Logistic modelling of smallholder livestock farmers' adoption of tree-based fodder technology in Zimbabwe

R Jera[1] and OC Ajayi[2]

Abstract

Based on field data collected from 131 small scale dairy farmers that were randomly selected from four agro-ecological zones, this study assessed the potential of adoption of fodder bank technology as a means for improving livestock production and income generation for smallholder farmers in Zimbabwe. Using a logit modelling approach, it also identified the drivers of adoption of the technology by analysing the influence of household characteristics and ecological factors on farmers' decision to adopt the technology. The model correctly predicted 75% of observed adoption and non-adoption by farmers. Results reveal that dairy herd size, land holding size, membership of dairy association and agro-ecological potential are the key factors influencing farmers' adoption of fodder bank. Age, sex, household size and educational level of farmers play lesser role. Male and female farmers were equally likely to take up and practice fodder bank if they are given equal access to information and incentives. The study recommends farmer-led extension approaches where farmers who possess certain key characteristics should constitute the initial group for disseminating information regarding the technology in rural communities. The results highlight the importance of access to dairy product markets as a driver for the adoption of fodder banks. It is recommended that forging a strategic partnership with the Dairy Development Programme (DDP) will offer high potential for enhancing the scaling up of the adoption and impact of fodder bank technology in the country.

Keywords: Agroforestry; animal nutrition; dairy production; economic modelling; sustainable agriculture

1. Introduction

Most smallholder farmers in Africa usually engage in livestock production as an important component of their farming systems. In Zimbabwe, in particular, the production of livestock in addition to crops is a strategy for farmers to raise their farm income and reduce the food insecurity that many rural households are experiencing due to the decline in the agricultural sector. But

[1] *Agricultural Economist, Southern Alliance for Indigenous Resources (SAFIRE), 132 Upper Fourth Street, PO Box 1166, Mutare, Zimbabwe (ritajera@yahoo.com).*

[2] *Senior Scientist (Agricultural Economics & Policy), World Agroforestry Centre (ICRAF), PO Box 30798, Lilongwe 03, Malawi (o.c.ajayi@cgiar.org).*

the low quality and quantity of feed resources for animals to maintain high levels of milk and meat production is one of the greatest constraints to improving the productivity of livestock in the country. Commercial feed supplements are not readily available or are too expensive for an increasing majority of smallholder farmers, especially following the downturn of the national economy since the early 2000s. In response to this challenge, international and national research and development institutions have over the past decade collaborated to identify technological options suitable for smallholder farmers to complement the sources of feed for their livestock.

One of these options, fodder bank technology, was developed based on agroforestry principles. The technology involves planting fast-growing (usually) leguminous trees and shrubs on land that is usually fenced. The legume species grown serve as reservoir or "*bank*" from where farmers can collect protein-rich fodder species to feed their animals. Fodder banks provide good quality fodder during the dry season because they are less susceptible to climatic changes than herbaceous plants once established (Hove *et al*., 2003). Biophysical assessments of a range of plant species have been carried out to evaluate their quality and potential to provide nutrition to livestock on smallholder farms. The assessments identified *Acacia angustissima, Leucaena leucocephala* and *Calliandra calothrysus* as important fodder species. Yields for *Calliandra* species range from 2.5 to 5.6 tons per hectare per year. *Acacia angustissima, Leucaena leucocephala* and *Gliricidia sepium* produce more than 3 tons per hectare per year when cut at the end of the wet season. The fodder can be fed to livestock, especially dairy animals, either on its own or as a supplement to commercial concentrate feeds. The results indicate that browse from legume species in fodder banks provides a source of low-cost, easy-to-produce protein and energy supplements, especially during the dry season when availability of pasture and vegetation cover is low in the fields (Hove *et al*., 2003; Hove, 2001).

Given its potential, efforts are being made to enhance the uptake of the technology among resource-poor smallholder farmers and to explore appropriate approaches to disseminate information on the technology to farming communities. However, apart from a few studies (e.g. Moyo & Ayuk, 2001) on the profitability of fodder banks, there is a critical information gap regarding acceptance and potential adoptability of the technology by smallholder farmers in Zimbabwe. The lack of such information constrains the identification of a sound strategy for scaling up the technology in Zimbabwe in particular and in southern Africa in general. An understanding of the driving forces of adoption is important for the development of appropriate extension and technology packages that can be adapted and are acceptable to farmers.

