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Why is adoption of agroforestry stymied in Zambia? Perspectives from the ground-up

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Small-scale farmers in Zambia are faced with problems of low crop productivity, scarcity of fuel wood and fodder, and subsequently are generally food insecure. Agroforestry can contribute to food and income security, amelioration of the environment and subsequently, to mitigation of climate change effects. However, despite all the potential of agroforestry technologies and the effort to promote them among smallholder farmers, their adoption and diffusion have remained low and so has their impact. Unless farmers adopt some of these technologies as part of their farming system, the potential benefits of agroforestry to food security, livelihoods and the environment will not be realized. This study investigated trialing and adoption levels of agroforestry in eastern Zambia where agroforestry has been researched and promoted for over two decades. A survey was completed of 388 small scale farmers. Data analysis shows that testing of improved fallows and biomass transfer, though low at 44.9 and 21.4% respectively, was higher than that of domestication of indigenous fruits (4.4%), Fodder banks (3.9%) and Woodlots (3.1%). The study however found that adoption rate of agroforestry among farmers that initially tested is high. Factors that affect adoption include lack of seed, limited land size, method of ploughing, lack of interest and access to extension services. Therefore we advocate for intensified promotion and encouragement support so that more farmers can trial these technologies. With high trialing rates, adoption of agroforestry is likely to increase. The key policy implication of this study is the necessity to embark on educating farmers so that they can trial and subsequently experience the impact of agroforestry technologies. Agroforestry will only make meaningful contribution to improving land productivity and farmer livelihoods if it is adopted.

Key words: Adoption, agroforestry, biomass transfer, improved tree fallows, logistic regression, smallholder farmers, Zambia.

INTRODUCTION

Although small-scale farmers face problems of low crop productivity, scarcity of fuel wood and fodder, and subsequently are generally food insecure, they have not been sufficiently stimulated to adopt agroforestry

technologies that can enable them to increase yields with minimal external agricultural inputs. In Zambia, agroforestry technologies have been trialed at research stations since 1988, and on farms since 1992 in

collaboration with farmers (Franzel et al., 2002). Agroforestry techniques have been deliberately promoted since 1997 by government agricultural extension systems, international organisations, Non-Governmental Organisations (NGO) and Community Based Organisations (CBO) to extend this knowledge to smallholder farmers (Böhringer, 2002; Franzel et al., 2001; Sanchez, 2002; Franzel et al., 2004). In 2004, eastern Zambia alone had over ten (10) organizations engaged in extension of agroforestry. Evidence of extension efforts in other countries have been reported by Chitakira and Torquebiau (2010), Masangano and Mthinda (2012), Mutua et al. (2014) and Kennedy et al. (2016).

Agroforestry can contribute to food and income security, amelioration of the environment and subsequently, to mitigation of climate change effects. Small scale farmers depend on land for their livelihoods and its ability to sustain production of food, feed, fibre and other goods. Agroforestry can improve crop productivity (Ajayi and Catacutan, 2012); Sileshi and Mafongoya, 2006; Kuntashula et al., 2006); enhance other ecosystem services (Sileshi et al., 2007); increase household access to wood energy; integrating fodder trees can improve animal feed availability as well as pasture productivity; agroforestry trees, when planted in the right place can reduce soil erosion and sequester substantial amounts of carbon. The potential of agroforestry in insulating smallholder farmers and agricultural landscapes against the negative impacts of climate change is also established to some degree in Zambia (FAO/IAEA, 2008). Farmers that get to adopt agroforestry can also benefit from the emerging carbon markets such as REDD+. A recent study in Zambia ranked agroforestry first among possible land use strategies for REDD+ (Kokwe, 2012).

There are five agroforestry technologies available for smallholder farmers in Zambia namely: improved fallows; biomass transfer; woodlots; fodder banks; and use of indigenous fruit trees (Kwesiga et al., 1993). The technologies developed for soil fertility improvement were improved fallows and biomass transfer (Kwesiga and Coe, 1994; Kwesiga et al., 1999; Kwesiga et al., 2003). Improved fallows are a deliberately planted crop of fast-growing leguminous nitrogen-fixing woody trees or shrubs left to grow on a field for a minimum of two years for rapid replenishment of soil fertility whereas biomass transfer refers to mulching or green-leaf manuring using tree or shrub foliage which is cut and incorporated to the cropping field so as to improve soil fertility (Kwesiga et

al., 2003). In addition to soil fertility improvement technologies, there were other technologies that were tested including: establishment of woodlots for supply of fuelwood (Kwesiga et al., 2003; Nyadzi et al., 2006; Nyadzi et al., 2003b; Pye-Smith, 2010); fodder banks as source of supplementary feed for animals (Chakeredza et al., 2007; Hove et al., 2003; Kwesiga et al., 2003); and domestication of indigenous fruit trees for nutritional security as well as contributing to household income (Iranbakhsh et al., 2009; Mng'omba et al., 2008; Akinnifesi et al., 2007; Kwesiga et al., 2003).

However, despite all the potential of these technologies and the effort to promote them among smallholder farmers (Zomer et al., 2009), their adoption and diffusion have remained low and so has their impact (Ajayi and Kwesiga, 2003; Mercer, 2004; Ajayi et al., 2007e; Ajayi and Catacutan, 2012). Unless farmers adopt some of these technologies as part of their farming system, the potential benefits of agroforestry to food security, livelihoods and the environment will not be realised. The objectives of this paper were to investigate the extent of adoption of agroforestry and the factors that lead to low adoption.

