it was solely that primary data was the focus of this study. The primary data captured through well designed questionnaire with simple questions but capture important information.

Regression Model

Logit regression is principally rely on probability of a dichotomous outcomes. It relates the set of independent factors that are assumed to impact the outcomes (Tasie et al., 2021). However, logit model is based on the cumulative logistic probability function (Nxumalo et al., 2019). It is computationally easier to use than the other types of regression choice models. The logistic regression model is assumed that ata is logistically distributed, thus

$$h\left(\mathbf{X}_{i1}, \mathbf{X}_{i0}, \boldsymbol{\beta}\right) = \frac{1}{1+\exp\left(-\mathbf{X}_i \boldsymbol{\beta}\right)}.$$

Log (P/1-P) = $\beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_n X_n + \varepsilon_i$
Where: β_o = Constant, $\beta_1 \ldots \beta_n$ = Coefficient, X_n = Variable, ε_i = Error term

Data Analysis

The data from semi-structured questions were coded into Statistical Package for Social Science (SPSS) version 20 before transferred to Stata software for logit regression analysis. The descriptive statistic was employed to analyse the distribution of demographic characteristics of respondents. In this aspect, frequency and percentage were presented in table to indicate the distribution across each demographic characteristic. Analysis of descriptive statistic was facilitated by SPSS.

4.0 RESULTS AND DISCUSSION

The results presented in a table to make it simple and easily visible. However discussion of each result was made to elaborate the findings and compare with previous similar studies. The result and discussion were organized into descriptive statistics and logit regression results.

Demographic Characteristics

The demographic was considered as important factors to understand the distribution and their implication to adoption of the farming innovation among smallholder farmers of maize in Mvomero district, Tanzania. The demographic was analysing descriptively to examine their distribution as indicated in table 1.

Table 1: Demographic Characteristics

Demographic Factors	Frequency	Percentage (%)
26-33 years	22	12.4

Demographic Factors	Frequency	Percentage (%)
34-41 years	44	24.5
42-49 years	39	21.8
50-57 years	39	21.8
More or equal to 58 years	28	15.8
Total	**180**	**100.0**
Female	56	31.1
Male	124	68.9
Total	**180**	**100.0**
Informal education	36	19.8
Primary education	136	75.5
Secondary education	7	4.0
University education	1	0.7
Total	**180**	**100.0**
Single	10	5.7
Married	147	81.9
Widowed	23	7.7
Divorced	8	4.7
Total	**180**	**100.0**
0-4 Members	42	23.2
5-10 members	121	67.4
11-30 members	17	9.4
Total	**180**	**100.0**

The result from table 1 suggests that most of respondents (75.5%) were of aged 34-41 years while the rest categories of ages were less than 50% of respondents. This finding implies that most of the younger farmers engaged in maize farming. In this aspect, it provides room for more youth who occupied large share of Tanzania population to improve the agriculture sector through adoption of farming innovation. This study contradicts with study of Lindsjö et al., (2020) who confirmed that most of them, younger smallholder farmers were out of adoption of conservation agriculture in Tanzania.

Toward gender inclusion, result reveals that about 68.9% of respondents were male while female observed to less than 50% of respondents involved in the study. The finding signifies that male respondents were more active than female smallholder farmers engaged in adoption of farming innovation. This finding contradicts with Joseph (2021) who found that female were dominant, playing crucial role in ensuring the food security. Similarly, Paudel et al., (2020) reported female farmers were less dominant in the agriculture. Unfortunately the finding conquers with Daudu et al., (2019).

The result indicates that 75.5% of respondents had primary education while the rest of education categories were less than 50% of them. In this aspect, most of smallholder farmers of maize were educated to primary education. This has great positive impacts on uptake of farming to ensure their faming practice done with consideration of what they instructed by extension officer or written guideline of crop production. The primary education could be enough for farmers to transfer theory to practice in their farm for maize production. Education of farmers also was reported to have significant effect on adoption of improved technologies by Wetengere (2009).

Marriage couple, about 81.9% of respondents were almost married, as few respondents were single, widowed and divorced; they were less than 50%. According to these results, most of respondents were in married couple. The married couple could have greater impact on adoption of farming innovation. Smallholder farmers in married couple play important role to facilitated adoption of farming innovation. The study by Mogaka et al., (2021) and Kaibartya et al., (2018) had shown married couple became active in agriculture.

It was observed that, 67.4% of respondents lived in the household of 5-10 people together. This occupied large share of the households with most members to live together and share the same dish. Given this result, it was confirmed that most of households were having 5 to10 members in the households; they lived together and share the same plate of food. This indicates that as members in household gets bigger, smallholder farmers increases their labour force from household to operate on the farm for adopting the farming technologies quickly if they involved in maize farming and production. This finding supported by studies (Oyetunde-Usman et al., 2021; Oyetunde-Usman et al., 2021).

Logit Regression Results

Number of observation is 180
-2Log likelihood is 120.283 (P < 0.000),
Nagelkerke R Square is 0.503

The logit regression used to estimate the demographic factors influencing the adoption of farming technologies in maize are presented in table 2. The fit of the model was statistically significant at (P <0.000). The accuracy of the prediction was 87%, while the Nagelkerke R2 = 0.503. The result shows that the specified explanatory variables were able to explain the adoption of farming technologies in the study area. The interpretation of the results is based on marginal effects since coefficients (β) were not probability.

