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Factors influencing adoption of agroforestry among smallholder farmers in Zambia

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Summary

Agroforestry technologies have been extensively researched and introduced to smallholder farmers in Zambia for over two decades. Despite the research and extension effort over this period, not many farmers have adopted these technologies. The purpose of this paper is to determine why agroforestry technologies are not being taken up by examining factors that influence the adoption of agroforestry practices. Based on data obtained from 388 farming households, statistical analysis show an association between adoption of both improved fallows and biomass transfer technologies with knowledge of the technology, availability of seed, and having the appropriate skills. In addition some household characteristics are found to be linked to the incidence of adoption. However, the strength of association between these variables is low, giving an indication that there might be other factors at play limiting agroforestry adoption. It is anticipated that these findings will point to other areas beyond the household and community level that need further exploration in order to understand factors limiting agroforestry adoption.

Keywords: Agroforestry adoption, smallholder farmers, limitations to adoption, chi-square tests of independence analysis, Zambia

Introduction

Over 60 percent of Zambia's population live in the rural areas and the majority of these people depend on agriculture for improving livelihoods (Government of Zambia, 2006). However smallholder agriculture faces many challenges including low productivity, high dependence on rain-fed agriculture, insecurity of the traditional land tenure system and environmental degradation due to unsustainable agricultural practices. As a result of these challenges, smallholder agriculture remains at low productivity and this has led to high incidence of poverty among rural smallholder farmers. The consequence of low productivity is increased pressure on government to provide food aid, which also is never sufficient to meet the needs of all affected households. Therefore, smallholder agricultural productivity needs to be improved so that it that can create employment and income opportunities of the poor and rapidly reduce poverty (Government of Zambia, 2006).

In Zambia, natural fallows have been a common practice among smallholder farmers (Chidumayo, 1988) for restoring soil fertility. However with rapid population increase and land use pressure, these fallows have been reduced to below the minimum threshold required for the system to sustain itself (Franzel, 1999; Opio, 2001). As a response to declining land productivity, farmers open up forests to expand to new areas and this has led to loss of extensive forests and subsequent land degradation (Government of Zambia, 2006).

Part of the solution to address low land productivity is the development of new agroforestry technologies. In Zambia, agroforestry technologies have been trialled at research stations since 1988 and also on farms since 1992 in collaboration with farmers (Franzel et al., 2002). In particular improved fallows and biomass transfer technologies have been developed (Kwesiga & Coe, 1994; Kwesiga et al., 1999; Kwesiga et al., 2003). A quick and easy method for replenishing nitrogen and other trace elements would be use of inorganic fertilisers; however, these are beyond most of the rural farmers' budgets. Therefore agroforestry technologies offer an alternative solution to resource-constrained smallholder farmers, who in the absence of inorganic fertilisers would otherwise grow crops without addressing nutrient requirements and harvest little or nothing for storage. However, unless farmers widely adopt these technologies as part of their farming system, the potential benefits of agroforestry on livelihoods and the environment will not be realised.

As findings on factors that influence adoption of agroforestry vary between studies, it is necessary to further probe the adoption process so as to understand what actually influences adoption of improved fallows and biomass transfer as these would be instrumental in furthering their effective promotion and accelerating their equitable uptake. Literature suggests that successful adoption depends on favourable convergence of technical, economic, institutional and policy factors (Feder et al., 1985; Rogers, 2003). It is in an attempt to understand some of these factors that this study was undertaken. This paper therefore presents findings of the study done in the Eastern Province of Zambia. It uses bivariate analysis, particularly chi-square tests of independence to establish the associations of different factors with both trialling and adoption of these technologies (Bryman & Cramer, 2009).

The objectives of this study are to:

1. Determine extent of adoption of improved fallows and biomass transfer technologies
2. Determine factors influencing adoption
3. Identify future areas of focus in dissemination

Agroforestry Technologies

The basis of improved fallows is natural vegetation fallow systems whereby land is deliberately abandoned to allow for regeneration of trees either as coppices or grown from seeds. In the case of improved fallows, short duration nitrogen fixing trees are planted at the site where crops are grown. Typically after two or three years of growth, they are cut back, and leaves and twigs are incorporated with the soil at the time of cultivation and these act as sources of nitrogen. Stems and branches are used as fuel wood for heating and cooking.