Adoption of agroforestry

There is confusion in the literature as to what constitutes 'adoption' by farmers (Giller et al., 2009; Jerneck and Isson, 2013; Glover et al., 2016). There also remains a gap in literature regarding understanding of adoption among subsistence farmers (Jerneck and Isson, 2013)). In this context, agroforestry has faced challenges, especially that different agroforestry technologies require different approaches and pathways to operationalisation. Different approaches to agroforestry adoption have been developed according to the technology under consideration (ICRAF, 2004). Distinctions have been made by some between testing farmers, experimenters and adopters (Adesina et al., 2000), whereas other authors have considered it as a continuum and hypothesized that farmers can be assigned positions on the continuum based on the uptake of the different components of the agroforestry technology (Ajayi and Kwesiga, 2003). Adoption definitions must take into account the farmer's own perception of adoption. According to Ajayi (2007), farmers' definition of adoption follows such attributes as good management of the field, density of planting and mix of species planted, number of years the farmer continuously practices agroforestry and

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the size of the plot with agroforestry practices. These variations in definition of agroforestry adoption make comparison between studies difficult.

Sechrest et al. (1998) considered adoption as a dynamic process, whereas Rogers defines it as the implementation of already transferred knowledge about a technological innovation and that adoption is the end product of the technology transfer process (Rogers, 2003). According to Rogers (2003), adoption occurs when one has decided to make full use of a new technology as a best course of action for addressing a need. It refers to the process through which one is exposed to, considers, and finally rejects or accepts and practices an innovation (Mosher, 1978).

THE ADOPTION-DIFFUSION MODEL

The adoption-diffusion of innovations model (Rogers, 1962) is useful for understanding farmers' decision making processes when they consider testing and eventually adopting new technologies. Adoption is reached after an innovation-decision process that occurs in a presupposed 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 rely on: the relative innovativeness and; the personal attributes of farmers, with some farmers adopting innovations more quickly than others (Jangu, 1997). 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).

A farmer is said to have adopted an innovation after at least two repeated uses (Mosher, 1978). It is worth noting that farmers that have adopted a particular innovation may decide to discontinue or dis-adopt. Cary et al. (quoted in Guerin and Guerin, 1994) found in Australia a dis-adoption rate of 1 in 3 among farmers that had successfully adopted conservation tillage practices (Guerin and Guerin, 1994). Farmer rejection or dis-interest to trial it again may not necessarily be due to fault in the extension service but may include other factors such as topography (Mosher, 1978), socioeconomic and institutional (Matata et al., 2010; Mazvimavi and Twomlow, 2009).

Experiences with agricultural technology adoption in Southern Africa

There are many experiences where adoption claimed during the course of active promotion of technologies by

NGOs and researchers, halted after the temporary influence of the project expired, without a sustained change in agricultural practice (Giller et al., 2009). When the project or research support stops, farmers quickly revert to their former crop management practices (Giller et al., 2009). The widespread adoption of conservation agriculture that was claimed through promotion programmes appears to have suffered the same fate in South Africa (Bolliger, 2007, quoted in Giller et al., 2009) and in Zambia (Baudron, 2008, quoted in Giller et al., 2009). Gowing and Palmer (2008 quoted in Giller et al., 2009) concluded that there has been virtually no uptake of conservation agriculture in most sub-Saharan African countries, with only small groups of adopters in Ghana, Tanzania and Zambia. Haggblade and Tembo (2003) suggest that 75,000 Zambian smallholder farmers practiced conservation farming in 2002/03 season, from about 20,000 in the 2001/02 season because of the 60,000 starter packs issued as a drought-relief measure by a consortium of donors. They estimated that some 15,000 were spontaneous adopters, while the remaining 60,000 practiced conservation farming as a condition for receiving their input. In many ways the problems that smallholder farmers face with adoption of conservation agriculture are analogous to the problems experienced with adoption of green manures or 'improved fallows' of fast-growing shrubby legumes (Giller et al., 2009).

Although there are many success stories of farmer uptake of green manures and improved legume tree fallows (also referred to as fertilizer trees) (Ajayi et al., 2006b; Ajayi et al., 2007), few of these have outlasted the lifetime of the promotion project (Giller et al., 2009). Where successes have been claimed there have been distortions of 'adoption' or 'farmer uptake' (Giller et al., 2009). In the late 1990s in Malawi during an intensive promotion campaign for intercropped green manures led by research scientists and NGOs, seed of the fish bean (*Tephrosia vogelii*) was worth three times as much in the local markets as the main staple legume, common bean, and farmers responded by producing and selling *Tephrosia* seed (Giller et al., 2009). Although widespread farmer adoption of improved legume tree fallows was claimed in western Kenya, these vanished from the fields of smallholder farmers, together with the seed market for the legume trees, when the intensive promotion campaigns stopped (Ojiem et al., 2006 quoted in Giller et al., 2009).

The above examples point to the complexity of adoption, showing that farmers adopt technologies for different reasons and therefore reports on adoption need to be considered within given contexts and not generalised. A technology can only be considered a successful 'innovation' that is likely to spread spontaneously when fully embedded within the local social, economic and cultural context (Leeuwis, 2004, quoted in Giller et al., 2009).

Literature review on factors influencing trialing and adoption agroforestry

Adoption is influenced by several factors, including socioeconomic and environmental, 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 and Alavalapati, 2003). Successful adoption depends on favourable convergence of technical, economic, institutional and policy factors (Feder et al., 1985; Rogers, 2003).

