

Original Research Article

BUILDING SUSTAINABLE RURAL LIVELIHOODS: WOMEN AND ADOPTION OF IMPROVED FARMING TECHNOLOGIES IN ZAMBIA

ABSTRACT

Aims: The ~~main~~ aims of this study were ~~two~~; ~~1. To~~ identify key factors that affect women farmers' awareness and knowledge of existing improved farming technologies and ~~2. 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~~ women household heads.

Place and Duration of Study: The study was conducted in Mkushi and Mazabuka districts in the ~~e~~Central and Southern provinces of Zambia respectively. Data ~~was~~ were collected between June 2012 and September 2012.

Methodology: Mkushi and Mazabuka districts located in the ~~C~~entral 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. Five camps from Mkushi and three from Mazabuka were randomly selected, after which stratification of women farmers was done among adopters and ~~non-adopters~~ non-adopters. Finally, simple random sampling was used in selecting ~~in~~ on gave 50 adopters and 114 non adopters from the two strata. Data ~~was~~ were analysed using ~~stata~~ STATA software. ~~Descriptive statistics~~ 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 ~~ingene~~ ingene ~~of the~~ technologies by the women farmers and the second stage looked at likelihood of adoption of ox plough and agroforestry technologies after being aware of them.

Results: Results revealed that much as women non adopters used more fertilizer per hectare, adopters had higher maize yields at 949Kg/ha compared to 861.9Kg/ha for ~~non-adopters~~ non-adopters. This is mainly attributed to the advantages that come with sustainable agricultural practices like agroforestry.

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

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Comment [MV2]: results should be reported in the same order as objectives i.e highlight results that pertain to awareness & knowledge about existing knowledge and then on adoption last

Comment [MV3]: Were these yields found to be statistically different?

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switch to advanced technologies like [use of](#) tractors but also cut down trees to open up land rather than planting them.

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~~[both animal](#) draught (~~ox plough~~[ox plough](#)) and ~~agroforestry~~[agroforestry](#) technologies ~~among women~~[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, 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. 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 [the about 52.2% of the working population](#).

[majority of the working population at 52.2%](#) [3].

Women comprise 50.7% of the total population of Zambia and form 51.6% of the economically active segment ~~of the of working~~[the working](#) population. 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~~[under](#) ~~category~~[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~~[in order](#) to raise their farm productivity to enable them

[to](#) 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 ~~on~~[on](#) 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

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40 production enhancing technologies like agroforestry for soil fertility and fuel and ox ploughs
41 for affordable smallholder mechanisation.

42

43 The main agricultural intensification technologies applied in maize production are use of
44 fertilizer and hybrid seed, use of ox-ploughs for land preparation, zero tillage in addition to
45 agroforestry which is one of the sustainable agricultural systems being promoted in Sub
46 Saharan Africa [8]. However, the main challenge is that the level of adoption of these
47 technologies is-are still low among smallholder farmers. Despite the fact that 55% of the
farmers

48 use fertilizer on their fields, the rate is still at 170kg/ha below the recommended 200kg/ha
49 [6]. However, the observed low levels of technology adoption are as a result of a number of
set of issues

50 that are sometimes under the farmer's control and in other cases external to them [9].

51 1.2 Factors affecting women technology adoption

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

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

65 In many cases, improved technologies tend to be laborious, in that man power is needed to
66 undertake them. This tends to put off many women from taking up such technologies given
67 their age or energy and the fact that women's time is also devoted to other household chores
68 such as cooking, fetching water, and gathering fuel wood, and -as-well-as child care [13]. [8]
found

69 that the number of active household members who can ably provide labour on the farm
70 positively and significantly promoted adoption of agroforestry technologies in Malawi. In

Comment [MV6]: what fertilizer(s) are referred to here? OR is it the amount of a particular nutrient element e.g. nitrogen?

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71 addition, the same authors found age ~~of the head~~ of household head to have a negative effect
on
72 adoption.