The overall objective of this study is to assess the adoption of fodder bank technology by smallholder farmers in Zimbabwe. The specific objectives of the study were to: (i) analyse household, resource-endowment and ecological factors that influence farmers' decisions to adopt fodder bank technology, and (ii) identify appropriate approaches to scale up the technology to realise its potential.

2. Materials and methods

2.1 Selection of study sites

Study sites were selected from a list of pilot districts where the World Agroforestry Centre (ICRAF) has been carrying out research and development activities on fodder banks. The sampling unit comprised members of the Smallholder Dairy Development Programme (DPP) and those who have been exposed to fodder through training and awareness programmes by ICRAF's field staff. The sampling frame consisted of all the farmers that have been trained on fodder bank technology in the selected sites. This included all the farmers who were selling their milk through established dairy centres, those who no longer sold milk through the centres because their cows were dry or ex-members who had pulled out of the scheme.

In 2004/05 a total of 131 dairy farmers were selected from five sites which were sampled from different DPP divisions based on milk performance[3]. The five study sites were selected as follows: *Nharira* from division one (high milk producing area, with milk sales of over 300 litres of milk a day), *Chikwaka* from division two (milk sales ranging from 200 to 300 litres a day), *Mvuma* from division three (milk sales ranging from 50 to 200 litres a day), *Zvimba* from division four (milk sales ranging from 20 to 50 litres a day) and *Gokwe* from division five (milk sales below 20 litres a day). These study sites are in the natural agro-ecological regions I, IIA, IIB, III, and IV respectively (rainfall and agricultural potential decreases with the number of the natural region).[4]

2.2 Data collection method

To gain insight to the type of fodder bank species that farmers planted, their perceptions on the performance of fodder banks, and the problems they face in adopting the technology, we first conducted informal surveys in one of the selected study sites using semi-structured questions.

---

[3] *In Zimbabwe there are 31 dairy centres of which 28 are fully functional. DPP grouped these centres based on level of performance in terms of the daily volume of milk sales.*

[4] *Zimbabwe is divided into five agro-ecological zones numbered I through IV. Natural region I is the wettest and highest agricultural potential while region IV is the driest and has the lowest agricultural potential.*

To ensure that farmers had a clear idea of the theme of the study, we asked them to define what they understood by "adoption" of fodder banks. About three-quarters (73%) of the farmers defined an adopter as an individual who grows fodder trees and feeds them to the animals. Other farmers responded that "adoption" means "growing of trees in large quantities or expanding the area under fodder" (22%). We then explained to them that in the present this study, we have defined "adoption" to mean establishment of *any* fodder tree species *and* feeding it to animals. This implies that if a farmer grows a tree species that could be used as fodder but was not feeding them to animals, such farmer was not considered to have "adopted" fodder bank technology. This is because the farmer may have planted the trees to improve soil fertility (some of the fodder trees species have multiple uses). Information on the assessment of factors of adoption was collected from all the 131 smallholder farmers through formal structured questionnaires.

2.3 Type of data

Several factors have been documented in past research as factors that affect farmers' decision to adopt agroforestry-based technologies (Ajayi *et al.*, 2006; Keil *et al.*, 2005; Thangata & Alavalapati, 2003; Ajayi *et al.*, 2003; Franzel & Scherr, 2002; Gladwin *et al.*, 2002; Kuntashula *et al.*, 2002; Place *et al.*, 2002). In the present study, the choice of the variables that were hypothesised to influence adoption was based on the regularity with which a variable was cited in the literature. Using this criterion, the following variables described below were included in the logit model (Table 1).