Ajayi et al. (2003) have synthesised studies in Zambia on adoption of improved fallows. It was found generally that wealth, labour, farm size, and exposure to improved fallows affected farmer decisions to establish improved fallows (trial) and to later continue with the practice (adopt), while use of fertiliser and oxen ownership positively influenced a farmer's decision to establish a fallow. Phiri et al. (2004) found an association with farmers' wealth status with the fallow planting being higher among farmers that were classified as wealthier than among the very poor households. Similar results were obtained by Keil et al. (2005) who found that adoption of improved fallows increased with wealth levels, starting with those described as fairly wealthy, and decreased with well-off farmers. In addition they found a relationship between planting of improved fallows and the ownership of oxen (an indicator of wealth status among rural communities). Farmers who own oxen are able to cultivate larger pieces of land within a short time or 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.

Farmers that are involved in on-farm experimentation of agroforestry technologies with the researchers are more likely to adopt than those who are not (Phiri et al., 2004; Keil et al. 2005). Keil et al. (2005) reported a 75.5% adoption rate of improved fallows among experimenting farmers.

Farmer awareness of problems associated with land productivity encourages them to seek possible solutions to address such problems. Franzel (1999) revealed that when farmers are aware they have to improve their soil in order to increase production, and inorganic fertilizer was not available, they are likely to take up improved fallows. Farmers have several soil fertility improvement technologies to select from such as agroforestry technologies, crop rotation, animal manure, inorganic fertilisers and conservation farming (Mafongoya et al., 2006). Place and Dewees (1999) indicated that competition exists between all organically-based soil fertility replenishment systems and mineral fertilizer options, and a fertiliser subsidy acts as a disincentive to using organic-based systems. Keil et al. (2005) concluded that improved fallows could only be suitable in situations

where there was inadequate access to markets for fertiliser, but that this result also depends on the wealth status of a household. Kwesiga et al. (2003) reported improved fallows as a technology for farmers that cannot afford fertiliser and have no access to animal manure.

In addition to bio-physical characteristics, farming systems are also constrained by socio-economic as well as cultural constraints (Giller et al., 2009). According to Giller et al. (2009) lack of uptake of some of the soil fertility management and productivity options result from farmers lacking the resources required to use a new technology and not due to technical problems with the new options. Marenja and Barrett (2007) also found that resource constraints were limiting many smallholder farmers in Kenya from adopting integrated soil fertility management techniques.

Sometimes, farmers do not adopt because the technology does not fit with existing practices. Farmers' involvement in new technologies requires tradeoffs with other activities from which they currently generate their livelihood (Giller et al., 2009) and if the new technology does not fit with them, they will hesitate to take it up. Doss and Morris (2001) have indicated that there are certain technology specific factors that influence adoption decisions. Rogers (2003) indicates attributes that farmers look for in a technology before they can apply it as relative advantage; trialability; observability; compatibility; and complexity.

Agroforestry technologies require access to germplasm, specific skill and knowledge (Styger and Fernandes 2006, Kwesiga et al. (2003) and their absence often limits the adoption of such technologies. Peterson (1999) found a lack of germplasm (seed and seedlings) as one of the reasons for farmers not practicing improved fallows. Ajayi et al. (2006c) list access to good quality seeds as one of the factors affecting adoption of agroforestry in Zambia.

Mercer and Miller (1998) have suggested that perceived risk and uncertainty about agroforestry could explain the low adoption rates. Pannell (2003) notes that uncertainty is one of the key factors inhibiting uptake of land conservation practices in Australia, but has not been extensively researched by agricultural related adoption studies due to the common focus on short-term productivity oriented practices. When farmers invest in planting trees that has uncertain outcomes, and requires them to wait before they can see yield results. Even when farmers are presented with information about the benefits of the technologies, they consider the labour investment for planting trees and the non-immediate returns, before they consider planting.

Negatu and Parikh (1999) and Zubair and Garforth (2006) attribute the low uptake and lack of participation in farm forestry activities to neglect of the perceptions of local people or potential beneficiaries of projects. Similarly, Keil et al. (2005) established that the probability

of improved fallow adoption increases when farmers perceive low soil fertility as their current problem. The limited acceptance of agroforestry activities may be due to farmers' considering local conditions, cultural values, people's needs and the importance of local participation (Zubair and Garforth, 2006).

Opio (2001) reports insecurity of tenure as a hindrance to adoption of agroforestry in Zambia, hampering female farmers from participating in the establishment of *Sesbania sesban* fallows in Katete District of Zambia. Equally the synthesis by Ajayi et al. (2003) revealed that three studies had found farm size to have a positive association with farmers' decisions to plant and even continue with improved fallows although the latter finding is not associated with gender. Zambia has dual land tenure systems, the statutory and customary tenure systems (van Asperen and Mulolwa, 2006). Nearly all small-scale farmers fall within the customary tenure system whereby families depend on acquiring land through ancestry accession. As each family is restricted to sharing land that belonged to their forefathers, if family size increases, individuals' share of land gets smaller. Some farmers end up cultivating on borrowed or rented land. In communities where potential adopters cultivate such land, adoption of agroforestry is expected to be low. There is a need to establish the minimum required land size for a farmer to be able to engage in agroforestry practices and the percentage of farmers above that threshold. Equally important is the examination of whether the customary tenure system is sufficient in itself to support agroforestry.

Although Keil et al. (2005) found land to be a limiting factor to increasing the size of portions grown to improved fallows in Zambia, Styger and Fernandes (2006) found that in Central America, planted fallows even get 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.

Farmers' planning time horizons are usually short and this influence how well environmental practices are fitted with other farm decisions (Vosti and Witcover, 1996). Franzel (1999) and Place and Dewees (1999) found that farmers rarely plan for fallowing the land but are forced to fallow when the harvests get too low, and when they cannot afford mineral fertilisers. If farmers do not plan for establishment of improved fallows, their inability to wait two years to see benefits constrains establishment of improved fallows (Peterson, 1999).