73 In many parts of Africa, women have limited rights on possession, ownership and access to
74 land. Their security of tenure on land is usually not guaranteed which incapacitates them
75 from taking on or expanding use of certain agricultural technologies that are tenure sensitive
76 [14, 15]. [16] stated that perceived stability of access to land, via stability of personal and
77 social relationships is a more important determinant of technology adoption than mode of
78 access.

79 2. METHODOLOGY

80 2.1 Study area and ~~Sampling~~ sampling procedure

81 Mkushi and Mazabuka districts of Zambia in the central and southern provinces respectively
82 formed the study area where women headed households were interviewed in 2012. ~~Theis~~
83 selection ~~of theof the~~ two districts was ~~not random but~~ purposive so as to ensure
sufficient

84 variation ~~as to in~~ factors assumed crucial for women related agricultural development within the
85 "maize belt". The districts were also selected because of the government restocking
86 program that has introduced more cows some used for ox ploughing in addition to
87 agroforestry programs in the area since the 1990's.

Comment [MV12]: and some of which are used for draught power in addition to

88 The districts were divided into agricultural blocks (stratification), which in turn ~~based on~~
~~89 extension/administrative arrangements~~ are divided into agricultural camps, which is the unit
90 catered for by an extension officer. A camp is further divided into zones corresponding to a
91 number of villages/communities located in the same neighbourhood. For the village
92 diagnostics and household survey, five camps (Musakamba, Musofu, Kalombe, Chitina and
93 Nkumb) in Mkushi and three Camps (Dumba Settlement, Oliver Settlement, Nega Nega) in
94 Mazabuka were selected as "village units"/sampling frames. Thereafter, women headed
95 households were randomly selected where 100 were from Mkushi and 64 from Mazabuka
96 giving a total sample of 164 households.

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97 2.2 Analytical methods

98 To outline the factors that influence women farmers' knowledge and adoption of given
99 farming technologies a multi-stage logit model as used by [17, 18] with modifications was
100 employed to analyse the data. The model is specified as;

101
$$Pr_{\text{aware}}(\text{KNOW} = 1, \text{ADOPT} = 1) = \frac{1}{1 + e^{-z}} \dots \dots \dots (3)$$

Comment [MV13]: why is this equation 3, when it is the first equation to be mentioned /presented? or does this refer to author number 3?

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 (4).

$$Y = \beta_o + \sum_{i=1}^{i=n} \beta_i X_i + \mu_j \dots\dots\dots (4)$$

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. Extension and credit have 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].

Comment [MV14]: see comment 10

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).⁵ engagement in a micro businesses by a woman head of household (MICRO_BIZ). Distance from farm to the nearest village centre (km) (DIST_VILCENTR).⁵ 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 an indication that the farmer can use news, text messages and adverts to access information. Membership to a farmer group or association (GRP_MEMBER).⁵ 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).

Comment [MV15]: not sure if this word is correct. How about "media"?

Comment [H16]: as aproxy to indicate that a farmer can access information and adverts from the media and text messages.

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 (5).

$$T_i = \beta_o + \sum_{i=1}^{i=n} \beta_i X_i + \mu_j \dots\dots\dots (5)$$

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

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132 found to improve [on](#)-food production among households and [to](#) generally improve food security
133 and sustainability of the farming business [19].

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

148

149 **Table 1: Variable description**

Variable	Description (units)
CROP_EXTSVC	Extension services related to crop production (dummy)
ADOPTER	Woman head of household 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)

Comment [MV17]: Try and avoid repetition of ideas, this information is the same as that in the table. It will be best to add more information in the section variable descriptions

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)
MAIZE_PRODNI	Quantity of maize produced by the woman's household in the current year (Kg)
OX_PLOUGH	Woman farmer adopted use of an ox plough (dummy)
AGROFORESTRY	Woman farmer adopted agro forestry 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)

Comment [MV18]: be consistent. It should be one word through out document.

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 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 [table1-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 outside~~ [hire outside](#) labour rather ~~than do~~ [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.

