

WOMEN AND ADOPTION OF IMPROVED MAIZE FARMING TECHNOLOGIES IN ZAMBIA

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ABSTRACT

Aims: 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 technologies in Zambia.

Study design: 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.

Place and Duration of Study: 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.

Methodology: Mkushi and Mazabuka districts located in the Central and Southern provinces of Zambia respectively 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. 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. The first stage of the logit model looked at awareness of existing technologies by the women household heads and the second stage looked at likelihood of adoption of ox plough and agroforestry technologies after being aware of them.

Results: 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%. This is because with increasing scale of production farmers tend to switch to advanced technologies like tractors but also cut down trees to open up land rather than planting them. Results revealed that women adopters had higher maize yields at 949Kg/ha compared to 861.9Kg/ha for non-adopters. This is mainly attributed to the advantages that come with sustainable agricultural practices like agroforestry.

Conclusion: 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 2013 respectively 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

42 the technology. Therefore the core problem to sustain production is adoption of other
43 production enhancing technologies like agroforestry for soil fertility and fuel and ox ploughs
44 for affordable smallholder mechanisation.

45

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

58 1.2 Factors affecting women technology adoption

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

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

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

80 In many parts of Africa, women have limited rights on possession, ownership and access to
81 land. Their security of tenure on land is usually not guaranteed which incapacitates them
82 from taking on or expanding use of certain agricultural technologies that are tenure sensitive
83 [14, 15]. [16] stated that perceived stability of access to land, via stability of personal and
84 social relationships is a more important determinant of technology adoption than mode of
85 access. Therefore, to find out more about such challenges, this study set out to identify the
86 factors that affect women farmers' awareness and knowledge about improved farming
87 technologies, and their adoption for maize cultivation under ox plough and agroforestry
88 farming practices

89 2. METHODOLOGY

90 2.1 Study area and sampling procedure

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

99 The districts were divided into agricultural blocks (stratification), which in turn are divided into
100 agricultural camps, which is the unit catered for by an extension officer. A camp is further
101 divided into zones corresponding to a number of villages/communities located in the same
102 neighbourhood. For the village diagnostics and household survey, five camps (Musakamba,
103 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;

$$Pr_{\text{aware}} (\text{KNOW} = 1, \text{ADOPT} = 1) = \frac{1}{1 + e^{-z}} \dots \dots \dots (1)$$

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).

$$Y = \beta_0 + \sum_{i=1}^{i=n} \beta_i X_i + \mu_j \dots \dots \dots (2)$$

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

138 information and adverts from the media and text messages. Membership to a farmer group
 139 or association (GRP_MEMBER); ability to make voluntary savings (VOL_SAVINGS) which
 140 measures the farmer's ability to invest in new or better farming technologies and total maize
 141 harvest in the most recent year (MAIZE_PRODN1).

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

$$147 \quad T_i = \beta_o + \sum_{i=1}^{i=n} \beta_i X_i + \mu_j \dots\dots\dots (3)$$

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

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

166

167 **Table 1: Variable description**

Variable	Description (units)	Expected sign	
CROP_EXTSVC	Extension services related to crop production (binary dependent variable)	Awareness	Adoption
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	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)		+

168

169 2.3 Empirical estimation procedure and hypothesis testing

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

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

176

177 3. RESULTS AND DISCUSSION

178

179 3.1 Characteristics of farmer women household heads

180 Tables 2 and 3 show the social economic characteristics of the sampled women headed
 181 households who adopted either the ox plough or agroforestry technologies in maize
 182 production. Results in Table1 indicated that adopter households had a significantly ($P = .05$)
 183 lower number of household members providing labour with four persons compared to five
 184 persons for the non adopters. This is because in some cases like the ox plough technology,
 185 farmers hire labour rather than do the ploughing themselves. This is however counter to the
 186 results by [8] that those households with more household labour are more likely to adopt a
 187 technology than those with less labour force.

188 Table1 results further indicated that adopters had smaller land under maize cultivation (2.73
 189 ha) compared to non-adopters (3.5 ha). Adopters also applied less fertilizer annually on
 190 average (318.2Kg) compared to non-adopters (342.61Kg). However results indicated that
 191 adopters produced more maize per unit area at 949.1Kg/ha compared to the non-adopters at
 192 861.88Kg/ha. This is an important result that indicates how technologies like ox ploughs and
 193 agroforestry can increase yields while reducing costs on fertilizer as well as reducing risks
 194 associated with unpredictable crop failure for the resource constrained women farmers. [21]
 195 noted that the low fertilizer use in many African maize farming systems are a result of risk
 196 aversion, lack of agricultural credit and fertilizer availability and timely delivery.