Gladwin et al. (2002a) report that what motivated the women farmers in Eastern Province to establish an improved fallow was the realisation that their soil was depleted; fertiliser was expensive and that their maize harvests could not meet their yearly consumption requirement. There appears to be a relationship between farmers' ability to purchase or access fertiliser and establishing a fallow. When farmers can afford fertiliser,

they prefer to use it to improve crop productivity than establishing a fallow and waiting for two to three years before they can see the benefits.

Age has been found to be significant in deciding whether to continue with the technology or not (Ajayi et al., 2006a). Older farmers were not willing to continue with the technology as compared to younger ones.

Other factors influencing farmers' decisions to get involved with agroforestry include availability of labour supply (Ajayi et al., 2006a). Labour is considered a limiting factor, not only to a farmer's decision to practice agroforestry (Ajayi et al., 2003) but also to the expansion of the practices (Keil et al., 2005). Keil et al. (2005) found that only 14% of the adopting farmers were willing to expand beyond the experiment size, citing limited land and labour as constraining factors to any expansions. Styger and Fernandes (2006) also indicate that improved fallows get adopted where labour and technologies are readily available. Levels of poverty could also explain the low rates of adoption of agroforestry. According to Keil et al. (2005) farmers that were classified as poor and very poor had lower rates of adoption. Farmers have to wait to see the benefits of agroforestry technologies, hence they would need to have other ways of survival during the establishment stage of improved fallows.

METHODOLOGY

Study area, data collection and data analysis

A survey of 388 smallholder farmer households from districts of Chadiza, Chipata, Katete and Petauke located in the Eastern Province was conducted between the months of April to September 2008. Data were collected in eight (8) agricultural camps from four (4) districts indicated above namely: Chadzombe and Kumadzi; Feni and Kapita; Chilembwe and Mwanamphangwe; and Chataika and Mondola respectively. The sample composed of 57% male and 43% females. The distributions of respondents per district are 23.2, 25.3, 25.8 and 25.8%; for Chadiza, Chipata, Katete and Petauke districts, respectively. The districts and agricultural camps were purposefully selected based on their exposure to agroforestry. An agricultural camp is an area managed by one agricultural extension officer and normally consists of 200 to 300 households. The random selection of villages and respondents from each village was based on a list held by the agricultural extension officer, or where records were lacking a list was created and 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 (Sekaran, 1992). Enumerators were recruited and trained to help with administering the questionnaire. Interviews were done in the local vernacular language, Chinyanja but the answers were recorded in English. A pre-test of the questionnaire was done to check for clarity and improve reliability. The timing of data collection was selected to coincide with the end of the rain season – a period when most farmers do not spend a great time on agricultural activities.

Table 1. (a) Testing of agroforestry technologies (percentages) where n=388 for each technology comprising the groups 'never tested' and 'tested'. (b) Adoption of agroforestry technologies (*with variable number of respondents).

Variables	Agroforestry technologies (%)				
	Improved fallow	Biomass transfer	Woodlots	Fodder banks	Indigenous fruits
a. Within the overall sample					
Never tested	55.2	78.6	96.9	96.1	95.6
Tested	44.9	21.4	3.1	3.9	4.4
b. Within the group who trialed a technology					
Adopted	73.6	89.2	91.7	80.0	82.4
Stopped	26.4	10.8	8.3	20.0	17.6
	(n=174)*	(n=83)*	(n=12)*	(n=15)*	(n=17)*

Classification of farmers into adoption classes

A household was classified as testing agroforestry if they had trial-planted agroforestry tree species. Those households that have tested agroforestry, continued practicing it and have gone over one planting cycle of the agroforestry species, were classified as adopters, as described by Rogers (2003). Households that have tested agroforestry but had decided to discontinue using it were classified as 'stopped (dis-adopters)'. Rogers (1995) defines discontinuance as the decision to reject an innovation after it has previously been adopted. This study did not establish whether the group of farmers that tested agroforestry technologies had only intended to trial or they had intended to use the technologies. It is assumed that farmers who had tested the technologies had intended to use them.

It is hypothesised that there are differences between the three types of identified farmers, and that examining these differences could help explain the observed adoption levels for agroforestry in the study area. It is also hypothesised that both testing and adoption of agroforestry technologies are influenced by internal and external factors.

Data analysis

Cross-tabulations and chi-square tests were used to examine relationships among extension factors that influence agroforestry testing and adoption. Chi-square tests of independence were used to compare the frequency of cases found in the variables (Bryman and Cramer, 1997; Leech et al., 2008), and were used as a step of analysis for selecting variables for inclusion later into logistic regression (Field, 2005; Pallant, 2007). Factors that influence testing and adoption of improved fallows and biomass transfer technologies were investigated using logistic models. Logistic regression estimations were necessitated by the binary nature of the dependent variables (1=Trials/adopt; 0= not trial/dis-adopt) (Agresti and Finlay, 2009) as well as the fact that independent variables collected in the study were a mixture of nominal, ordinal and continuous ones (Hosmer and Lemeshow, 1989; Pallant, 2007; Agresti and Finlay, 2009). The logistic model was applied to the data using the LOGISTIC REGRESSION command in SPSS version 15 (Bryman and Cramer, 2009; Kinnear and Gray, 2008; SPSS, 2006) in the Windows 2003 environment. The logistic regression procedures on analysing and presenting results followed those described by Hosmer and Lemeshow (1989), Field (2009), Pallant (2007), and Sweet and Grace-Martin (2008).