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170 Table1 results further indicated that adopters had smaller land under maize cultivation (2.73
171 ha) compared to ~~non-adopters~~non-adopters (3.5 ha). Adopters also applied less fertilizer
172 annually on average (318.2Kg) compared to ~~non-adopters~~non-adopters (342.61Kg).
173 However results indicated that adopters produced more maize per unit area at 949.1Kg/ha
174 compared to the ~~non-adopters~~non-adopters at
175 861.88Kg/ha. This is an important result that indicates how technologies like ox ploughs and
176 agroforestry can increase yields while reducing costs on fertilizer as well as reducing risks
177 associated with unpredictable crop failure for the resource constrained women farmers. [21]
178 noted that the low fertilizer use in many African maize farming systems are a result of risk
179 aversion, lack of agricultural credit and fertilizer availability and timely delivery.
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Table 2: Characteristics of farmer women household heads and technology adoption

Variable	Overall mean (Std. Dev)	Mean (Std. Dev)	
		Adopter	Non adopter (114)
	(164)	(50)	
Age of the woman head of household (years)	51.20 (11.67)	52.16 (10.99)	50.77 (11.98)
Education level of woman head of household (years in school)	4.93 (3.59)	4.28 (3.28)	5.21 (3.70)
Size of the household (Number of people living in the household)	7.36 (3.42)	7.00 (2.97)	7.51 (3.59)
Distance to the nearest village centre (Km)	7.04 (4.80)	7.16 (5.29)	6.99 (4.59)
Quantity of maize produced by household in current year (Kg)	2,780.49_(2,619.20) (2,534.81)	2,738.00_(2,828.55)	2,799.12_

Quantity of fertilizer used on maize in current year(Kg)	335.17 (280.64)	318.20 (278.02)	342.61 (282.68)
Number of household members providing labour	4.34 (2.49)**	3.74 (2.03)	4.60 (2.64)
Area of land under maize (ha)	3.26 (2.17)**	2.73 (1.62)	3.50 (2.34)
Maize yield in the current year (Kg/ha)	888.47 (484.40)	949.10 (521.81)	861.88 (466.97)

188 *Standard deviations in parentheses; Significant level: ** = 5%.*

189
190 Results in [table-Table 3](#) show that there is a significant difference ($P = .05$) between the
191 percentage of women household heads who engage in micro businesses who are adopters
192 of the ox- plough or agroforestry technologies and those are ~~non-adopters~~non-adopters. It
193 is indicated that 76% of women adopters of these technologies were engaging in micro
194 businesses as well compared to 57.89% of the ~~non-adopters~~non-adopters. The reason for
195 this is that incomes from outside the farm are used to invest in farm technologies that
196 enhance agricultural production. This is consistent with the findings of [22] that earning off
197 farm income, in this case income from the micro businesses enhances and positively
198 affects the likelihood of natural resource management practices.

199 Results also indicated that a significantly ($P = .05$) higher percentage of technology adopters
200 (84%) possessed a communication gadget like a mobile phone, radio or television compared
201 to the women non adopters at 64.91%. This result points to the fact that access to
202 information through a number of media concerning agricultural technologies can augment
203 adoption among smallholder farmers. [23] noted that mobile phones significantly reduce
204 search costs for information concerning input and output prices in addition to complementing
205 existing extension services where they are used by farmers.

206 [Results inTable 3](#) ~~results~~ also ~~pointed-out~~highlighted the scenario that a significantly (P
207 $< .01$) higher percentage of ~~non-adopter~~non-adopter women farmers (43.86%) had access to
208 credit compared to only 20% of the technology adopter women farmers. This is consistent
209 with the previous result that more adopters are involved in micro business to earn income
210 outside the farm than ~~non-adopters~~non-adopters and hence adopters face a higher
211 production risk than their counterparts given the investment they make in taking up the new
212 technologies. Therefore, the ~~non-adopters~~non-adopters resort to borrowing as a safety net to
213 smooth their consumption through paying school fees, buying consumables and other
214 services. In the same line, more non-adopters made voluntary savings (85.96%) compared
to adopters (84.00%). The result is in support of [24] who found

Comment [MV19]: could these percentages be significantly different?