2.3.1 Farmer characteristics

i) Membership of dairy association and performance of dairy centres: Membership of a co-operatives or commodity association increases access to productive resources such as seed, information and training. It also provides a ready market for milk, for instance, the group may hire transport and procure processing material and refrigeration. With an efficient market provided by dairy associations, it is expected that farmers will adopt new technologies quickly. A synthesis of adoption of agroforestry technologies in Zambia reveals that farmers' adoption is positively influenced by membership in cooperative groups (Ajayi *et al.*, 2003). If a farmer has been a member of dairy association for a long period, such a farmer is more likely to have received information on fodder trees for a longer time and the possibility of adoption would be higher. This variable is hypothesised *a priori* to have a positive effect on farmer adoption of fodder banks.

ii) Level of formal education: The level of formal education attained was used as a proxy for farmer's ability to acquire and effectively use information. Human capital is an important asset for adoption and an educated farmer is more likely accept new farm technologies. This variable is therefore assigned *a priori* positive effect indicating that farmers who are more educated are expected to adopt fodder more than farmers with no formal education.

iii) Gender: Women headed households may respond less favourably to new technology than men because the traditional power structure and control over household productive resources are less favourable to women, i.e. negative effect on adoption. On the other hand, women may not have access to cash to purchase commercial feed concentrate for the livestock and therefore they may readily embrace fodder banks than men. In addition, fodder banks may be more attractive to women given that it provides other benefits such as fuelwood which will result in less labour inputs fire wood collection by women. The effect of gender on adoption of fodder may be ambiguous and was, therefore, not assigned *a priori.*

iv. Age: The household head is the final decision-maker in terms of the allocation of land for fodder tree growing and therefore age may enhance adoption. However, age may constrain fodder bank adoption because older farmers may not be too enthusiastic to plant trees whose benefits are not immediate, whereas younger farmers might be more willing to try out new technologies. Hence, *a priori* age can be positively or negatively related to the adoption of tree-based fodder.

2.3.2 Characteristics of the farm

i) Land size: Most empirical studies find that larger farms are more likely to adopt new agroforestry technology than smaller ones. The larger the farm size, the more likely that a farmer can afford to set aside an extra piece of land to grow fodder trees. *A priori*, farm size is positively related to farmers' decision to adopt the technology.

ii) Herd size: This is an indicator of wealth in most communal areas in Zimbabwe. Wealth enhances risk-taking and the probability that a farmer will invest in a new technology, i.e. positive relationship. Large dairy herd size increases the demand for livestock feeds and if a farmer cannot afford purchased concentrates for all the animals, the feed may be complemented with fodder banks. However, large herd size may constrain fodder establishment because a farmer may not have sufficient land to plant fodder to feed large number of animals. Such farmers who have large herds are wealthier and are more likely to afford commercial feeds than those with small herds. The influence of wealth may therefore *a priori* be either positive or negative.

iii) Household size: This variable determines the availability of household labour supply. During field planting and establishment of fodder trees, availability of "free" household labour might increase adoption of the technology. Household size is expected to have a positive relationship with adoption.

2.3.3 Spatial variables

i) Agro-ecology and natural region: The performance of fodder species under different climatic conditions is expected to influence farmer's decision to invest in the technology. *A priori,* the natural regions with higher rainfall (i.e. those with lower ordinal numbers) are expected to have higher level of adoption because fodder plants grow better in such areas. This variable is expected to have a negative sign.

ii) Access to markets: The performance of dairy centres is used as a proxy for the performance of the local market, i.e. demand for milk at the district level. Rating was done by the Dairy Development Programme (DDP) in 2003. The presence of milk market facility is an incentive to increase productivity. Farmers who are members of highly rated dairy centres are expected to have a greater incentive to adopt the fodder technology than farmers who are members of lowly rated milk groups. However, farmers whose farms produce more milk may be expected to have access to more cash and therefore better place to afford concentrates for their animals rather than plant trees. This variable could have an *a priori* negative or positive sign.