RESULTS

Trialing and adoption levels

Generally both the initial testing and adoption of agroforestry in the study area are low (Table 1). This study focused on testing and adoption of two (2) agroforestry technologies namely: improved fallows and biomass transfer technologies. The sample population owned one to five plots per household and therefore every household was considered as having sufficient means to trial and adopt improved fallows. However, the proportion of the sample that had never tested this technology was higher than those who had (Table 1). For example, 44.9% of farmers reported they had tested improved fallows.

Biomass transfer technology is the other common agroforestry technology tested within the study area. In contrast to improved fallows, only 21.4% of the total sample had tested biomass transfer (Table 1). It is worth noting that not all farmers in the study area owned gardens. This study established that 285 (73.5%) of the sampled farmers had gardens. Therefore, the proportion of farmers who had tested biomass transfer among farmers and who owned gardens was 34.8%. In both cases however, that is, among the total sample as well as among those that own gardens, the proportion of farmers who have tested biomass transfer is low. The analysis for testing of biomass transfer however was done based on the total sample since the goal was to establish the proportions of farmers that had tested within the sample.

Factors influencing testing and adoption of agroforestry technologies

Two of the factors that appear to influence agroforestry adoption are the lack of seed and lack of knowledge. Figure 2 indicates that lack of seed and knowledge



Figure 1. Map of Zambia showing the study site of four districts in Eastern Province of Zambia.

influence adoption of improved fallows and biomass transfer more than other factors do. Each of the other factors' influence account for below 20% each.

Generally, the level of awareness in regards to both improved fallows and biomass transfer technologies was very high. The number of farmers that identified lack of awareness as factors influencing testing and adoption of both improved fallows and biomass transfers were less than five and ten percent respectively (Figure 1). Therefore lack of awareness is not the reason farmers would not trial improved fallows or biomass transfer. However, lack of knowledge and lack of seed of soil fertility nitrogen fixing trees were identified as affecting trialling of both technologies. Since lack of knowledge and seed were said to influence testing of both improved fallows and biomass transfer technologies they deserve particular attention when planning and implementing agroforestry development. The majority of farmers, irrespective of whether they had tested improved fallows and biomass transfer or not, did not think that any of the

identified factors were influencing the decisions to trial the technologies.

Results of the logistic regression on adoption of improved fallows

The variables in the model to explain adoption of improved fallows (Table 2) are non-farm income (nfsinco), method of ploughing used (howploup), land limitation (landIF), lack of seed (seedIF), lack of interest (intrIF), and the frequency of visits by farmers to extension (farvists). In Table 2, the variable farmer visited extension (nofarv) substitutes variable farvists. Variables nfsinco, howploup and farvists are recoded into 5, 2 and 5 dummy variables respectively.

The model containing the six explanatory variables was found to be statistically significant ($\chi^2=74.781$, $df =15$, $p=0.000$) (Table 2). This indicates that the model was able to distinguish between farmers who were classified

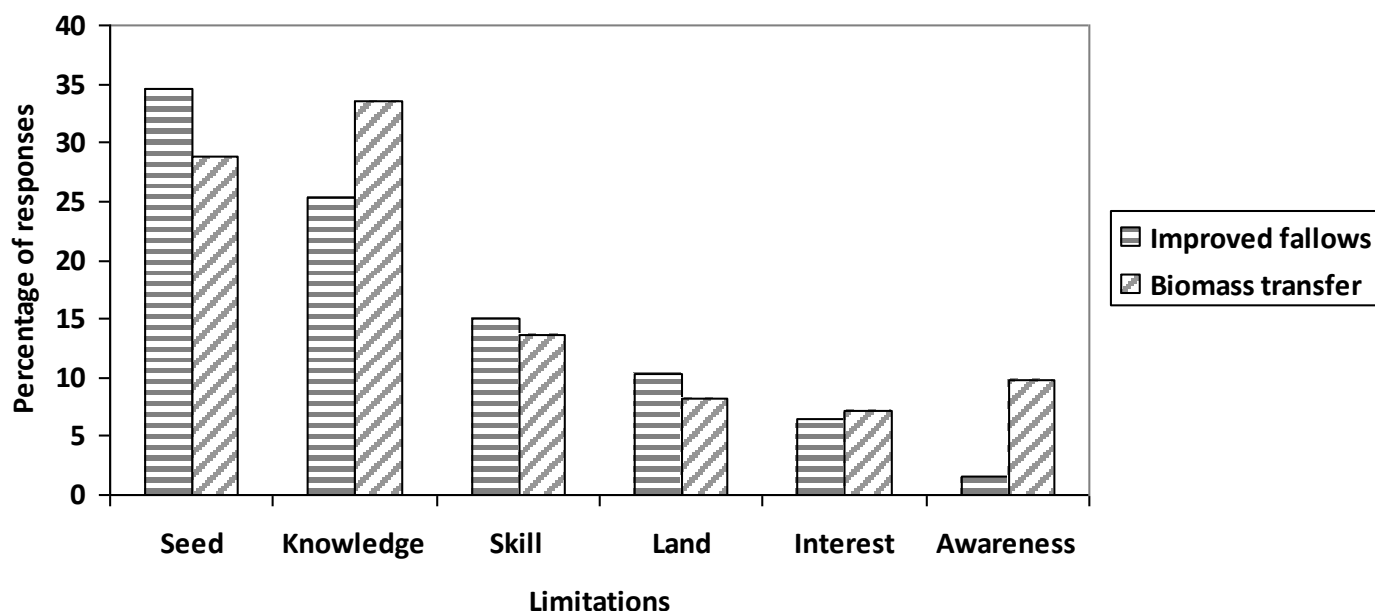


Figure 2. Factors influencing adoption of agroforestry in the study area of eastern Zambia.

