Who adopts agroforestry in a subsistence economy?

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Abstract

Land degradation has reduced agricultural productivity in Nepal's Terai. This has raised concern over the viability of conventional agriculture of the Terai farming system. Agroforestry can be a potential solution to the above problem. This paper aims at identifying socio-economic biophysical and institutional factors affecting the adoption of agroforestry with respect to conventional agriculture. Data were collected from a survey of 288 households through a face-to-face interview. A multinomial logistic regression (MNL) was run with conventional agriculture as a base category. It was found male-headed households were more likely to adopt agroforestry. Having an off-farm income source was positively associated with the adoption decision of farmers as it provides a safety net in case of crop failure. Landholding size was found as a major constraint to adoption. Therefore, smallholder farmers were reluctant to adopt Agroforestry as sparing a part of farmland for tree planting means reducing field crop production and thus failing to meet their annual food demand. Some other variables affecting positively include livestock herd size, provision of extension service, home-to-nearest government forest distance, farmers' group membership and awareness of farmers about environmental benefits of agroforestry. Irrigation was another constraint that has stopped farmers from promoting the tree-based farming systems. The households with means of transport and with larger family (household) size were found to be reluctant towards agroforestry adoption.

1. Introduction

Land degradation, a persistent decline in soil quality and its productivity caused by natural or anthropogenic factors, has adversely affected food production, the supply of ecosystem services and livelihoods globally (Kotiaho and Halme, 2018). Even though it occurs throughout the world, the extent and degree of degradation vary with regions. For instance, dryland areas of African countries and Australia; mountain ranges of the Himalayas; and densely populated areas of South Asia are more vulnerable (Bai et al., 2008; Nachtergaele et al., 2011). The consequences of land degradation are severe as it impacts adversely on agronomic productivity, food security and the quality of life (Conacher, 2009). By 2030, the demand for food is expected to increase by at least 50%, which requires conservation and restoration of the productivity of agricultural land. It is estimated that a 60% increase in agricultural productivity, will be necessary by 2050 in order to overcome hunger and food insecurity (Alexandratos and Bruinsma, 2012).

Many factors play a role in the global spread of agricultural land degradation. The spread and growth of populations, inappropriate land-use practices, excessive use of chemicals, mechanized agriculture and natural phenomena such as erosion (by water and wind), floods and drought are the proximate causes of degradation (Conacher, 2009). In countries like Nepal, where the demographic pattern is changing substantially due to the outmigration of the economically active population, agriculture land degradation is becoming a serious issue (Jaquet et al., 2015). In a subsistence economy, farmers are forced to cultivate marginal lands; use agrochemicals; and follow intensive farming and mechanized agriculture to sustain their livelihoods. All these activities have resulted in a gradual depletion of soil nutrients (Rasul and Thapa, 2003; Westarp et al., 2004).

Reducing further degradation and restoring the degraded agricultural land may contribute to the first three sustainable development goals (SDGs) including no poverty; and good health and well-being substantially. Since the underlying causes of land degradation are multifaceted, it requires an integrated approach of farmland management (Conacher, 2009). A single strategy may be counterproductive, for instance, reduction in chemical fertiliser application may result in decreased crop yield and hence, food insecurity. In this context, agroforestry, which is an integrated tree-based farming system, has come into the forefront given the potential to address land degradation with additional environmental and social benefits (Jose, 2009; Ramachandran Nair et al., 2009). Agroforestry plays an important role in biodiversity conservation (Dhakal et al., 2012; Harvey et al., 2006; Kabir and Webb, 2008; Moguel and Toledo, 1999) Similarly, it has higher financial returns compared to that of the conventional agriculture (Neupane and Thapa, 2001). It also provides biosafety as it is less likely to have crop failure compared to the treeless system (Dhakal, 2013). This may be because the agroforestry system restores soil fertility (Neupane and Thapa, 2001; Schwab et al., 2015), and rehabilitates degraded agricultural land (Acharya and Kafle, 2009).

Having so many economic and environmental benefits, agroforestry should be a widely adopted practice. However, the adoption status of such promising land use is not encouraging and not widespread as expected even though there are several national and international organizations working in the promotion of this agricultural practice. There might be disincentives to establishing trees including lack of knowledge, upfront costs, length of time until there is a return and a short to medium-term reduction in cash flow and/or household food production (Cockfield, 2005). Nonetheless, there has been a wealth of research works on agroforestry adoption (Mercer, 2004). Most of the existing literature is focused on the social, economic and environmental contributions of an agroforestry system (Mbow et al., 2014; Tscharntke et al., 2015; Waldron et al., 2017).