Table 1: Description of variables and *a priori* expectation, fodder bank study, Zimbabwe

Variable	Description and type of variable	Expected sign
Y	Dependent variable is Tree based fodder adopted: *categorical* *1= Yes, 0= No*	
YRMEMB	Years of membership in dairy association or cooperative group: *Continuous*	+
EDUC	Formal Education level: *categorical* *(0=None, =-primary, 2=Secondary, 3=Tertiary)*	+
PERFD	Performance of dairy centre according to ranking by Dairy Development Programme (DDP) *(Division 1 to 4 i.e. 1-more milk and 4 less milk)*	-/+
LANDS	Size of land holding: *Continuous (hectares)*	+
AGE	Age of household head managing the dairy enterprise: *Continuous*	+/-
GENDER	Gender of household head: *Dummy (0=female 1= male)*	-
HHDSIZE	Household size: *Continuous*	+/-
NR	Natural Region: *Categorical (I=wettest, IV=driest)*	-
HERD SIZE	Number of dairy animals: *Continuous*	+

3. Data analysis

The data were analysed with the aid of SPSS software. A diagnosis of farmers' resource endowments and delineation of their definition of adoption and factors that affect technology adoption was carried out. A characterisation was done using contingency tables (cross tabulation) to compare the proportion of adopters and non-adopters in respect of a particular characteristic. Chi-square tests were carried out to assess relationships between adoption and several variables.

A Logit model is used as the main analysis tool for this study. The choice of the model is informed by the fact that the dependent variable (adoption of fodder) is a dichotomous (yes/no) variable and, and most of the independents variables are also are categorical. The parameter estimates of the model are asymptotically consistent and efficient. The standardised coefficients correspond to the beta-coefficients in the ordinary least squares regression models. The binary logistic model does not make the assumption of linearity between dependent and independent variables and does not assume homoskedasticity.

Another advantage of using the logit model is that it does not require normally distributed variables. The model's appropriateness to data can be detected using the model chi-square, which is analogous to the F-test in the OLS regression model. This approach assumes that the dichotomous choice to adopt the fodder technology or not (yes = 1; no = 0) can be represented by a logistic regression model. The probability of adoption is explained as follows:

Probability of adoption= $P_{(y=1)} = \dfrac{e\beta_0 + \beta_1 X_i}{1 + e\beta_0 + \beta_1 X_i}$ -------------- ***equation (1)***

The logit transformation of the probability of adoption, P(y=1) can be represented as follows:

L**og** $\left[\dfrac{p_{(y=1)}}{\left(1 - p_{(y=1)}\right)} \right] = \beta_0 + \beta_1 X_i$ ------------------------------------- ***equation (2)***

Equation (2) represents the logarithm of the odds of adoption of fodder banks conditional on the explanatory variables that were included in the model. Since the logit model is a non-linear model, the normal R^2 measure for goodness-of-fit is not valid. To determine the percentage of correct predictions, the predicted probability of adoption is calculated for each farm and the prediction is compared with actual adoption decisions. The model is assumed to predict adoption if the predicted probability is greater than 0.5, and to predict non-adoption otherwise. The model chi-square (β=0) was the goodness of fit measure and it tests the null hypothesis that all population logistic regression coefficients, except the constant, are zero. The binary model used in the study is specified implicitly and explicitly as follows:

Yi = $f(\beta \chi_i)$= f (gender, age, education, land size, herd size, household size, performance of dairy centre, natural region, years of membership in dairy association).

4. Results and discussion

4.1 Farmer categorisation

The results of the categorisation of farmers into adopters and non-adopters for a selected set of variables are presented in Table 2. About a quarter of farmers (23%) had established a fodder bank plot but were not feeding their animals fodder from the trees because the trees were still too young and the vegetative biomass was small. There is a significant difference in the proportion of adopters between farmers who are more resource endowed — those with more draft power, ox-ploughs, family labour or household size, and dairy herd. A comparison between the two wealth groups further reveals that there is also a significant difference in the proportion of adopters and non-adopters between the better-offs and those less resource-endowed. In regard to the years of membership in dairy associations, results show that a higher proportion of adopters are farmers with more years of experience and skills in the dairy sector. The explanation for this is that the more experienced a farmer is, the greater the likelihood that the farmer will be able to evaluate a new technology to identify the potential benefits to their household, and the more likely they are to experiment with the technology.