Table 2. Logistic regression estimation for the adoption of improved fallows.

Parameter	B	Sig.	S.E.	Exp(B)
Non-farm income <100000 (nfsinco1)	1.081	0.234	0.909	2.949
Non-farm income 100001+ (nfsinco2)	1.721	0.023	0.755	5.591
Non-farm income ZMK500001+ (nfsinco3)	0.767	0.315	0.763	2.153
Non-farm income ZMK1000001 (nfsinco4)	0.352	0.776	1.241	1.422
Non-farm income >ZMK1500000 (nfsinco5)	2.051	0.084	1.188	7.773
Hand hoeing only (howploup1)	0.624	0.412	0.760	1.866
Combining hand hoeing and ox plough (howploup2)	-1.506	0.007	0.561	0.222
Land limitation (landIF)	-2.491	0.003	0.840	0.083
Lack of seed (seedIF)	-1.63	0.001	0.503	0.196
Lack of interest (intrIF1)	-4.734	0.000	1.345	0.009
Farmer visited extension officer 1-3 times (farvists1)	1.464	0.025	0.655	4.322
Farmer visited extension officer 4-6 times (farvists2)	0.439	0.651	0.972	1.552
Farmer visited extension officer 7-9 times (farvists3)	18.865	0.999	22687.59	155882993
Farmer visited extension officer 10-12 times (farvists4)	0.226	0.856	1.245	1.254
Farmer visited extension officer more than 12 times (farvists5)	2.122	0.026	0.951	8.348
Constant	1.317	0.007	0.485	3.734
Model Chi-square	74.781			
Model df	15			
Model Sig.	0.000			
-2 Log likelihood	126.215			
Cox and Snell R Square	0.349			
Nagelkerke R Square	0.510			
Hosmer and Lemeshow Chi-square	1.868			
Hosmer and Lemeshow df	7			
Hosmer and Lemeshow Sig.	0.967			
% correct predictions	83.9			

as having adopted improved fallows and those who had not. Cox and Snell R Square (0.349) and Nagelkerke R Square (0.510) indicate that approximately 34.9 and 51% variance in adoption of improved fallows can be predicted from a combination of the six independent variables. From Table 2, we note that overall, 83.9% of the respondents were predicted correctly. In the initial model 73.6% of farmers were correctly predicted as belonging to the group that adopted improved fallows.

The significant variables in the adoption of improved fallows model are shown in Table 2. The variables include: land limitation, lack of seed and lack of interest, visiting the extension officer between 1 to 3 times in a year, visiting the extension officer for more than 12 times in a year, and cultivation of fields using a combination of hand hoeing and ploughing. The strongest predictor of improved fallow continuance was the dummy *farvists5* (farmers visited extension more than 12 times a year), which recorded an odds ratio of 8.348. The reference group for this dummy variable was *novisits* i.e. farmers that had never visited extension. This result indicates that farmers who adopted improved fallows were over 8.3 times more likely than those who had not adopted to report that they had visited the extension officer more than 12 times in a year. On the other hand, farmers that adopted improved fallows were also 4.3 times more likely than those who had not adopted to report they have visited the extension officer up to three visits per year.

In the case of the association between non-farm income and adoption of improved fallows, the groups that reported income between ZMK100,001 and ZMK500,000 and also over ZMK1,500,000 were found to be statistically associated with adoption of improved fallows. Their odds ratios were 5.6 and 7.7 respectively. The group without non-farm income were a reference group for this variable. Other income groups were not found to be statistically significantly different from the reference group.

The odds ratio of 0.222 for a combination of hand hoeing and ploughs to cultivate their fields was less than 1, indicating that farmers who adopted improved fallows were less likely to report that they used a combination of hand hoeing and ploughs to cultivate their fields.

Other predictors found to influence adoption of improved fallows were, limited land, lack of seed, and lack of interest. The odds ratios presented in Table 2 for these variables are less than 1, which suggests that the odds of adopting improved fallows are less for farmers who own little land, and lack tree seeds and also farmers who lack interest.

Adoption of biomass transfer technology

The variables in the model to explain adoption of biomass transfer technology are household yearly income ranging between ZMK 100,001-500,000 (*yrlyinco2*), household

yearly income ranging between ZMK500,001 – ZMK1,000,000 (*yrlyinco3*), household yearly income above ZMK1,000,001 (*yrlyinco4*), lack of seed (*seedBT*), lack of interest (*intrBT*) and no extension visits (*noextnv*).

The model in Table 3 explained variability in adoption of biomass transfer of between 24.9 (Cox and Snell = 0.249) and 50.1 (Nagelkerke R squared = 0.501%). Equally, the Hosmer and Lemeshow test was not significant ($p = 0.816$) which according to Pallant (2007) implies support for the model. The model also correctly classified 90.4% of the farmers.

The variables *yrlyinco2*, *yrlyinco3*, *yrlyinco4*, *seedBT*, *intrBT* and *noextnv* were significant. The -2LL improved from 56.98 for that of the model with the constant only to 33.07. The Omnibus test of model coefficients is significant ($\chi^2 = 23.733$, $df = 7$, $p = 0.001$), indicating that the model was able to distinguish between adopters of biomass transfer and those that were not. The combination of these variables explained variability in adoption of biomass transfer of between 25 (Cox and Snell = 0.25) and 50.4 (Nagelkerke R squared = 0.504%). Equally, the Hosmer and Lemeshow test was not significant ($p = 0.825$). The model also correctly classified 90.4% of the farmers.

