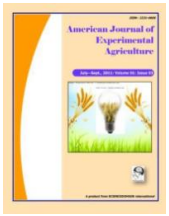

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Adoption of Improved Maize Farming Technologies by Women Farmers in Zambia

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Authors' contributions

This work was carried out in collaboration between both authors. Author MW designed the study and oversaw the whole process of data collection and entry. Author CS managed the analysis of the data and wrote the first draft. Both authors read and approved the final manuscript.

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ABSTRACT

The aims of this study were to identify key factors that affect women household heads' awareness and knowledge of existing improved farming technologies and to determine the factors that influence women farmers' adoption of animal draught (ox plough) and agroforestry in Zambia. The study was a survey in which semi structured questionnaires were used to interview women household heads. The focus of this study was mainly on women farmers who are household heads cultivating maize under draught animal (ox) and agroforestry farming practices. The study was conducted in Mkushi and Mazabuka districts in the Central and Southern provinces of Zambia respectively. Data were collected between June 2012 and September 2012.
Mkushi and Mazabuka districts were purposively selected because they lie within the "maize belt" of Southern Africa where maize production intensification technologies have been implemented since the 1990's. The study was conducted at micro level (village level) in the selected agricultural blocks, after which stratification of women farmers was done among adopters and non adopters.

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Finally, simple random sampling was used in selecting 50 adopters and 114 non-adopters from the two strata. Data were analysed using STATA software. Descriptive statistics and the multi-stage logit regression model formed the basis of analysis.
Access to communication gadgets like phones and membership to farmers' groups was found to increase the probability of awareness of technologies among women farmers by 90% and 35% respectively. The size of land under cultivation was found to increase the likelihood of adoption of ox plough technology by 29% while at the same time reducing the likelihood of adopting agroforestry technologies by 68%.Results revealed that women adopters had higher maize yields at 949 Kg/ha compared to 861.9 Kg/ha for non-adopters. This is mainly attributed to the advantages that come with sustainable agricultural practices like agroforestry.
Communication related factors are key in creating and increasing awareness of existing technologies among women farmers. Similar factors seem to promote adoption of both animal draught (ox plough) and agroforestry technologies among women farmers though expanding scale of production leads to more likelihood of ox plough adoption and later transition to more sophisticated machinery like tractors.

Keywords: Women household heads; technology adoption; multi-stage logit model; Zambia.

1. INTRODUCTION

1.1 Women and Agriculture in Zambia

The agricultural sector in Zambia supports about 80% of the population that is exclusively dependent on agricultural related livelihoods many of whom are poor people in the rural country side [1]. The sector contributed 18% and 20% to GDP in 2011 and 2013respectively and continues to be the largest employer of the Zambian labour force [1,2]. It employs about 52.2% of the working population [3].

Women comprise 50.7% of the total population of Zambia and form 51.6% of the economically active segment of the working population [3]. The majority of the women in Zambia (50.2%) live in the rural areas with 24.1% of rural households headed by females [3]. Many households have less than two hectares of land in the rural area with 71% falling under this category [4]. This is a clear indication that land being a limiting factor in agricultural production, the farmers many of whom are smallholders have to employ intensive farming technologies in order to raise their farm productivity to enable them produce for home consumption but also have a marketable surplus [5]. The main crops grown by the rural people by household numbers in 2011/2012 season in Zambia are maize (86%), groundnuts (39.2%), cassava (37.5%), cotton (20%) and sweet potatoes (12.7%) [6].

In addition, the government has been implementing the food security pack and the fertilizer support program (FISP) through the ministry of agriculture and cooperatives (MACO) since the year 2000 through distributing fertilizer and hybrid maize seed to the farmers in a bid to improve food security. Currently over 85% of all farmers in the study area apply fertilizer (though in inadequate amounts) and use hybrid maize seed [3]. [7] reported that only 29% of female headed households had adopted improved tree fallows after ten years of promoting the technology. Therefore the core problem to sustain production is adoption of other production enhancing technologies like agroforestry for soil fertility and fuel and ox ploughs for affordable smallholder mechanisation.