Table 2: Characterisation of adopters and non-adopters of tree-based fodder, 2004/05

Characteristic	% Adopters	% Non adopters	Chi-square	Significance level
Draft Power:				0.027
Less than 2	41.0	59.0	4.863**	
Two or more	62.0	38.0		
Plough:				0.036
One only	22.2	77.8	4.397**	
Two or more	58.2	41.8		
Sex of household head:				0.428
Male	57.1	42.9	0.629	
Female	47.4	52.6		
Age of household head:	46.7	53.3	0.573	0.751
Young middle age	57.4	42.6		
Old age	56.5	43.5		
Household size:				0.044
Less than 7	49.4	50.6	4.038**	
7 years or more	68.3	31.7		
Education level:	59.6	40.4	2.250	0.522
None	50.8	49.2		
Primary	75.0	25.0		
Secondary	55.7	44.3		
Diploma				
Wealth Class:			11.403***	0.001
Medium	42.3	57.7		
Rich	71.7	28.3		
Farm size				0.256
Less than 4ha	51.9	48.1	1.290	
4 ha and above	62.0	38.0		
Natural Region: IIa	52.2	47.8	0.608	0.895
IIb	63.6	36.4		
III	57.7	42.3		
IV	54.5	45.5		
Performance of dairy centre:			0.582	0.901
Division 1	58.3	41.7		
Division 2	52.9	47.1		
Division 3	57.1	42.9		
Division 4	63.6	36.4		
Herd size:				0.000
3 or less	42.5	57.5	14.568***	
4 or more	76.5	23.5		
Dairy membership (years):				0.000
Seven or less	33.3	66.7	20.357***	
More than 7 years	74.6	25.4		

*** Significant at 1% level; ** Significant at 5% level;

The probabilities of adoption of fodder banks increase for farmers who have more draft power, plough and labour (Table 2). Farmers with more resources at their disposal are more likely to invest in the new technology. The result may also be interpreted as a measure of the likelihood of wealthier farmers taking risks with farm technology innovations. Adoption increased with dairy herd size. An explanation for this is that possession of more dairy cows implies that more feed supplements are required, especially in the dry season when natural grazing is insufficient to meet the food and nutrition requirements of animals. Fodder leaves could fill this gap and maintain milk production.

4.2 Factors affecting adoption

The maximum likelihood estimates, in terms of odds ratios, measures of goodness of fit and significance level are presented (Table 3). The model has a good fit and it correctly predicted 75% of the observed data on adoption and non-adoption of fodder technology.

Table 3: Results of binary logistic regression model, fodder bank adoption, Zimbabwe

Variable	β (Coefficient)	Significance	Exp. β (Odds ratio)
Natural region	-0.450*	0.082	0.638
Dairy Herd size	0.235***	0.003	1.265
Land size	0.188**	0.038	1.207
Years as a dairy association member	0.210***	0.000	1.234
Sex of household head	-0.791	0.285	0.453
Age of household head	-0.024	0.284	0.977
Household size	0.036	0.627	1.037
Household head education level	-0.210	0.617	0.811
Performance of the dairy centre	0.258	0.434	1.294
Constant	-0.067	0.975	0.935
Model chi-square	*45.741****		
Level of significance	*0.000*		
Level of correct prediction	*75.2%*		

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Six out of the nine variables exhibited the expected effects on adoption. Dairy herd size, land size and years of membership in dairy associations all exert a significant positive influence on the decision to adopt fodder technology. Herd size increased the probability of adoption. Herd size is an asset and indication of wealth that may have been considered by farmers as insurance against innovation risks. This result indicates that farmers who have more dairy cattle (which implies higher demand for feed supplements) tend to establish fodder banks to increase the quantity of feed available for their animals. The fodder bank is likely to be used by farmers with large herds to supplement commercial feed concentrates they buy for their livestock. This is because natural grazing does not provide adequate nutrient requirements such as crude protein that is essential for high milk yields, especially in the dry season. Land size has a positive effect on adoption because farmers with more cultivable land are more likely to set aside a piece of land for fodder trees without impacting much negatively on land available to grow food crops or disturbing household food security that is the case for those with smaller farms.

The likelihood of farmers adopting fodder bank technology increases with the number of years of they have been members of dairy associations. The associations offer training sessions that equip farmers and build their confidence to manage the trees, milk production and marketing process.