197

198 **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	7.36 (3.42)	7.00 (2.97)	7.51 (3.59)	0.85	0.40

household)					
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

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 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
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 indicated that as hypothesized engaging in a micro business significantly ($P < .01$) increased the likelihood of a woman's

236 farmer awareness of a farming technology by 9.7times than when the woman was not
237 engaged in micro business. This is basically because farming is their primary source of
238 income and undertaking a micro business involves moving outside the farm or village to
239 look for merchandise, and in so doing, the woman gets exposure to information on
240 availability of given farming technologies. In addition, many of the extension trainings usually
241 take place in town or village centres where the micro business women usually go to trade.
242 This seems to be in agreement with the findings of [18] that farm operators, whose primary
243 income source is farming, though they may be engaged in other non-agricultural activities in
244 generating income, tend to seek out information on new farming technologies.

245

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

253

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

264 Women farmers were found to be more likely to be aware of farming technologies the farther
265 away they are from the village centre. Every unit increase in the distance away from the
266 village centre could lead to 3.5% increase in awareness. This is because many of the
267 extension agents usually target those farmers outside the trading centres for training and
268 demonstrations. Furthermore, the farther the women farmers are from town the more they
269 will be entirely involved in farming as a core occupation, hence prompting them to seek

270 knowledge of new and better farming technologies which is solely provided by extension
 271 workers who are sometimes overwhelmed by the number of farmers to attend to [27].

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277 **Table 4: Factors affecting women's awareness of a farming technology**

278

Variable			
Access to extension (proxy for technology awareness	Coefficient	(Std. Err)	Odds Ratio
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	-0.389	0.698	0.677

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(dummy)

Pseudo R² = 0.2025

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

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. [30] 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 because different technologies in different environments are adopted differently depending on the prevailing conditions.

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

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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 (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	2.840e ⁻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.

Adoption of the ox-drawn plough is affected by age of the woman farmer beyond a certain point due to its man power 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

355 pursued by the authorities to ensure sustainable engagement of women farmers in
356 agriculture.

357

358 The benefits from agroforestry are medium to long term. Therefore the likelihood of its
359 adoption by women farmers is promoted by factors related to medium-long term for example
360 age of the woman household head and size of the household (labour). However, expanding
361 scale of production in terms of land put under cultivation negatively affects the likelihood of
362 adoption of the technology. Therefore for sustainable agricultural systems and farmer
363 livelihoods, policy emphasis needs to be focused on the medium to long term agroforestry
364 interventions.

365

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367

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375

376 **COMPETING INTERESTS**

377

378 We, the authors declare that we do not have any competing interests whatsoever concerning
379 to this research work.

380

381 **AUTHORS' CONTRIBUTIONS**

382

383 Mr. Wamulume designed the study and oversaw the whole process of data collection and
384 entry. Mr. Sebatta managed the analysis of the data and wrote the first draft. Both authors
385 read and approved the final manuscript.

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387 **REFERENCES**

388

- 389 9. Adesina, A.A. and Baidu-Forson. Z . (1995). Farmers' perceptions and adoption of new
390 agricultural technology: Evidence from analysis in Burkina Faso and Guinea, West
391 Africa. Agricultural Economics 13 (1995) 1-9.

10. Adesina, A.A.; Mbila, D., Nkamleub, G.B. and Endamana, D. (2000). Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. *Agriculture, Ecosystems and Environment* 80 (2000) 255–265.
23. Baumüller, H. (2012). Facilitating agricultural technology adoption among the poor: The role of service delivery through mobile phones. ZEF Working Paper Series, No. 93. Available: <http://hdl.handle.net/10419/88382>.
5. Binswanger, H.P. and von Braun, J. (1991). Technological Change and Commercialization in Agriculture: The Effect on the Poor. *The World Bank Research Observer*, 6(1):57-80.
27. Budak, D.B., Darcan, N. and Kantar, M. (2005). Women farmers and extension services in small ruminant production in mountain areas of Turkey. *Journal of Arid Environments*, 62 (2005): 507–515.
3. Central Statistical Office (CSO), Ministry of Labour and Social Security (2013). *Zambia Labour Force Survey Report*.
13. Doss, C.R. (1999). Twenty-Five Years of Research on Women Farmers in Africa: Lessons and Implications for Agricultural Research Institutions; with an Annotated Bibliography. CIMMYT Economics.
29. Doss, C.R. (2002). Men's Crops? Women's Crops? The Gender Patterns of Cropping in Ghana. *World Development*, 30(11) 1987–2000.
30. Doss, C.R. (2001). Designing Agricultural Technology for African Women Farmers: Lessons from 25 years of experience. *World Development*, 29(12):2075-2092.
12. Fernandez_Cornejo, J., Hendricks, C. and Mishra, A. (2005). Technology Adoption and Off-farm Household Income: The Case of Herbicide Tolerant Soybeans. *Journal of Applied and Agricultural Economics*, 37(3):549-563.
24. Giné, X. and Yang, D. (2008). Insurance, credit, and technology adoption: Field experimental evidence from Malawi. *Journal of Development Economics* 89(2009):1-11.
20. Green, W. H. (2003). *Econometric Analysis* 5th Edition .Prentice Hall, Upper Saddle River. New Jersey, Prentice-Hall Inc.
21. Heisey, P.W., and Mwangi, W. (1996). Fertilizer Use and Maize Production in Sub-Saharan Africa. CIMMYT Economics Working Paper 96-01. Mexico, D.F.: CIMMYT.
17. Karki, L.B. and Bauer, S. (2004). Technology Adoption and Household Food Security. Analyzing factors determining technology Adoption and impact of project intervention. A case of smallholder peasants in Nepal. Paper prepared to present in The Deutscher