The main agricultural intensification technologies applied in maize production are use of fertilizer and hybrid seed, use of ox-ploughs for land preparation, zero tillage in addition to agroforestry. Agroforestry is one of the sustainable agricultural systems being promoted in Sub Saharan Africa [8]. However, the main challenge is that the levels of adoption of these technologies are still low among smallholder farmers. Despite the fact that 55% of the farmers use nitrogen fertilizer on their fields, the rate is still at 170 kg/ha below the recommended 200 kg/ha [6]. However, the observed low levels of technology adoption are as a result of a number of issues that are sometimes under the farmer's control and in other cases external to them and out of their control [9]. Therefore to ensure sustainable and increased adoption of yield enhancing technologies, there is need to understand the dynamics and determinants of the area specific characteristics of the farmers and the factors affecting technology uptake by such farmers.

1.2 Factors Affecting Women Technology Adoption

Women household heads face a number of challenges in their bid to sustain their families. In the first case, they have to cater for the household food security and then produce a marketable surplus to earn some income [10]. All this calls for extra efforts in organising labour and other inputs to be able to produce enough. However, a number of factors hamper women's ability to acquire the necessary technologies which include access to extension services, gender disparities with their male peers and ability to associate with a social club like a farmer's group or association for collective action [10]. In other cases, labour constraints and inaccessibility of technologies rather than their availability hinder women from adopting them [11].

Though many rural women lack opportunities for off farm work, studies have always pointed to earning extra income outside the farm as one of the factors promoting technology adoption. This is due to the fact that such incomes are invested in promoting new or better technologies on the farm like buying oxen, ploughs, improved seeds and fertilizers [12].

In many instances, improved technologies tend to be laborious, in that man power is needed to undertake them. This tends to put off many women from taking up such technologies given their age or energy and the fact that women's time is also devoted to other household chores such as cooking, fetching water, gathering fuel wood and child care [13]. [8] found that the number of active household members who can ably provide labour on the farm positively and significantly promoted adoption of agroforestry technologies in Malawi. In addition, the same authors found age of the household head to have a negative effect on adoption.

In many parts of Africa, women have limited rights on possession, ownership and access to land. Their security of tenure on land is usually not guaranteed which incapacitates them from taking on or expanding use of certain agricultural technologies that are tenure sensitive [14,15]. [16] stated that perceived stability of access to land, via stability of personal and social relationships is a more important determinant of technology adoption than mode of access. Therefore, to find out more about such challenges, this study set out to identify the factors that affect women farmers' awareness and knowledge about improved farming technologies, and their adoption for maize cultivation under ox plough and agroforestry farming practices.

2. METHODOLOGY

2.1 Study Area and Sampling Procedure

Mkushi and Mazabuka districts of Zambia in the central and southern provinces respectively formed the study area where women headed households were interviewed in 2012 as part of an ongoing project on pro-poor agricultural growth. The selection of the two districts was purposive so as to ensure sufficient variation in factors assumed crucial for women related agricultural development within the "maize belt". The districts were also selected because of the government restocking program that has introduced more cows some used for ox ploughing and some for draught power in addition to agroforestry programs in the area since the 1990's.

The districts were divided into agricultural blocks (stratification), which in turn are divided into agricultural camps, which is the unit catered for by an extension officer. A camp is further divided into zones corresponding to a number of villages/communities located in the same neighbourhood. For the village diagnostics and household survey, five camps (Musakamba, Musofu, Kalombe, Chitina and Nkumb) in Mkushi and three Camps (Dumba Settlement, Oliver Settlement, Nega Nega) in Mazabuka were selected as "village units"/sampling frames. Thereafter, women headed households were randomly selected where 100 were from Mkushi and 64 from Mazabuka giving a total sample of 164 households.