As for biomass transfer technology, trees are established either as an improved fallow or per farmers' practice, around the periphery of their gardens. Once trees are two to three years old and with sufficient biomass, leaves are harvested and incorporated at the cropping site. Although biomass transfer technology can be applied to any crops, it has been recommended for use on high value crops due to high labour requirement (Kuntashula et al., 2004). The species suitable for both improved fallows and biomass transfer include *Sesbania sesban* (L.) Merr., *Tephrosia vogelii* Hook .f., *Cajanus cajan, Gliricidia sepium* (Jacq.) Walp., and *Leucaena leucocephala*(Lam.) De Wit., *Acacia angustissima* (Kwesiga et al., 2003) and *Tephrosia candida* (Madagascar) (Mafongoya et al., 2003).

In addition to research on technologies, an extensive dissemination program was initiated by the International Centre for Research in Agroforestry (ICRAF) in 1997 to promote agroforestry to farmers (Bohringer, 2002).

Agroforestry Adoption

Although Franzel et al. (2001) reported of high adoption, recent adoption studies indicate that both trialling and adoption of these technologies are low (Ajayi, Pers. Comm., March 2007). Ajayi estimates adoption of improved fallows in eastern Zambia at 20.6 percent and that of biomass transfer at 10.7 percent (Ajayi, Pers. Comm., March 2007).

Studies by Phiri et al. (2004) and Keil et al. (2005) found an association between wealth and the planting of improved fallows. In addition the synthesis by Ajayi et al. (2003) reveals a relationship between planting of improved fallows and the ownership of oxen. The ownership of oxen is an indicator for wealth among rural communities. These studies found that planting of fallows was higher among farmers that were said to be wealthy than among the very poor households. Farmers that own oxen are able to cultivate larger pieces of land within a short time or they would hire out oxen for extra resources to pay for labour or purchase other inputs. This in turn enables them to find time and resources to establish and manage improved fallows.

According to Phiri et al. (2004) and Keil et al. (2005) farmers that are involved in on-farm experimentation of agroforestry technologies with the researchers are more likely to adopt than those who are not. Keil also considered information and knowledge about a given technology as key to adoption of agricultural practices, especially ones associated with ecological benefits.

Lack of planting materials (seed and seedlings) is another factor considered to constrain establishment of fallows (Peterson, 1999; Kwesiga et al., 2003). Sometimes seeds and seedlings have not been sufficient to meet the needs of the farmers, or the preferred species have not been available. Generally, lack of planting materials is a limitation to adoption of agroforestry (Kwesiga et al., 2003).

The inability to wait two years to see the benefits also constrains establishment of improved fallows (Peterson, 1999). This factor is related with availability and timely distribution of planting materials. This usually leads to late planting and hence longer waiting time to benefits. To lessen waiting time to benefits, some species like *Tephrosia candida* can be grown for one year and cut in readiness for the next crop season and; other options exist too such as intercropping trees with crops in the establishment stages (Chirwa et al., 2003). How well these one-year long fallows perform depend on good timing for planting and also proper management.

Gladwin et al. (2002) and Keil et al. (2005) established that the probability of improved fallow adoption increases when farmers perceive low soil fertility as their current problem. In most cases however, even when low crop productivity is observed, farmers have been known to continue cultivating same plots; or where natural forests still exist, to extend their agricultural fields by opening up new forests, a practice attributed to enhance environmental degradation (Government of Zambia, 2006). With the latter case being less practiced due to dwindled forest areas, alternatives such as agroforestry that allow intensive management of already cultivated areas for resource poor-farmers offer best solution.

Opio (2001) found that lack of security of tenure was hampering female farmers from participating in the establishment of improved fallows with *Sesbania sesban* in Katete District. Most of the studied emphasise on cultivated land size effects on adoption than security of tenure. In the case of Zambia, most if not all smallholder farmers are situate in designated traditional lands, without formal written tenure but still believed to be a secure tenure. The synthesis by Ajayi et al. (2003) revealed that 3 studies had found farm size to have a positive association with farmers' decisions to plant and even continue with improved fallows although this finding is not associated with gender.