- 427 Tropentag to be held on 5-7 October, 2004, Humboldt-University, Berlin.
- 428 14. Keil, A., Zeller, M. and Franzel, S. (2005). Improved tree fallows in smallholder maize
429 production in Zambia: do initial testers adopt the technology?. *Agroforestry Systems*,
430 64:225-236.
- 431 25. Kuhlmann, F. and Brodersen, C. (2001). Information technology and farm management:
432 developments and perspectives. *Computers and Electronics in Agriculture*, 30
433 (2001):71–83.
- 434 11. Kumar, S.K. (1985). Women's Role and Agricultural Technology. Chapter adapted from
435 a presentation at a seminar sponsored by the international service for National
436 agricultural research and the Rockefeller foundation, held in Bellagio, Italy March 1985:
437 135-147.
- 438 1. Kuteya, A. and Kambole, C. (2011). 2012 Zambian Agricultural Sector Budget Analysis.
439 Presented by ACF/IAPRI Budget Breakfast Meeting Pamodzi Hotel, Lusaka November
440 30, 2011.
- 441 26. Lubwama, F.B. (1999). Socio-economic and gender issues affecting the adoption of
442 conservation tillage practices. Available: <http://www.atnesa.org>.
- 443 22. Marenja, P.P. and Barret, C.B. (2006). Household-level determinants of adoption of
444 improved natural resources management practices among smallholder farmers in
445 Western Kenya. *Food Policy*, 32(2007): 515-536.
- 446 4. Mason, M.N., Jayne, T.S. and Myers, R.J. (2012). The effects of the Food Reserve
447 Agency on smallholder production patterns and maize market prices. Stakeholders'
448 Meeting on Evidence-Based Agricultural Policy Decisions to Shape Agricultural
449 Development for Poverty Reduction 5 December 2012 Taj Pamodzi Hotel, Lusaka,
450 Zambia. Indaba Agricultural Policy Research Institute (IAPRI).
- 451 18. McBride, W.D. and Daberkow, S.G. (2003). Information and the Adoption of Precision
452 Farming Technologies. *Journal of Agribusiness*, 21 (1):21-38.
- 453 15. McCulloch, A.K., Meinzen-Dick, R. and Hazell, P. (1998). Property Rights, Collective
454 Action and Technologies for Natural Resource Management: A Conceptual Framework.
455 SP-PRCA Working Paper No.1, International Food Policy Research Institute, CGIAR
456 System-wide Program on Property Rights and Collective Action.
- 457 4. Mercer, D.E. (2004). Adoption of agroforestry innovations in the tropics: A review.
458 *Agroforestry System*, 61(1):311-328.
- 459 2. Ministry of Finance (2013). The next steps, budgetary changes. Budget of Zambia.
460 www.pwc.com/zm.

- 461 7. Phiri,D., Franzel, S., Mafongoya,P., Jere,I., Katanga,R. and Phiri, S. (2004).Who is using
462 the new technology? The association of wealth status and gender with the planting of
463 improved tree fallows in Eastern Province, Zambia. *Agricultural Systems*, 79 (2004)
464 131–144.
- 465 19. Pretty, J. and Hine, R. (2001). Reducing Food Poverty with Sustainable Agriculture: A
466 Summary of New Evidence. Centre for Environment and Society, University of Essex,
467 Final Report from the “SAFE-World” (The Potential of Sustainable Agriculture to Feed
468 the World) Research Project, University of Essex, February 2001.
- 469 16. Smucker, G.R., White, T.A. and Bannister, M. (2002). Land Tenure and the Adoption of
470 Agricultural Technology in Haiti. Paper presented at the 9th Biennial Conference of the
471 International Association for the Study of Common Property Victoria Falls, Zimbabwe –
472 17-21 June 2002. This paper was released as CAPRI Working Paper No.6. Available:
473 <http://www.capri.cgiar.org/wp/capriwp06.asp>.
- 474 6. Tembo, S. and Sitko,N. (2013). Technical Compendium: Descriptive Agricultural
475 Statistics and Analysis for Zambia. Indaba Agricultural Policy Research Institute (IAPRI),
476 Lusaka Zambia, Working Paper 76 August 2013. Available:
477 <http://www.iapri.org.zm/index.php?> Accessed on 25th September 2014.
- 478 8. Tembo, S. and Sitko,N. (2013). Technical Compendium: Descriptive Agricultural
479 Statistics and Analysis for Zambia. Indaba Agricultural Policy Research Institute (IAPRI),
480 Lusaka Zambia, Working Paper 76 August 2013. Available:
481 <http://www.iapri.org.zm/index.php?> Accessed on 25th September 2014.
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