2.2 Analytical Methods

To outline the factors that influence women farmers' knowledge and adoption of given farming technologies a multi-stage logit model as used by [17,18] with modifications was employed to analyse the data. While in the normal double hurdle the second stage uses a continuous variable (non-binary), in this multi-stage logit, the second stage on adoption uses a dichotomous dependent variable but with only the sub-sample of farmers who are aware of the technology [17]. The other advantage of this model is that the treatment groups can be compared with control groups using predicted probability created

through Logit regression [18]. The model is specified as;

$$\Pr_{\text{aware}}(\text{KNOW}=1,\ \text{ADOPT}=1)=1/1+e^{-z}\ldots\ldots \quad (1)$$

Where, KNOW and ADOPT are dichotomous dependent variables (1 if the farmer has knowledge or adopts a farming technology, 0 otherwise) and e = base of natural logarithms.

The farmer first gets knowledge of the technology as represented in equation (2).

$$Y=\beta_O+\sum_{i=1}^{i=n}\beta_i X_i+\mu_j \quad (2)$$

Where X_i includes a vector of variables in the model that affect a woman farmer's awareness of the existence of available farming technologies, β_i parameters to be estimated and μ_j = error term. Y represents the access to extension services (awareness=1, 0 otherwise), used in this study as a proxy for awareness of existence of a technology on the premise that extension agents act as a link between technology centres and technology users (farmers). Extension access has for long been advocated as instruments that accelerate adoption of technologies by small farmers especially when adverse effects of economies of scale in technology use have been mitigated [5].

Where X_i is defined by the following variables; Age of the woman household head (HH_AGE). Education level of the woman household head specified as the number of years completed in formal school (HH_EDUC). Household size measured as the total number of people living in the household including children (HH_SIZE); engagement in a micro businesses by a woman head of household (MICRO_BIZ). Distance from farm to the nearest village centre (km) (DIST_VILCENTR); main maize selling point (MAIZE_SALPT) which may be the farm gate or outside the farm which is an indicator of the woman farmer's knowledge of what happens outside her farm. Possession of a communication gadget like a phone or radio/TV (COMM_GADGET) taken here as a proxy to indicate that a farmer can access information and adverts from the media and text messages. Membership to a farmer group or association (GRP_MEMBER); ability to make voluntary savings (VOL_SAVINGS) which measures the farmer's ability to invest in new or better farming technologies and total maize harvest in the most recent year (MAIZE_PRODN1).

After the woman farmer gets knowledge of the existence of a technology, she makes a decision to adopt or not to adopt that technology subject to the economic and demographic factors faced. Hence, the second stage of the model estimates the variables responsible for adoption or non-adoption as indicated in equation (3) where T is a binary dependent variable for adoption of a technology (T=1 for adopters, T=0 for non adopters).

$$T_i=\beta_O+\sum_{i=1}^{i=n}\beta_i X_i+\mu_j \quad (3)$$

Intensification of a single component of farm system (with little change to the rest of the farm) - such as home garden intensification with vegetables and/or tree crops has been found to improve food production among households and to generally improve food security and sustainability of the farming business [19].

Where X_i is defined by the variables in Table 1. Age of the woman household head (HH_AGE). Age is also taken as a measure of farming experience in this study, education level of the woman household head specified as the number of years completed in formal school (HH_EDUC). Household size measured as the total number of people living in the household including children (HH_SIZE), Non-farm income (NONFAM_INCOME) earned by the woman head of the household was measured as all income from activities other than farming including micro businesses, remittances and pensions in US dollars. Distance from farm to the nearest village centre (km) (DIST_VILCENTR), highest unit price earned for maize in the most recent season (UPRICE_HIGH1) measured in US dollars, possession of a communication gadget like a phone or radio/TV (COMM_GADGET), membership to a farmer group or association, taken as an indication of collective action participation by a woman farmer but also signifying ability to share knowledge and information with others (GRP_MEMBER) and total land under cultivation in the most recent year, measured in hectares (TOTCULTIV_LAND).