It appears that annual household income, availability of agroforestry tree seeds and interest among farmers influence adoption of biomass transfer. For example, the odds ratios of 24.4, 47.95 and 140.2 with incomes of *yrlyinco2*, *yrlyinco3* and *yrlyinco4* respectively, were obtained (Table 3). The adopting farmers are 24 times more likely to report a higher income bracket of greater than ZMK100,000. It would therefore be expected that most of the farmers that have not adopted biomass transfer would report that they have no annual income. Lack of seed and lack of interest have negative signs and odds ratios below 1, implying that adopting farmers were less likely to report that they would be influenced by lack of tree seed and lack of interest in their decisions to adopt biomass transfer.

DISCUSSION

Trialing and adoption of agroforestry

Testing of both improved fallows and biomass transfer remains quite low. Despite the technological advantages of improved fallows and biomass transfer as established by research and some of the practicing farmers, farmers have not been testing these technologies to the extent that they can realise the benefits from them. Franzel et al. (2002a) reported improved fallows as a suitable practice for similar socioeconomic and biophysical conditions to those experienced by smallholder farmers in eastern Zambia. For those farmers whose fields had little or no yield, improved fallows are an obvious option to natural

Table 3. Logistic regression estimation for the adoption of biomass transfer.

Parameter	B	Sig.	S.E.	Exp(B)
Yearly income <100000 (yrlyinco1)	20.321	0.998	8705.206	669126989
Yearly income 100001+ (yrlyinco2)	0.445	0.827	2.038	1.561
Yearly income ZMK500001+ (yrlyinco3)	-0.076	0.973	2.241	0.926
Yearly income ZMK1000001 (yrlyinco4)	2.925	0.130	1.933	18.634
Limitation of seed (seedBT)	-2.453	0.134	1.637	0.086
Lack of interest (intrBT)	-22.935	0.998	9026.10	0.000
Extension officer visited farmer 1-3 times (farvistd1)	0.496	1.000	22615.9	1.642
Extension officer visited farmer 4-6 times (farvistd2)	-18.948	0.999	20736.6	0.000
Extension officer visited farmer 7-9 times (farvistd3)	-21.024	0.999	20736.6	0.000
Extension officer visited farmer 10-12 times (farvistd4)	-0.268	1.000	24349.2	0.765
Extension officer visited farmer more than 12 times (farvistd5)	-16.207	0.999	20736.6	0.000
Had no extension visits (noextnv)				
Constant	19.514	0.999	20736.6	298551497
Model Chi-square	31.568			
df	11			
Sig.	0.001			
-2 Log likelihood	25.408			
Cox and Snell R Square	0.316			
Nagelkerke R Square	0.637			
Hosmer and Lemeshow Test				
Chi-square	1.037			
df	7			
Sig.	0.994			
% correct predictions	94			

fallowing as it would reduce the time of fallowing as well as considerably increase soil fertility, and subsequently increase yields. The assumption is that farmers would start testing of improved fallows as a response to soil fertility depletion. This means that farmers would start using improved fallows in fields that they have cultivated for a period of time even when they can still harvest a crop from it without the use of external inputs. This study found that 44.9% had tested improved fallows and 21.4% had tested biomass transfer. However, the retention proportions of farmers that adopt improved fallows after testing is higher than for those that stopped (Table 1). From this study, adoption of improved fallows was estimated at 73.6%, a result similar to Keil et al. (2005). Similarly, not all farmers that initially tested the biomass transfer technologies adopted them. Nevertheless, the discontinuance rate for biomass transfer (10.8%) is lower than that of improved fallows (Table 1). Floyd et al. (2003) also found similar results in adoption studies involving multiple agricultural technologies in Nepal where the probability of retention once a technology had been trialed was 60%. It appears that when farmers have

trialed a particular technology, they are more likely to adopt it than if they did not try it at all. Both studies by Floyd et al. (2003) and Keil et al. (2005) concluded that testing the technology is an important step in the adoption process. The question remains therefore why not as many farmers get to trial these technologies in the first place; and how we could get them to trial the technologies.

Factors affecting adoption of improved fallows

Seed availability

Lack of seed emerged as one of the important reasons for farmers not testing both improved fallows and biomass transfer technologies. This finding is in line with Ajayi (2007) who reported that availability, sufficient amounts of and good quality seed were constraining the widespread uptake of improved fallows. The introduction of agroforestry technologies in the study sites started with ICRAF, an international research organisation, distributing

seeds to the interested farmers mostly through formal extension and farmer groups. Groups were established particularly to promote agroforestry and the members of the groups were called farmer trainers. The role of the farmer trainers was to train fellow farmers and to distribute seed. Although lack of seed appeared to be a limiting factor for testing of improved fallows, it affected less than 40% of the sample. Some farmers in Zambia were discouraged from planting improved fallows due to late delivery of seed and that this mostly affected the seeds that required establishment of nurseries. Provision of small quantities of “starter seeds” as loans to farmers who are first time planters (Ajayi, 2007; Kiptot et al., 2006) the need for seed support systems through research and extension (Pisanelli et al. 2008) are necessary if improved fallows have to be trialed and subsequently adopted.

Farmer trainers/contact farmers get involved in capacity building activities that help to improve their understanding of the technologies they are intended to promote and therefore get exposed to various activities outside their communities such as tours, exchange visits, trainings and workshops. However, such farmers are perceived as being ‘better off’ and if jealousy arises some farmers do not feel comfortable associating with them (Kiptot et al., 2006). Not all farmer trainers or first generation farmers plant the seed that is distributed to them. Kiptot et al. (2006) found that, although seed was distributed to the farmer trainers/contact farmers for free, 60.8% of the recipient farmers in Kenya had not planted them. When farmer trainers/contact farmers do not plant agroforestry species themselves but encourage other farmers in the area to plant, the likelihood that those other farmers would plant is low. The effect of free seed distribution in the Zambian context must be investigated to establish how adoption and the associated processes are affected.