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)
Percentages			
Woman engages in running a micro business (dummy)	63.41**	76.00	57.89
Access to a communication gadget like a phone or radio (dummy)	70.73**	84.00	64.91
Membership to a farmers' group/association (dummy)	90.24	92.00	89.47
Maize selling point regularly used by the woman farmer (dummy)	34.15***	0.00	49.12
Woman farmer's ability to make voluntary savings (dummy)	85.37	84.00	85.96
Woman head of household has access to credit (dummy)	36.59***	20.00	43.86

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

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 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.

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229 In addition, many of the extension trainings usually take place in town or village centres
230 where the micro business women usually go to trade. This seems to be in agreement with
231 the findings of [18] that farm operators, whose primary income source is farming, though
232 they may be engaged in other business, tend to seek out information on new farming
233 technologies.

Comment [H20]: Other non-agricultural activities in generating income

234
235 A woman farmer's access to a communication gadget such as a phone or radio was also
236 found to significantly ($P < .10$) increase the probability of awareness of farming technologies
237 by about 2.5 times than without the gadget. This is because mobile phones and radios in
238 modern times are used to disseminate and deliver information on agricultural prices, inputs
239 and new technologies. Imperfect information and knowledge concerning existence of inputs,
240 outputs and new technologies is very prevalent in developing world rural areas, though
241 information technology has potential to reduce the situation [25].

Comment [H21]: How is a mobile phone used to deliver inputs

242
243 Results also indicated that awareness of farming technologies decreased with increasing
244 education levels. Table 4 Results also results indicate that every single year increase in
245 education level, leads to about 8% decrease in awareness. This is due to the fact that
246 education has a tendency of leading to migration of labour from the agricultural sector into
247 other service and industrial sectors. Therefore, the more women get educated the less they
248 will be enthusiastic about learning about new farming technologies. [26] also emphasised
249 that Education-education and training programmes have favoured the male leaving the
250 rural women in many areas with
low education levels and more are illiterate compared to men.

Comment [H22]: I suggest when using binary response models there is need to explain your results using your odds ratio or the marginal effects.

251 Women farmers were found to be more likely to be aware of farming technologies the farther
252 away they are from the village centre. Every unit increase in the distance away from the
253 village centre could lead to 3.5% increase in awareness. This is because many of the
254 extension agents usually target those farmers outside the trading centres for training and
255 demonstrations. Furthermore, the farther the women farmers are from town the more they
256 will be entirely involved in farming as a core occupation, hence prompting them to seek
257 knowledge of new and better farming technologies which is solely provided by extension
258 workers who are sometimes overwhelmed by the number of farmers to attend to [27].

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

266

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 (dummy)	-0.389	0.698	0.677

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

268

269 3.3 Factors affecting women farmers' adoption of ox plough and agroforestry farming technologies

270

271 Results of the second stage of the logit model indicated that access to a communication
 272 gadget and total land the woman ~~head-of-household head~~ -put under cultivation were
 273 positive and statistically significant at the conventional levels for probability of adoption of ox plough

Comment [H23]: The same goes for the results interpretation for this model, odds ratio and marginal effects are more robust.

What is the general agreed line of spacing , there is some inconsistency in this paper.

technology in maize farming. For the same technology, likelihood of adoption was negatively and significantly affected by age, 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-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 head of household being a member of a farmer's group or association has negative impact of adoption of both ox ploughs and agroforestry technologies. Results in table-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-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 to shift from ox plough to tractors and also clear new land rather than practicing practising 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.

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

Variable	Ox plough Adoption			Agro-forestry Adoption		
	Coefficient	(Std.Err)	Odds	Coefficient	(Std.Err)	Odds
			Ratio			Ratio

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Age of the woman head of household (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 head of household 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%.*

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4. CONCLUSION

Though many factors ~~were came-out found~~ to affect awareness and knowledge of farmers about existing technologies, ~~interaction factors~~ ~~were quite came-out~~ prominently..... 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.