Table 2: Logit Regression Analysis

Variables	β	Std. Err	Marginal effects (dy/dx)	Std. Err.
Gender of Household Head (GHH)	0.561	0.318	0.302**	0.057
Age of Household Head (AHH)	-0.454	-0.214	-0.125***	-0.012
Education of Household Head (EHH)	0.563	0.304	0.241***	0.099
Experience of Household Head (EHH)	0.817	0.695	0.509*	0.491
Income of Household Head (IHH)	-0.406	-0.566	-0.145	-0.135
Marital Status of Household Head (MHH)	0.505	0.611	0.302	0.301
Extension Service Contact (ESC)	0.785	0.772	0.444	0.451
Participation in Demonstration in Farmer field School	0.668	0.660	0.542	0.522
Constant	0.196	0.189		

***, **,* = 1%, 5% and 10% respectively

Table 2 shows that the gender of household head (GHH), it was statistically significant (ρ≤0.005). It is suggested that the male household head influences the adoption of technologies in maize production. It suggests male increases the adoption of farming technologies by 30% in comparison to female. Given that, men in Tanzania are considered as decision maker since culture of Tanzania gives men mandatory to make final decision on whether to adopt or not so men are largely make decision at household level. An increase of household headed by men, they had high possibility of increasing the uptake of farming technologies. Based on community culture and tradition, women had little chance to advise men in the household to adopt farming technologies unless those households are headed by women. This finding supported with Theriault et al., (2017) who found female was less expected to adopt the technologies, simply because it seems that, female farmers were reluctant to consider the technologies for crop farming.

Age plays important role in household and agriculture, Age of household head (AHH) was statistically significant and negatively influence on adoption of farming technologies in maize production (P<0.01). Thus, it was found that an increase of age by 1 year was less likely to promote adoption of farming technologies by 12.5%. This simply suggests that, younger people were r\less adopter than old people. It is clear that, old people found to be active in adoption of technologies since old people have been cultivating maize for long time than younger people. Old people are easily to obtain the information related to farming technologies than younger people being for long time in the sector. This confirms that older smallholder farmer was less expected to uptake improved farming practice than younger smallholder farmers, due to old farmers may have more contact to technologies. Similarly the study by Kadipo Kaloi et al., (2021) had observed that old people or old farmers were less likely to adopt the technologies, simply because it seems that, old farmers were reluctant assuming that they were more experienced and thought that, it is duplication of practice typically increased with age. Unfortunately the finding contradict with Tan et al., (2020) who found that age had significantly influence on adoption of farming technologies.

Recognizing contribution of education to smallholder farmers in farming technologies could led to widely adoption of farming technologies. Education of household head (EHH) was found to be significant (ρ≤0.01) and positively influences the farming technologies. This suggests that education influences the adoption of farming technologies in Maize production. It was discovered that, smallholder farmers with formal education were largely adopted the farming technologies and likely to increases adoption by 24.1%. Smallholder with high education had high probability of adopting farming technologies than those with uneducated or informal education. In this aspect, it is assumed that education is a knowledge which enables farmers to realize the importance of farming technologies in improving production or yield of maize. This finding conquers with Shah & Panigrahi, (2015) who revealed that education of people were crucial to influence participation in the program. Similarly the study by Wang et al., (2017), supported the finding where it was observed that, it was crucial to promote adoption of maize hybrid in Kenya.

Experience is normally acquired through frequency practicing something in repeated ways. In attempted to capture the importance of experience among smallholders in farming technologies, it was necessary to trace its association with farming technologies. The result indicates experience of household head (EHH) was statically significant, positively influencing the adoption of farming technologies under maize production. This means as experience of smallholder farmer exceed by one year, the adoption of farming technologies also increases by 50.9% provided that other factors held constant. Experience is typically increases the confidence of smallholder farmers in practicing the technology in farming production. In maize production, most of smallholder farmers who have experience usually adopted agronomic practice that are likely to be familiar to them (Rugema et al., 2018). In this aspect, adopt of farming technology requires experience in that enable the smallholder farmers to apply the technology in crop farming (Catherine et al., 2017).

5.0 Conclusion and Recommendation

The study was analysing the implication of demographic factors on adoption of farming technologies in maize production in Mvomero district, Tanzania. However the study focuses on age, education, gender and farming experience as demographic characteristics of smallholder farmers were essentially examined to trace its effect on adoption of farming technologies. While gender and education were positively influencing the uptake of farming technologies, age of smallholder farmers was negatively influence on adoption of farming technologies. The magnitude of age, gender and education influences on adoption of farming technologies was almost moderate. In this finding it was found that, male household head was more likely to adopt farming technologies by 30.2% compared to female smallholder farmers. As age of smallholder farmers considered as an important factor, its finding revealed that older smallholder farmers was less likely to adopt farming technologies by 12.5% in comparison to younger smallholder farmers. The finding also justifies that education was more influential to uptake of farming technologies, smallholder farmers with formal education had high probability of uptake the farming technologies by 24.1% compared with those with informal education. Other hand, experience of household head suggests who are smallholder farmer, it suggests that those with huge experience was more expected to adopt farming technologies by 50.9% compare with those with low experience in maize farming. Based on study findings, it recommends that:-

i. Since the male household heads were more adopter than female household heads, male smallholder farmers of maize must be encouraged and promoted to adoption of farming technologies in maize production

ii. It is observed that education and experience were the key factors for adoption of farming technologies in maize production, therefore smallholder farmers should be trained and smallholder farmers with formal education must be encouraged and put effort to them for adoption of farming technologies in maize production. It is also smallholder farmers with long history of maize production should be considered in technologies dissemination.

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