Age is another factor that has been extensively considered as a socioeconomic factor influencing adoption of agroforestry (Ajayi et al., 2003). Other studied factors include membership in farmers' clubs and cooperative groups, availability of labour supply, the degree of innovativeness of individual farmers (Ajayi et al., 2006) and expensive fertiliser prices (Gladwin et al., 2002).

Theoretical Context

There are different types of models that have been used to explain adoption decisions of new technologies. However, no single model can embrace and explain all aspects of adoption and the traditional attitude of smallholder farmers towards technologies ((Thangata & Alavalapati, 2003). Rogers (1995) developed the adoption and diffusion of innovations theory, which has been widely used to identify factors that influence decisions to adopt or reject an innovation. He defines an innovation as a "new idea, practice or object that is perceived as new by an individual or other unit of adoption" and said that the perceived newness of the idea for the individual is what determines their reaction to it (Rogers, 1995).

According to Rogers (2003), adoption occurs when one has decided to make full use of the new technology as a best course of action for addressing a need. Adoption is determined by several factors including socioeconomic, environmental, and mental processes that are governed by a set of intervening variables such as individual needs, knowledge about the technology and individual perceptions about methods used to achieve those needs (Thangata & Alavalapati, 2003).The adoption and diffusion model identifies five aspects that influence adoption: perceived attributes of the innovation; type of innovation decision; communication channel; nature of the social system; and the extent of change agent promotion efforts (Rogers, 2003). Some of Rogers' generalizations as significant variables that affect adoption, which have also been used in other adoption studies, include educational level, farm size and income.

The adoption-diffusion of innovations model is a useful model for understanding farmers' decision making processes when they consider taking up and eventually adopting new technologies. Adoption is reached after an innovation-decision process that occurs in a five-step time-ordered sequence namely: knowledge; persuasion; decision; implementation; and confirmation (Rogers, 2003). This model assumes that the heart of the diffusion process lies in the modelling and imitation by potential adopters of their neighbours with the new practice (Rogers, 2003), and that the tendency to adopt new practices relies on: the relative innovativeness and; the personal attributes of farmers, with some farmers adopting innovations more quickly than others. There is an assumption in this model that research generates information that is inherently valuable, desirable and suitable for increasing farm production and productivity (Jangu, 1997). In this study, it is also assumed that agroforestry technologies are feasible, efficient and suitable for increasing productivity in Eastern Zambia and that it is the best option for use by resource-poor smallholder farmers.

Rogers (2003) has categorised adopters into five including innovators, early adopters, early majority, late majority and laggards. This kind of classification is a problem to use in the situation where adoption has not reached 100 percent use (Rogers, 2003) as it does not include those that cannot be grouped within the five groups, the discontinuance and non-adopters. Therefore this study adapts Rogers' model but also looks at other studies conducted on agroforestry in Zambia and elsewhere to gain insights on levels of adoption and influencing factors (Peterson, 1999; Peterson et al., 1999; Gladwin et al., 2002; Phiri et al., 2004; Kuntashula et al., 2004; Ajayi et al., 2006; Ajayi, 2007; Ajayi et al., 2007; Kiptot et al., 2007).

Methodology

Method

A survey of 388 smallholder farmer households from four districts was conducted between the months of April to September 2008. The sample composed of 57 percent male and 43 percent females. The distributions of respondents per district are 23.2 percent for Chadiza, 25.3 percent for Chipata, 25.8 percent for Katete and 25.8 percent for Petauke. The four districts and two agricultural camps from each district were purposefully selected based on their exposure to agroforestry. An agricultural camp is an area managed by one agricultural extension officer. The random selection of villages and respondents from each village was then based on a list held by the agricultural extension officer or where records were lacking, physical random selection of households was done following a random number sequence. Appointments were made through the agricultural extension officer for the farmers to be present at their households during the period of administering the questionnaires. Data were collected by personal interviews through use of a structured questionnaire. Enumerators were recruited and trained to help with administering the questionnaire. Interviews were done in the local language, Chinyanja and the answers were recorded in English. A pre-test of the questionnaire was done to check for clarity and improve reliability.