2.3 Empirical Estimation Procedure and Hypothesis Testing

Estimation of the model outlined above in equations followed a series of regression diagnostics. Variables used in both stages of the model were first checked for normality using

Table 1. Variable description

Variable	Description (units)	Expected sign	
		Awareness	Adoption
CROP_EXTSVC	**Extension services related to crop production (binary dependent variable)**		
ADOPTER	Woman household head who adopted either an ox-plough or Agro forestry technology		
HH_AGE	Age of the woman head of household (years)	_	_
MICRO_BIZ	Woman engages in running a micro business (dummy)	+	
COMM_GADGET	Access to a communication gadget like a phone or radio (dummy)	+	+
HH_EDUC	Education level of woman head of household (years in formal school)	+	+
HH_SIZE	Size of the household (Number of people living in the household)	+	+
DIST_VILCENTR	Distance to the nearest village centre (Km)	_	_
GRP_MEMBER	Woman being a member of any farmer group or association (dummy)	+	+
MAIZE_SALPT	Maize selling point regularly used by the woman farmer (farm gate=1, otherwise=0)	_	
VOL_SAVINGS	Woman farmer's ability to make voluntary savings (dummy)	+	
OX_PLOUGH	**Woman farmer adopted use of an ox plough (binary dependent variable)**		
AGROFORESTRY	Woman farmer adopted agroforestry as a technology (dummy)		
NONFAM_INCOME	Annual income a woman head of household earns outside the farm in non-farm related work (USD).		+
UPRICE_HIGH1	Highest price earned per Kg of maize in current year (USD)		+
TOTCULTIV_LAND	Total land the woman's household put under cultivation in current year (ha)		+

Exploratory Data Analysis using the coefficient of kurtosis and skewness. Regression diagnostics included tests for multicollinearity, self-selection bias and heteroscedasticity. Multicollinearity was tested using the variance inflation factor (VIF) while heteroscedasticity was checked using Breusch-Pagan/Cook-Weisberg tests [20].

3. RESULTS AND DISCUSSION

3.1 Characteristics of Farmer Women Household Heads

Tables 2 and 3 show the social economic characteristics of the sampled women headed households who adopted either the ox plough or agroforestry technologies in maize production. Results in Table 1 indicated that adopter households had a significantly (P = .05) lower number of household members providing labour with four persons compared to five persons for the non adopters. This is because in some cases like the ox plough technology, farmers hire labour rather than do the ploughing themselves. This is however counter to the results by [8] that those households with more household labour are more likely to adopt a technology than those with less labour force.

Table 1 results further indicated that adopters had smaller land under maize cultivation (2.73 ha) compared to non-adopters (3.5 ha). Adopters also applied less fertilizer annually on average (318.2 Kg) compared to non-adopters (342.61 Kg). However results indicated that adopters produced more maize per unit area at 949.1 Kg/ha compared to the non-adopters at 861.88 Kg/ha. This is an important result that indicates how technologies like ox ploughs and agroforestry can increase yields while reducing costs on fertilizer as well as reducing risks associated with unpredictable crop failure for the resource constrained women farmers. [21] noted that the low fertilizer use in many African maize farming systems are a result of risk aversion, lack of agricultural credit and fertilizer availability and timely delivery.

Results in Table 3 show that there is a significant difference (P=.05) between the percentage of women household heads who engaged in micro businesses who are adopters of the ox-plough or

agroforestry technologies and those are non-adopters. It is indicated that 76% of women adopters of these technologies were engaging in micro businesses as well compared to 57.89% of the non-adopters. The reason for this is that incomes from outside the farm are used to invest in farm technologies that enhance agricultural production. This is consistent with the findings of [22] that earning off farm income, in this case income from the micro businesses enhances and positively affects the likelihood of natural resource management practices.

Results also indicated that a significantly (P = .05) higher percentage of technology adopters (84%) possessed a communication gadget like a mobile phone, radio or television compared to the women non adopters at 64.91%. This result points to the fact that access to information through a number of media concerning agricultural technologies can augment adoption among smallholder farmers. [23] noted that mobile phones significantly reduce search costs for information concerning input and output prices in addition to complementing existing extension services where they are used by farmers.