Animal draught technology (ox plough) being energy demanding, its adoption is affected by age of the woman farmer beyond a certain point. 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.

The benefits from agroforestry are medium to long term. Therefore ~~its-the~~ likelihood of ~~its~~ adoption by women farmers is promoted by ~~such~~ factors related to medium-long term ~~for~~ ~~example, like~~ age of the woman ~~head-of~~ 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.

REFERENCES

1. Kuteya, A. and Kambole, C. (2011). 2012 Zambia Agricultural Sector Budget Analysis. Presented by ACF/IAPRI Budget Breakfast Meeting Pamodzi Hotel, Lusaka November 30, 2011.
2. Budget of Zambia. (2013). The next steps, budgetary changes. www.pwc.com/zm.
3. Central Statistical Office (CSO), Ministry of Labour and Social Security (2013). Zambia Labour Force Survey Report.
4. Mason, M.N., Jayne, T.S. and Myers, R.J. (2012). The effects of the Food Reserve Agency on smallholder production patterns and maize market prices. Stakeholders' Meeting on Evidence-Based Agricultural Policy Decisions to Shape Agricultural Development for Poverty Reduction 5 December 2012 Taj Pamodzi Hotel, Lusaka, Zambia. Indaba Agricultural Policy Research Institute (IAPRI).
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.
6. Tembo, S. and Sitko, N. (2013). Technical Compendium: Descriptive Agricultural Statistics and Analysis for Zambia. Indaba Agricultural Policy Research Institute (IAPRI), Lusaka Zambia, Working Paper 76 August 2013. Available: <http://www.iapri.org.zm/index.php?>
7. Phiri, D., Franzel, S., Mafongoya, P., Jere, I., Katanga, R. and Phiri, S. (2004). Who is using the new technology? The association of wealth status and gender with the planting of

Comment [MV24]: What are these?

Comment [MV25]: Rephrase. may start with: "Adoption of the ox-drawn plough is affected by....due to...."

Comment [MV26]: specify how adoption is affected by age? From this research what was the cut off age?,