The findings by Kiptot et al. (2006) concerning the choice of species by farmers are critical to improving the adoption of agroforestry. The study shows that farmers prefer to plant species of their choice, not those imposed upon them. Most farmers would prefer species with multiple uses, that are edible, saleable and with coppicing ability to those solely for soil fertility.

Agroforestry seed needs to be available through seed markets or farmer owned seed orchards if agroforestry technologies are to be part of the farming systems. Unless the seed is readily available to farmers and farming communities, agroforestry trialing and adoption will remain low.

Farmer interest in agroforestry

Lack of interest emerged as the second most important factor to lack of seed in influencing adoption. There is need to devise ways in which farmers’ interest can be

aroused: perhaps through ensuring that they observe benefits accruing from use of improved fallows, and through provision of incentives that go with involvement in agroforestry programmes. Kiptot (2007) and Kiptot et al. (2007) found that smallholder farmers face the problem of addressing daily basic needs, hence their perception and prioritisation of technologies whose benefits are perceived to be in the far future are low. Ignoring the circumstance of smallholder farmers and simply addressing soil fertility issues, will negatively affect adoption of technologies such as agroforestry.

Lack of sustained interest could result in higher discontinuance rates and therefore promoters of improved fallows will require understanding on how to sustain farmer interest. One way would be to ensure that benefits of improved fallows are well established and demonstrable especially at the trialing stage. In addition, the impact of getting involved in improved fallows must be evident to those that adopt earlier.

Land Limitation

Land limitation was measured as a perception question, and farmers answered either ‘yes’ or ‘no’ to whether land was limiting them from testing improved fallows. This variable was only found to negatively influence adoption of improved fallows. It would appear that at testing stage, farmers are interested to see how the technology performs, however when they consider continuing with the practice, they assess land availability. It is necessary to help farmers with planning how to integrate improved fallows on land when they perceive it to be limited in relation to what they have to use it for. It needs to be emphasised to farmers that improved fallows can be applied to all sizes of land, especially now that there are species that have been found to effectively ameliorate soil fertility within one year’s growth.

Non-farm income

Non-farm income was found to positively influence the adoption of improved fallows. This contrasts with Baidu-Forson (1999) who did not find non-farm income to be associated with adoption of land-enhancing technologies in Nigeria and attributed this to the absence of options for households to earn non-farm income within the study region. Holden et al. (2004) concluded that access to non-farm income in the Ethiopian highlands reduced the incentives of farm households to invest in conservation. It can be argued that when farmers have sufficient income from non-farm activities, they will opt out of using technologies such as agroforestry which are labour intensive and require a longer period of time to realise the benefits, and engage in intensive agriculture including

use of inorganic fertilizers. In eastern Zambia, non-farm income is usually earned during the dry season when there is little or no farm activity.

Annual household income positively influenced adoption of biomass transfer. Farmers usually obtain household income from sale of agricultural produce. In this study however it was established that farmers also obtained income from sale of livestock, off-season employment, and small businesses, but not from remittances. Ayuk (1997) also found in Burkina Faso that most of the household income comes from sale of agricultural produce and that 65% of households' income was derived from off-season farming. Use of biomass transfer is labour intensive, which means a household lacking family labour might need to hire from outside the family in order to manage it. In addition biomass transfer complements other garden activities and farmers usually have to invest in purchase of garden inputs such as inorganic fertilisers, vegetable seed and watering cans.

Method of ploughing

Farmers cultivate either by use of hand hoes, ox-drawn plough or a combination of the two. The adoption of improved fallows was found to be negatively influenced by the combined methods of ploughing. Farmers that used a combination of these methods would not adopt improved fallows compared to those who used either hand hoes or ox-drawn ploughs only. This study also found that most farmers depend on hand cultivation. The cultivation season starts during the dry season and usually the soil is hard to break but if farmers wait for the rains to start, they may be late to sow and plant their crop risking a reduction in crop yields. This therefore requires that they cultivate the land before the first rains or that they have the means to cultivate their fields fast enough for the crop to be grown with the first rains. Therefore, how farmers cultivate their fields gives them advantage to ensuring speedy and early planting.

Conclusions

This study has shown that there is a low level of adoption of agroforestry in eastern Province despite the high level of awareness about agroforestry in the study area. Improved fallows have a higher adoption compared to the other four technologies developed alongside it in eastern Province. This could be attributed to its direct contribution to increased yields of the staple crop – maize. The study found that adoption rate of agroforestry among farmers that initially tested is high. Therefore we advocate for intensified promotion and support so that more farmers can trial these technologies. With high trialing rates, adoption of agroforestry is likely to increase. The evidence

provided suggests that with seed being made available to farmers, offering training on how to practice these technologies and exposing farmers to success stories where they have demonstrable effects, would increase the rate of trialing and subsequently adoption. Land distribution among small-scale farmers will remain an issue as over 50% of the farmers own less than two (2) hectares. Biomass transfer is not limited by land since it can be practiced even on small gardens exclusive of the tree component.

The key policy implication of this study is the necessity to embark on educating farmers so that they can trial and subsequently experience the impact of agroforestry technologies. However doing so requires more technical intervention as well as financial commitment by institutions and government agencies whose mandates require them to promote agroforestry. Agroforestry will only make meaningful contribution to improving land productivity and farmer livelihoods if it is adopted carefully.

Conflict of Interests

The authors have not declared any conflict of interests.

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