Results in Table 3 also highlighted the scenario that a significantly (P <.01) higher percentage of non-adopter women household heads (43.86%) had access to credit compared to only 20% of the technology adopter women household heads. This is consistent with the previous result that more adopters are involved in micro business to earn income outside the farm than non-adopters and hence adopters face a higher production risk than their counterparts given the investment they make in taking up the new technologies. Therefore, the non-adopters resort to borrowing as a safety net to smooth their consumption through paying school fees, buying consumables and other services. In the same line, more non-adopters made voluntary savings (85.96%) compared to adopters (84.00%) though the two were not statistically significant at the three conventional significance levels. The result is in support of [24] who found that actually production risk suppresses demand for credit among smallholder farmers who would want to invest in production technologies.

Table 2. Characteristics of farmer women household heads and technology adoption

Variable	Overall mean (Std. dev)	Mean (Std. dev)		t-value	P-value
	(164)	Adopter(50)	Non adopter (114)		
Age of the woman head of household (years)	51.20 (11.67)	52.16 (10.99)	50.77 (11.98)	-0.70	0.48
Education level of woman head of household (years in school)	4.93 (3.59)	4.28 (3.28)	5.21 (3.70)	1.54	0.13
Size of the household (Number of people living in the household)	7.36 (3.42)	7.00 (2.97)	7.51 (3.59)	0.85	0.40
Distance to nearest village centre (Km)	7.04 (4.80)	7.16 (5.29)	6.99 (4.59)	-0.21	0.83
Quantity of maize produced by household in current year (Kg)	2,780.49(2,619.20)	2,738.00 (2,828.55)	2,799.12(2,534.81)	1.4	0.89
Quantity of fertilizer used on maize in current year(Kg)	335.17 (280.64)	318.20 (278.02)	342.61(282.68)	0.51	0.61
Number of household members providing labour	4.34 (2.49)	3.74 (2.03)	4.60 (2.64)	1.98	0.05
Area of land under maize (ha)	3.26 (2.17)	2.73 (1.62)	3.50 (2.34)	2.10	0.04
Maize yield in the current year (Kg/ha)	888.47 (484.40)	949.10 (521.81)	861.88 (466.97)	-1.06	0.29

Table 3. Characteristics (%) of women household heads and technology adoption

Characteristic (Variable)	Overall sample (164)	Adopter (50)	Non adopter (114)	P-Value
		Percentages		
Woman engages in running a micro business (dummy)	63.41	76.00	57.89	0.03
Access to a communication gadget like a phone or radio (dummy)	70.73	84.00	64.91	0.01
Membership to a farmers' group/association (dummy)	90.24	92.00	89.47	0.62
Maize selling point regularly used by the woman farmer (dummy)	34.15	0.00	49.12	0.01
Woman farmer's ability to make voluntary savings (dummy)	85.37	84.00	85.96	0.74
Farmer adopted ox plough technology		17.07	82.93	
Farmer agroforestry technology		19.51	80.49	
Woman head of household has access to credit (dummy)	36.59	20.00	43.86	0.003

3.2 Factors Affecting Women Farmers' Awareness of and Knowledge of Farming Technologies

The results of the first stage of the multi-stage logit model Table 4 indicated that as hypothesized engaging in a micro business significantly ($P < .01$) increased the likelihood of a woman's farmer awareness of a farming technology by 9.7 times than when the woman was not engaged in micro business. This is basically because farming is their primary source of income and undertaking a micro business involves moving outside the farm or village to look for merchandise, and in so doing, the woman gets exposure to information on availability of given farming technologies. In addition, many of the extension trainings usually take place in town or village centres where the micro business women usually go to trade. This seems to be in agreement with the findings of [18] that farm operators, whose primary income source is farming, though they may be engaged in other non-agricultural activities in generating income, tend to seek out information on new farming technologies.

A woman farmer's access to a communication gadget such as a phone or radio was also found to significantly ($P < .10$) increase the probability of awareness of farming technologies by about 2.5 times than without the gadget as previously expected Table 4. This is because mobile phones and radios in modern times are used to disseminate information on agricultural prices, inputs and new technologies availability. Imperfect information and knowledge concerning existence of inputs, outputs and new technologies is very prevalent in developing world rural areas, though information technology has potential to reduce the situation [25].