Study Area

The study was conducted in the Eastern Province of Zambia. The Eastern Province is located between 10° 30′ to 15° S latitude and 30° 25′ to 34° E longitudes. It covers a total area of 69 000 km^2, representing 9% of the total land area of Zambia (Ngugi, 1988). Precipitation averages 800-1000mm per year, although when droughts are experienced, rainfall averages less than 600mm per year. The length of the growing season ranges from 139-155 days (Ngugi, 1988). Average daily temperature minima and maxima vary from 18-31°C during the hottest month of October to 6-23°C during the coldest month of July (Ngugi, 1988). The population density is 25 to 40 persons per square kilometre (Phiri et al., 2004) in clustered settlements, referred to as villages, of up to 100 homesteads (Ngugi, 1988). Agriculture accounts for 84% of the household income (Franzel, 1999).

Statistical Analysis

The responses to the individual household questionnaires with respect to individual technologies were processed and analysed using standard univariate and bivariate statistical techniques (frequency tables, cross-tabulations and chi-square analysis) using the software SPSS v15 (Pallant, 2007; Kinnear & Gray, 2008; Agresti & Finlay, 2009; Bryman & Cramer, 2009). Descriptive statistics were used to characterize households; chi-square test of independence was used to compare various factors with adoption of both improved fallows and biomass transfer technologies. Two levels of analysis have been done. Firstly, Farmers have been classified as testers of the agroforestry technologies if they have ever practiced the technologies. Secondly, the level of adoption with agroforestry practice is analysed including only those farmers who have tested agroforestry technologies.

Results and Discussion

Adoption of Agroforestry Technologies

A household is classified as trialling agroforestry if they have test planted any agroforestry technologies: improved fallows and biomass transfer. Generally both the initial trialling and adoption of agroforestry in the study area are low (Table 1). Nevertheless, improved fallows have a higher percentage of farmer's trialling than biomass transfer. For example, 44.9 percent farmers reported to have trialled improved fallows and 21.4 percent trialled biomass transfer (Table 1). Farmers who have trialled agroforestry include both those who have adopted and discontinued use.

Table 1: Adoption of agroforestry

	Improved fallow	**Biomass transfer**
Within the overall sample	**(N=388)**	**(N=388)**
Did not trial the technology	55.2%	78.6%
Trialled the technology	44.9%	21.4%
Within the group who trialled a technology	**(N=174)**	**(N=83)**
Adopted	73.6%	89.2%
Discontinued	26.4%	10.8%

Trialling and Adoption of Improved Fallow Technology

The sample population owns one to five plots per household and therefore every household is considered to have had a chance to practice improved fallows. However, the proportion of the sample that has never trialled this technology is higher than those who have trialled (Table 1). Some of the factors influencing trialling of improved fallows are discussed below.

The retention proportions of farmers that adopt improved fallows after trialling is higher than for those that discontinue (Table 1). It appears that when farmers have trialled a particular technology, they are likely to adopt the technology (continue practicing) than if they did not try at all. Floyd et al. (2003) found similar results in an adoption study involving multiple agricultural technologies in Nepal where the probability of retention once a technology had been trialled was 60 percent. Keil et al. (2005) studied experimenting farmers and also reported a 75.5 percent adoption of improved fallows among them. The question remains therefore why not many farmers get to trial these technologies in the first place; and how we could get them to trial.