Natural region had a negative effect on the decision to adopt the technology. This implies that the potential for the adoption of the fodder trees decreases from the wetter to the drier agro-ecological regions of the country. Measured by the odds ratio, adoption is less likely than 1 (0.638) as one moves from the high rainfall area to one with lower rainfall. Lack of water and low irrigation potential is widely considered to be a major constraint to sustainable technology adoption in the drier parts of Zimbabwe. As a result, fodder tree species such as *Acacia* provenances that are more tolerant to drought would be more appropriate and should be recommended for the drier parts of the country in efforts to scale up the technology.
Another explanation for the differences in adoption between the natural regions is that dairy centres were first introduced in the areas with high rainfall. This explanation is corroborated by the sign exhibited by the proxy for experience, i.e. longer years as a member of the dairy association enhances likelihood of adoption. The presence of dairy development centres and their performance are *de facto* indicators of access to markets and the extent to which milk farmers are integrated into the markets.

However, sex or age of the household head does not have a significant influence on the decision to adopt fodder bank technology. The negative sign on the coefficient for age indicates a mild lack of receptivity toward new technologies for older farmers. The results indicate that men and women are equally likely to adopt the technology if they are given similar opportunities and incentives. Although the model suggests that being a male household head would decrease the odds for adoption close to 1 (0.977), the difference is nominal. The result supports theoretical expectation that younger farmers are more likely to experiment and have a longer time to accrue benefits from adopting fodder tree technology.

Availability of a ready market for milk is an incentive for dairy farmers to increase productivity. Performance of a dairy centre, as expected, is positively related to adoption of fodder trees. This indicates that dairy centres can be used as entry points for information dissemination and promoting the adoption of the technology.

A farmer's level of formal education is not a significant determinant of adoption. This is because the knowledge that farmers acquire as members of dairy centres is more important in decision making on whether or not to establish fodder banks than the knowledge gained through formal education, which, often, does not necessarily focus on livestock or dairy production.

5. Summary and conclusion

Farmers' adoption of tree-based fodder is influenced by dairy herd size, land size, number of years as a dairy association member and agro-ecological potential. The potential for adoption of fodder banks varies across regions due to bio-physical performances of trees and access to milk market in the different regions. The results do not support the general perception that a farmer's sex is the central key to decision to practice agroforestry technologies or to adopt fodder bank technology in particular. Rather, male and female farmers are equally likely to adopt the technology if exposed to similar information, training opportunities and incentives.

Experience acquired in dairy farming influences the adoption of new technology as indicated by the positive significant relationship between years of dairy association membership and the decision to adopt tree-based fodder. It is recommended that the scaling up of the technology should initially target farmers who are already members of such and in villages where dairy centres exist. Given the profile of dairy development centres in Zimbabwe, strengthening of partnerships and institutional collaboration with the centres will create synergy and offer an opportunity to enhance the adoption of fodder trees. Given that not all fodder-bank tree species perform equally well in all locations, there is need to incorporate biophysical limits of the available species to improve targeting and ensure that appropriate types are promoted in the different agro-ecological zones.

Land is an important variable that influences farmers' decision to adopt fodder trees. Farmers with larger farms are more likely to set aside land for fodder trees. As a result, farmers who possess bigger land should be targeted. Besides being able to set aside land for trees, such farmers could establish seed banks for the others in their community.

It is noted that the adoption of tree-based technologies such as the fodder bank is much more complicated than for annual crops (Mercer, 2004; Scherr & Müller, 1991) because it takes several years for farmers test, adapt and eventually 'adopt' agroforestry technologies. As a result, a 'testing' phase of fodder bank technology should be distinguished from 'adoption' phase (Franzel *et al.*, 2002), as much as 'experimenters' need to be delineated from 'adopters' (Adesina *et al*., 2000). Factors that affect adoption of a given agroforestry technology at the initial 'testing' phase may be different or assume different levels of importance compared with what obtains in the 'expansion' phase (Ajayi *et al*., 2007; Ajayi *et al*., 2006).