Results also indicated that awareness of farming technologies decreased with increasing education levels. Results Table 4 indicated that every single year increase in education level, leads to about 8% decrease in awareness. This was counter intuitive and counter hypothesis, as education was expected to increase awareness due its effect on decoding information at disposal to the farmer. This is due to the fact that education has a tendency of leading to migration of labour from the agricultural sector into other service and industrial sectors. Therefore, the more women get educated the less they will be enthusiastic about learning about new farming technologies. [26] also emphasised that education and training programmes have favoured the male leaving the rural women in many areas with low education levels and more are illiterate compared to men.

Women farmers were found to be more likely to be aware of farming technologies the farther away they are from the village centre. Every unit increase in the distance away from the village centre could lead to 3.5% increase in awareness Table 4. This is because many of the extension agents usually target those farmers outside the trading centres for training and demonstrations. Furthermore, the farther the women farmers are

from town the more they will be entirely involved in farming as a core occupation, hence prompting them to seek knowledge of new and better farming technologies which is solely provided by extension workers who are sometimes overwhelmed by the number of farmers to attend to [27].

3.3 Factors Affecting Women Farmers' Adoption of Ox Plough and Agroforestry Farming Technologies

Results of the second stage of the logit model indicated that access to a communication gadget and total land the woman household head put under cultivation were positive and statistically significant at the conventional levels for probability of adoption of ox plough technology in maize farming. For the same technology, likelihood of adoption was negatively and significantly affected by age (as hypothesised), education level, size of household, distance to the nearest village centre. The signs on coefficients are almost the same for both ox plough and agroforestry apart from age, household size, distance to village centre and total land under cultivation.

A one year increase in age leads to a 6% decrease in the likelihood of adoption of the ox plough technology but increases that of agroforestry by 8.3% Table 5. The main reason for this observation is that ox plough use is an energy demanding task, hence the older the woman farmer, the less they are likely to adopt it unlike agroforestry that is relatively less laborious. [28] noted that the benefits from agroforestry are long term yet the costs of abandonment can be high, this may be one of the reasons why its adoption increases with age.

Collective action, represented by the woman household head being a member of a farmer's group or association has negative impact of adoption of both ox ploughs and agroforestry technologies, which is counter hypothesis. Results in Table 5 indicate that membership to a group reduces the likelihood of ox plough adoption by 5.9% and that of agroforestry by 4.5%. The reason for this is that these technologies are undertaken individually at the farm, and in the case of ox ploughs, there are specialized male attendants who do the ploughing using the oxen [13], hence group work may not be called for, actually a farmer may see it as time wasting.

Results also indicated that the highest price of maize received by the woman farmer decreased the likelihood of adopting both ox plough and agroforestry technology by big percentage points Table 5. This is because when the price is high, women farmers are more likely to expand their production as much as men farmers, which makes them shift from ox plough to tractors and also clear new land rather than agroforestry. [29] highlighted the fact that many women farmers in Africa are increasingly growing staple crops, and hence are affected by any policies like price stabilization policies in the same way as men farmers are affected.

Total land under cultivation by a woman farmer was found to significantly (P =.05) increase the likelihood of adoption of ox plough technology (by 29.4% for a unit increase in cultivated land). However, it was also found to reduce the probability of adoption of agroforestry technology by 68.4%. This is basically due to the fact that expanding the land under cultivation requires either a better land preparation technology than a hand hoe, or increasing the manual labour hired. Also when a farmer is to expand production, there is a high chance of foregoing agroforestry and instead open up virgin lands. Noted that access to land by women and its related security of tenure has an effect on technology adoption given its implications for credit and other inputs access.

Education was found to negatively and significantly affect adoption of Ox-plough but it had a positive though not significant effect on adoption of agroforestry technology. This is basically because these technologies are unique in such a way that they require a lot of time to adopt and yet those farmers that are more educated are fond of engaging in other off farm employment which may limit their uptake. However, other studies such as [10,13] found education to be positively associated with technology adoption. It is worth noting that different technologies in different environments are adopted differently depending on the prevailing conditions.