Trialling and Adoption of Biomass Transfer Technology

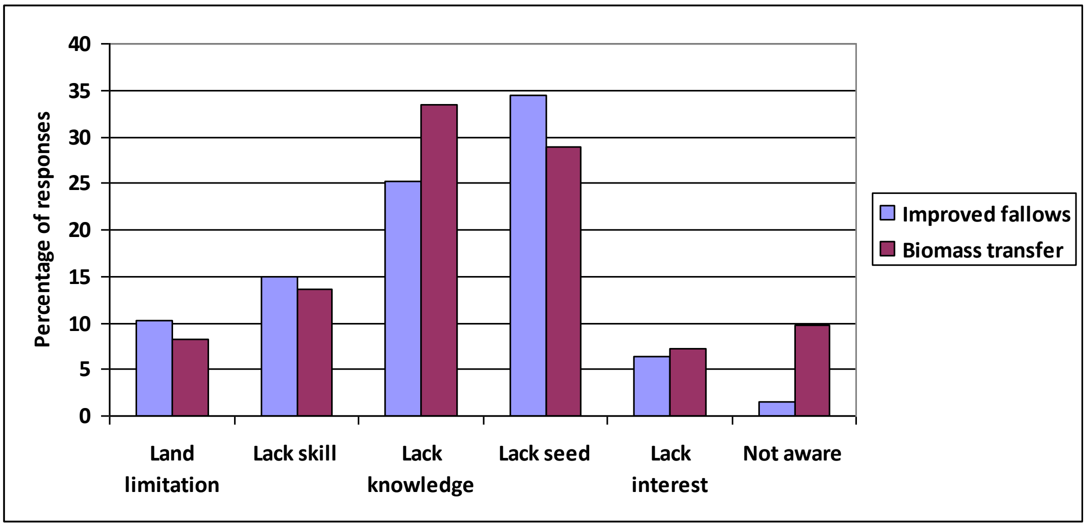
Biomass transfer technology is the other common agroforestry technology tested within the study area. In contrast to improved fallows, only 21.4 percent of the total sample had trialled biomass transfer (Table 1). It is worth noting that not all farmers in the area owned gardens. This study established that 253 (65.2%) of the sampled farmers had gardens. Therefore, the proportion of farmers who had trialled biomass transfer among farmers who owned gardens was 34.8 percent. In both cases however, the proportion of farmers who have trialled biomass transfer is low.

Like improved fallows, not all farmers that initially trialled the biomass transfer technologies adopted them. Nevertheless, the discontinuance rate for biomass transfer (10.8%) is lower than that of improved fallows (Table 1). This retention finding is in line with Floyd et al. (2003) and Keil et al. (2005) who concluded that trialling the technology is an important step in the adoption process.

Factors Influencing Adoption of Agroforestry

Farmers' responses to questions on whether or not there were some reasons that prevented them from trialling agroforestry technologies are different (Figure 1). Generally none of the reasons provided in the survey could be considered to greatly influence agroforestry practice. Figure 1 indicates that lack of seed and lack of knowledge influence trialling of improved fallows and biomass transfer more than other factors do. Each of the other factors influence accounts for below 20% each.

Figure 1: Factors influencing adoption of agroforestry technologies



NB: Columns do not add to 100% because respondents could give more than one response

Improved fallows have a higher percentage of awareness than biomass transfer (figure 1). Generally however, level of awareness is high. Therefore lack of awareness was not one of the main reasons preventing farmers from trialling agroforestry. Since lack of knowledge and lack of seed were said to influence agroforestry trialling more than would lack of awareness, limited land, lack of skill and lack of interest, they perhaps deserve particular attention when planning and implementing agroforestry development.

The results of chi-square test of independence in Table 2 show a significant association between trialling of improved fallows and lack of skill, lack of knowledge, lack of seed and lack of interest. The chi-square test finding of non-statistical association between awareness and trialling of improved fallows matches the descriptive statistics finding that nearly 93 percent of farmers were aware of agroforestry. Therefore lack of awareness would not be the reason farmers would not trial improved fallows because the level of awareness is high. The finding of land limitation not being significantly associated with trialling of improved fallows is consistent with Styger and Fernandes (2006) who found that planted fallows in Central America even got adopted in areas where land is limited since farmers have to intensify their production and are forced to improve the only available pieces of land. Although limited land, lack of knowledge, skill, seed, land and awareness were found to have an association with practicing of improved fallows, the strength of the relationship (phi) is either medium or low (Table 2). Lack of knowledge has a stronger negative relationship than do other factors.

Table 2: Factors influencing trialling of agroforestry technologies

Trialling	**Improved fallows (N=388)**				**Biomass transfer (N=388)**			
Factor	χ^2	**df**	**P**	**phi**	χ^2	**df**	**P**	**phi**
Limited land	3.333	1	0.068	-0.101	5.787	1	0.016*	-0.134
Lack skill	49.237	1	0.000*	-0.363	12.577	1	0.000*	-0.189
Lack knowledge	104.197	1	0.000*	-0.524	47.618	1	0.000*	-0.357
Lack seed	19.544	1	0.000*	-0.230	22.752	1	0.000*	-0.249
Lack interest	3.837	1	0.030*	-0.110	2.788	1	0.095	-0.097
Lack awareness	3.285	1	0.070	-0.113	10.097	1	0.001*	-0.172

* Significant at 5% level

All other considered factors for improved fallows were also found to be significantly associated with trialling biomass transfer except for lack of interest (Table 2). The trends for the strengths of association are the same as for improved fallows in that lack of knowledge has a stronger association than do other factors. In addition, lack of interest was found to be significantly associated with trialling of biomass transfer. Contrary to the finding on improved fallows however, land limitation was found to be significantly associated with trialling of biomass transfer.