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- 359 improved tree fallows in Eastern Province, Zambia. *Agricultural Systems*, 79 (2004)
 360 131–144.
- 361 8. Thangata, P.H. and Alavalapati, J.R.R. (2003). Agroforestry adoption in southern Malawi:
 362 the case of mixed intercropping of *Gliricidia sepium* and maize. *Agricultural Systems* 78
 363 (2003) 57–7.
- 364 9. Adesina, A.A. and Baidu-Forson, Z. (1995). Farmers' perceptions and adoption of new
 365 agricultural technology: Evidence from analysis in Burkina Faso and Guinea, West
 366 Africa. *Agricultural Economics* 13 (1995) 1-9.
- 367 10. Adesina, A.A.; Mbila, D., Nkamleub, G.B. and Endamana, D. (2000). Econometric
 368 analysis of the determinants of adoption of alley farming by farmers in the forest zone of
 369 southwest Cameroon. *Agriculture, Ecosystems and Environment* 80 (2000) 255–265.
- 370 11. Kumar, S.K. (1985). Women's Role and Agricultural Technology. Chapter adapted from
 371 a presentation at a seminar sponsored by the international service for National
 372 agricultural research and the Rockefeller foundation, held in Bellagio, Italy March 1985:
 373 135-147.
- 374 12. Fernandez_Cornejo, J., Hendricks, C. and Mishra, A. (2005). Technology Adoption and
 375 Off-farm Household Income: The Case of Herbicide Tolerant Soybeans. *Journal of*
 376 *Applied and Agricultural Economics*, 37(3):549-563.
- 377 13. Doss, C.R. (1999). Twenty-Five Years of Research on Women Farmers in Africa:
 378 Lessons and Implications for Agricultural Research Institutions; with an Annotated
 379 Bibliography. CIMMYT Economics.
- 380 14. Keil, A., Zeller, M. and Franzel, S. (2005). Improved tree fallows in smallholder maize
 381 production in Zambia: do initial testers adopt the technology?. *Agroforestry Systems*,
 382 64:225-236.
- 383 15. McCulloch, A.K., Meinzen-Dick, R. and Hazell, P. (1998). Property Rights, Collective
 384 Action and Technologies for Natural Resource Management: A Conceptual Framework.
 385 SP-PRCA Working Paper No.1, International Food Policy Research Institute, CGIAR
 386 System-wide Program on Property Rights and Collective Action.
- 387 16. Smucker, G.R., White, T.A. and Bannister, M. (2002). Land Tenure and the Adoption of
 388 Agricultural Technology in Haiti. Paper presented at the 9th Biennial Conference of the
 389 International Association for the Study of Common Property Victoria Falls, Zimbabwe –
 390 17-21 June 2002. This paper was released as CAPRI Working Paper No.6. Available:
 391 <http://www.capri.cgiar.org/wp/capriwp06.asp>.
- 392 17. Karki, L.B. and Bauer, S. (2004). Technology Adoption and Household Food Security.
 393 Analyzing factors determining technology Adoption and impact of project intervention. A
 394 case of smallholder peasants in Nepal. Paper prepared to present in The Deutscher
 395 Tropentag to be held on 5-7 October, 2004, Humboldt-University, Berlin.
- 396 18. McBride, W.D. and Daberkow, S.G. (2003). Information and the Adoption of Precision
 397 Farming Technologies. *Journal of Agribusiness*, 21 (1):21-38.
- 398 19. Pretty, J. and Hine, R. (2001). Reducing Food Poverty with Sustainable Agriculture: A
 399 Summary of New Evidence. Centre for Environment and Society, University of Essex,
 400 Final Report from the "SAFE-World" (The Potential of Sustainable Agriculture to Feed
 401 the World) Research Project, University of Essex, February 2001.
- 402 20. Green, W.-H. (2003). Econometric Analysis 5th Edition. Prentice Hall, Upper Saddle
 403 River. New Jersey, Prentice-Hall Inc.
- 404 21. Heisey, P.W., and Mwangi, W. (1996). Fertilizer Use and Maize Production in Sub-
 405 Saharan Africa. CIMMYT Economics Working Paper 96-01. Mexico, D.F.: CIMMYT.
- 406 22. Marenja, P.P. and Barret, C.B. (2006). Household-level determinants of adoption of
 407 improved natural resources management practices among smallholder farmers in
 408 Western Kenya. *Food Policy*, 32(2007): 515-536.

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UNDER PEER REVIEW

- 409 23. Baumüller, H. (2012). Facilitating agricultural technology adoption among the poor: The
410 role of service delivery through mobile phones. ZEF Working Paper Series, No. 93.
411 Available: <http://hdl.handle.net/10419/88382>.
- 412 24. Giné, X. and Yang, D. (2008). Insurance, credit, and technology adoption: Field
413 experimental evidence from Malawi. *Journal of Development Economics* 89(2009):1-11.
- 414 25. Kuhlmann, F. and Brodersen, C. (2001). Information technology and farm management:
415 developments and perspectives. *Computers and Electronics in Agriculture*, 30
416 (2001):71–83.
- 417 26. Lubwama, F.B. (1999). Socio-economic and gender issues affecting the adoption of
418 conservation tillage practices. Available: <http://www.atnesa.org>.
- 419 27. Budak, D.B., Darcan, N. and Kantar, M. (2005). Women farmers and extension services
420 in small ruminant production in mountain areas of Turkey. *Journal of Arid Environments*,
421 62 (2005): 507–515.
- 422 28. Mercer, D.E. (2004). Adoption of agroforestry innovations in the tropics: A review.
423 *Agroforestry System*, 61(1):311-328.
- 424 29. Doss, C.R. (2002). Men's Crops? Women's Crops? The Gender Patterns of Cropping in
425 Ghana. *World Development*, 30(11) 1987–2000.
- 426 30. Doss, C.R. (2001). Designing Agricultural Technology for African Women Farmers:
427 Lessons from 25 years of experience. *World Development*, 29(12):2075-2092.
428
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430
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