Table 4. Factors affecting women's awareness of a farming technology

Variable	Coefficient	(Std. Err)	Odds Ratio
Access to extension (proxy for technology awareness			
Age of the woman head of household (years)	0.015	0.023	1.015
Woman engages in running a micro business (dummy)	2.274***	0.674	9.722
Access to a communication gadget like a phone or radio (dummy)	0.897*	0.520	2.451
Education level of woman head of household (years in formal school)	-0.083	0.075	0.920
Size of the household (Number of people living in the household)	0.057	0.078	1.059
Distance to the nearest village centre (Km)	0.035	0.056	1.036
Woman being a member of any farmer group or association (dummy)	0.346	0.847	1.413
Maize selling point regularly used by the woman farmer (farm gate=1, otherwise=0)	1.240*	0.654	3.457
Woman farmer's ability to make voluntary savings (dummy)Pseudo R^2 = 0.2025	-0.389	0.698	0.677

*Significant level: * = 10%; ** = 5%; *** = 1%.*

Table 5. Factors affecting women's adoption of two farming technologies

Variable	Ox plough adoption			Agroforestry adoption		
	Coefficient	(Std.Err)	Odds ratio	Coefficient	(Std. err)	Odds ratio
Age of the woman household head (years)	-0.060*	0.035	0.943	0.083*	0.051	1.087
Access to a communication gadget like a phone or radio (dummy)	1.300*	0.733	4.902	4.217*	2.255	67.842
Education level of woman head of household (years in formal school)	-0.239**	0.109	0.780	-0.153	0.129	0.858
Size of the household (Number of people living in the household)	-0.505*	0.300	0.614	0.419*	0.231	1.521
Distance to the nearest village centre (Km)	-0.005	0.088	0.994	0.092	0.185	1.097
Woman being a member of any farmer group or association (dummy)	-0.593	1.141	0.502	-0.448	1.473	0.639
Income a woman household head earns outside the farm in non-farm related work annually (USD).	0.004	0.003	1.004	-0.005	0.007	0.995
Highest price earned per Kg of maize in current year (USD)	-29.667	20.014	2.840 e^{-13}	-6.070	12.819	0.002
Total land the woman's household put under cultivation in current year (ha)	0.294**	0.145	1.383	-0.684**	0.334	0.505

*Significant level: * = 10%; ** = 5%; *** = 1%*

4. CONCLUSION

Though many factors were found to affect awareness and knowledge of farmers about existing technologies, factors that ensure collective action were quite prominent. Those elements of society that allow women farmers to interact among themselves and other members such as communication through the phones, belonging to a group or association and point of sale of their produce create an atmosphere of sharing knowledge and create awareness about technologies. The implication of increased awareness of technologies is that increased agricultural production and food security will be attained and eventually household incomes will increase.

Adoption of the ox-drawn plough is affected by age of the woman farmer beyond a certain point due to its manpower demands. However, economic status of the woman farmer as measured by the size of land under cultivation promotes ox plough adoption. Therefore, the more women farmers expand in their scale of agricultural operations the more they are likely to adopt better technologies such as shifting from the hand hoe to the ox plough and later to tractors. Hence, it is highly recommended that livestock restocking programs and land tenure systems that ensure increased women access to and expansion of cultivated land be pursued by the authorities to ensure sustainable engagement of women farmers in agriculture.

The benefits from agroforestry are medium to long term. Therefore the likelihood of its adoption by women farmers is promoted by factors related to medium-long term for example age of the woman household head and size of the household (labour). However, expanding scale of production in terms of land put under cultivation negatively affects the likelihood of adoption of the technology. Therefore for sustainable agricultural systems and farmer livelihoods, policy emphasis needs to be focused on the medium to long term agroforestry interventions with the implication that soil productivity will be improved and the negative effects of climate change mitigated.

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COMPETING INTERESTS

The authors declare that we do not have any competing interests whatsoever concerning to this research work.

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