Table 3 shows results of chi-square test of independence only for the group of farmers that indicated to have trialled agroforestry technologies. Land limitation, lack of seed and lack of awareness were found to be significantly associated with adoption of improved fallows, with the latter two factors also being significantly associated with adoption biomass transfer. Lack of knowledge and lack of skill were not found to be associated with adoption of both improved fallow and biomass transfer. In fact, all farmers of improved fallows said lack of knowledge was not the reason that would prevent them from adopting. Although the strength of association is medium in all significant factors, the order of strength between the two technologies is different. Lack of seed has a higher strength among factors associated with adoption of improved fallows whereas lack of interest is highest among factors influencing adoption of use of biomass transfer (Table 3). With limited land being significantly associated with adoption of both improved fallows, it would be right to assume that expansion of improved fallows at household level would be restricted. Whereas lack of knowledge and skill were found to be significantly associated with trialling farmers, they were not significant with farmers who adopted. We could therefore safely conclude that actual involvement with agroforestry improves both skill and knowledge about them.

Table 3: Factors influencing adoption of agroforestry

Adoption	Improved fallows (N=174)				Biomass transfer (N=83)			
Factor	χ^2	**df**	**P**	**phi**	χ^2	**df**	**P**	**phi**
Limited land	13.063	1	0.000*	-0.300	1.605	1	0.205	-0.317
Lack skill	0.287	1	0.592	-0.127	0.000	1	1.000	0.039
Lack knowledge					0.000	1	1.000	0.000
Lack seed	14.351	1	0.000*	-0.303	6.356	1	0.012*	-0.352
Lack interest	7.536	1	0.006*	-0.244	8.725	1	0.003*	-0.451

* Significant at 5% level

Other factors influencing adoption of agroforestry

Various factors relating to the farm and farmer characteristics were also tested using chi-square test of independence. Measures of strength were either phi, if the degree of freedom was 1, and or Cramer's V if the degrees of freedom were more than 1 (Pallant, 2007; Agresti & Finlay, 2009; Bryman & Cramer, 2009). Variables were selected based on previous studies (Peterson, 1999; Ajayi et al., 2003; Phiri et al., 2004; Keil et al., 2005; Ajayi et al., 2006). Farm and farmer characteristics tested include gender, age, education level attained, membership to clubs, location, income from livestock sales, marital status, non-farm income, main occupation, number of years of cropping (used a proxy for farming experience), size of garden owned (in case of biomass transfer), perception of status of soil fertility, method of cultivation, previous land use of plots, length of tenure and status of land ownership (Table 4).

Table 4: Other factors influencing trialling of agroforestry

Trialling	Improved fallow				Biomass transfer			
Variable	$\chi 2$	**df**	**P**	**phi/ Cramer's V**	$\chi 2$	**df**	**P**	**phi/ Cramer's V**
Gender	4.305	1	0.029*	-0.111	2.262	1	0.103	0.083
Age	12.219	4	0.016*	0.177	5.487	4	0.241	0.119
Education	2.689	4	0.611	0.083	2.807	4	0.591	0.085
Club membership	24.999	1	0.000*	0.259	13.075	1	0.000*	0.19
District	3.509	3	0.320	0.095	3.632	3	0.304	0.097
Marital status	2.909	2	0.233	0.087	2.147	2	0.342	0.074
livestock sales	3.142	5	0.678	0.09	18.498	5	0.002*	0.218
Non-farm income	5.656	5	0.341	0.121	6.856	5	0.232	0.133
Main occupation	6.102	4	0.192	0.125	8.559	4	0.073	0.149
Ploughing method	2.621	2	0.270	0.082	6.461	2	0.040*	0.129
Farming experience	36.196	10	0.000*	0.305	17.716	10	0.060	0.214
Previous land use	2.909	3	0.406	0.087	3.693	3	0.297	0.098
Tenure type	0.041	1	0.422	0.088	1.1	1	0.294	-0.053
Soil fertility status	0.728	2	0.695	0.043	1.189	2	0.552	0.055

* Significant at 5% level

This study found that only gender, age, club membership and farming experience were significantly associated with trialling of improved fallows, and that club membership, income from livestock sales and method of ploughing were significantly associated with trialling of biomass transfer (Table 4).