The results of the present study should be interpreted as an understanding of the factors that are key to farmers' uptake of fodder bank technology during the early years of the dissemination of the technology in farming communities in Zimbabwe. Over time, institutional factors such as fire and grazing (Ajayi & Kwesiga, 2003), land tenure and other policies will most likely assume greater importance than they presently assigned.

References

Adesina AA, Mbila D, Nkamleu GB & Endamana D (2000). Econometric analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. *Agriculture, Ecosystems and Environment* 80:255-265.

Ajayi OC, Akinnifesi FK, Gudeta S & Chakeredza S (2007). Adoption of renewable soil fertility replenishment technologies in southern African region: lessons learnt and the way forward. *Natural Resource Forum* 31(4):306-317.

Ajayi OC, Massi C, Katanga R & Kabwe G (2006). Typology and characteristics of farmers planting improved fallows in southern Africa. *Zambian Journal of Agricultural Sciences* 8(2):81-92.

Ajayi OC & Kwesiga F (2003). Implications of local policies and institutions on the adoption of improved fallows in eastern Zambia. *Agroforestry Systems* 59(3):327-336.

Ajayi OC, Franzel S, Kuntashula E & Kwesiga F (2003). Adoption of improved fallow soil fertility management practices in Zambia: synthesis and emerging issues. *Agroforestry Systems* 59(3):317-326.

Franzel S & Scherr SJ (2002). *Trees on the farm: assessing the adoption potential of agroforestry adoption in Africa*. Wallingford, UK: CAB International.

Franzel S, Phiri D & Kwesiga F (2002). Assessing the adoption potentials of improved tree fallow in eastern Zambia. In: Franzel S & Scherr SJ (eds), *Trees on the farm: assessing the adoption potential of agroforestry practices in Africa*. Wallingford, UK: CAB International. p. 37–64.

Gladwin CH, Peterson JS, Phiri D & Uttaro R (2002). Agroforestry adoption decisions, structural adjustment and gender in Africa. In: Barrett CB, Place F & Aboud A (eds), *Natural resources management in African agriculture: understanding and improving current practices.* Wallingford, UK: CAB International. p. 115-128.

Hove L (2001). *Tree legume fodder research and development in Zimbabwe: experiences of the Zimbabwe SADC ICRAF Agroforestry Project*. Annual report of the ICRAF-Zimbabwe Project, ICRAF, Harare, Zimbabwe.

Hove L, Ndlovu LR & Sibanda S (2003). The effects of drying temperature on chemical composition and nutritive value of some tropical fodder shrubs. *Agroforestry Systems* 59(3):231-141.

Keil A, Zeller M & Franzel S (2005). Improved tree fallows in smallholder maize production in Zambia: do initial planters adopt the technology? *Agroforestry Systems* 64:225-236.

Kuntashula E, Ajayi OC, Phiri D, Mafongoya P & Franzel S (2002). *Factors influencing farmers' decision to plant improved fallows: a study of four villages in eastern province of Zambia*. In: Kwesiga F, Ayuk E & Agumya A (eds), Proceedings of the 14th Southern African Regional Review and Planning Workshop, 3-7 September, Harare, Zimbabwe. p. 104-110.

Mercer DE (2004). Adoption of agroforestry innovations in the tropics: a review. *Agroforestry Systems* 61:311-328.

Moyo S & Ayuk ET (2001). Costs and benefits of tree fodder with small-scale dairy farmers in Zimbabwe. *Living with Trees in Southern Africa* 6:1-3.

Place F, Franzel S, deWolf J, Rommellse R, Kwesiga F, Niang A & Jama B (2002). Agroforestry for soil replenishment: evidence on adoption processes in Kenya and Zambia. In: Barrett CB, Place F & Aboud AA (eds), *Natural resources management in African agriculture: understanding and improving current practices*. Wallingford, UK: CAB International. p. 155-168.

Scherr SJ & Müller EU (1991). Technology impact evaluation in agroforestry projects. *Agriforestry Systems* 13:235-257.

Thangata H & Alavalapati JRR (2003). Agroforestry adoption in southern Malawi: the case of mixed intercropping of *Gliricidia sepium* and maize. *Agricultural Systems* 78:57-71.