When analysis are done with only farmers that had trialled agroforestry technologies, it was found that only non-farm income and method of ploughing were associated with adoption of improved fallows and that none of the considered factors influenced adoption of biomass transfer (Table 5). Considering that not many factors were found to be significantly associated with adoption of improved fallows and that none of these factors are associated with biomass transfer adoption, we might assume that influencing farmers to trial agroforestry is essential to ensuring higher adoption.

Table 5: Other factors influencing adoption of agroforestry

Adoption	**Improved fallow**				**Biomass transfer**			
Variable	**$\chi 2$**	**df**	**P**	**Phi/ Cramer's V**	**$\chi 2$**	**df**	**P**	**Phi/ Cramers V**
Gender	0.000	1	0.871	0.12	0.07	1	0.526	0.069
Age	0.92	4	0.922	0.073	2.395	4	0.664	0.17
Education	1.924	4	0.750	0.105	1.32	4	0.858	0.126
Club membership	1.958	1	0.162	0.106	1.282	1	0.258	0.124
District	1.529	3	0.678	0.094	2.629	3	0.452	0.178
Marital status	0.093	2	0.468	1.517	2.86	2	0.239	0.186
Livestock sales	9.282	5	0.098	0.231	6.226	5	0.285	0.274
Non-farm income	6.707	5	0.005*	0.31	8	5	0.156	0.31
Main occupation	3.8	4	0.284	0.148	0.123	4	1	0.039
Ploughing method	7.404	2	0.025*	0.207	1.14	2	0.566	0.117
Farming experience	12.235	10	0.270	0.265	8.222	10	0.512	0.315
Previous land use	1.105	3	0.776	0.08	0.568	3	0.904	0.568
Tenure type	2.799	1	0.094	-0.127				
Soil fertility status	1.427	2	0.490	0.091	0.08	2	0.767	0.08

* Significant at 5% level

Conclusion and Recommendation

The purpose of this study was to determine the extent of adoption of improved fallows and biomass transfer technologies, and also to consider factors that influence adoption of these technologies in Eastern Zambia. This study found that trialling of agroforestry technologies is very low within the study area. For improved fallows, 44.9 percent of respondents have trialled whereas only 21.4 percent of the sample has trialled biomass transfer. Of those who have tested however, the retention rate for both technologies is high. For example biomass transfer had a retention rate of 80 percent. Trialling of both improved fallows and biomass transfer were found to be influenced by club membership, farming experience, lack of skill, lack of seed and lack of knowledge. In addition, trialling of improved fallows was also found to be associated with gender, age and lack of interest, while trialling of biomass transfer was also found to be influenced by income from sales of livestock, method of ploughing, land limitation and lack of awareness. This study establishes that the most important step to improving agroforestry adoption is to get farmers to trial. Once they trial, the probability of adoption is high. Therefore, understanding factors that influence farmers to trial is crucial to ensuring that many smallholder farmers get to trial improved fallows and biomass transfer.

Furthermore, an assessment of factors influencing farmers' decisions to adopt improved fallows showed that non-farm income, method of ploughing, limited land, lack of seed and lack of interest were statistically associated with adoption. Only lack of seed and lack of interest were associated with adoption of biomass transfer. There are more factors to consider at the trialling stage of both improved fallows and biomass transfer than there are at the adoption stage. Since these results result from a chi-square test of independence, at which variables are determined for their individual association with either trialling or adoption, it would be better to undertake further multivariate analysis so as to consider the interaction between these variables and how they jointly influence adoption.

In addition, restricting the study to farmers who have adopted practicing and studying the impact of these technologies on their livelihoods and also evaluating how extensively exposed other farmers are to these benefits might be another approach to increasing an understanding of adoption. Moreover, explorations of extension factors that help improve access to impacts, and provide capacity for implementation of agroforestry technologies deserve some attention.

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