However, the main question to be answered is what the determinants of adopting an agroforestry system are. This study assesses the determining factors of agroforestry adoption in Nepal. The findings of the study are useful for policymakers, development agencies and academicians.

2. Methods

2.1 Study area descriptions

This study was conducted in the southern foothills of the *Churia*hills of Dhanusha District (35^0-27.5^0 N and 85.5^0-86.2^0 E) from May to August 2014. The Dhanusha District is in the central development region of Nepal, 350 km south-east of the capital city, Kathmandu. The district abuts India in the south. The elevation is approximately 95 m and the climate is sub-tropical with three distinct seasons: spring, monsoon and winter. The mean monthly minimum/maximum temperature is $9.3/21.4^0$ C in January and $26.7/39.6^0$ C in April. The average annual rainfall is 2199 mm. The District covers an area of 119,000 ha, out of which 76,792 ha is used for agriculture. Administratively the district consists of one sub-metropolitan city, eleven urban municipalities and six rural municipalities. The Terai Private Forest Development Association (TPFDA), a local NGO, has worked to promote a tree-based farming practice in then nine Village Development Committees (VDCs11Now, VDCs are a part of either urban or rural municipalities after restructuring the state.) covering 10,500 hectares (Figure 1). Therefore, these nine VDCs were selected for this study. After the state is restructured, some parts of the study site fall in the urban municipality while most parts are still VDCs, now known as rural municipalities.

Figure 1: Study Area

2.2 Household survey

A two-stage sampling approach was adopted for this study. First, one ward22Ward is the lowest administrative unit. from each VDC was selected through purposive sampling. This means a total of nine wards were selected. Second, thirty-two households from each ward were selected randomly. This means 288 sample households were selected. In-person interviews were conducted with the head of the sample households using a questionnaire.

The questionnaire contains detail information on agroforestry practices adopted by farmers and the data on adoption variables including socio-economic, demographic, institutional, and biophysical. The questionnaire was pre-tested through a pilot survey in a village of the study area. A few modifications were made following the pre-testing. A total of 18 households were dropped out of the analysis since these households were practicing a combination of two or more agroforestry practices, agroforest/woodlot, boundary plantation and alley cropping.

2.3 Analytical model

There are four types of agroforestry practices in the study area. These are (i) agroforest/woodlot system (AFS), (ii) alley cropping system (ACS), (iii) combination of two or more AF practices, and (iv) conventional agricultural system (CAS). Since the third system is very rarely practiced in the study area, this has been dropped off from the analysis and we considered the rest three practices only as major farm practices for this study. Farmers can choose one they prefer most from the three alternatives. That means their choice is discrete and mutually exclusive. Therefore, the choice model for this study is either a multinomial probit (MNP) or a multinomial logit (MNL) model. We considered the MNL model the best fit because it gives more precise parameter estimation (Kropko, 2007). The other reason for choosing this model is that this has been more commonly used in recent studies (Deressa et al., 2009; Hassan and Nhemachena, 2008; Kurukulasuriya and Mendelsohn, 2007). Besides, the MNP model is not usually used largely because of the practical difficulty involved in its estimation process (Cheng and Long, 2007).

According to the random utility theory, consumers generally choose what they prefer from among the alternatives available. More precisely, they are assumed to select the alternative that has the highest utility. In this study too, a farmer has three choices and selects a practice from these choices. We assume that the selection of one of the practices is independent of other practices. The choice of one practice is characterized by various factors such as age, education, tenure status, and extension services. Under the random utility theory, the utility of each alternative is modelled as a linear function of observed characteristics (farmer and/or alternative specific) plus an additive error term. More particularly, the utility a farmer i associating to alternatives j and k is given by

$$U_{\mathrm{ij}} = V_{\mathrm{ij}} + \varepsilon_{\mathrm{ij}} \dots\dots\dots\dots\dots\dots\dots (1)$$

$$U_{\mathrm{ik}} = V_{\mathrm{ik}} + \varepsilon_{\mathrm{ik}} \dots\dots\dots\dots\dots\dots .. (2)$$

where V implies the deterministic or systematic component of the utility and represents the stochastic component which represents the uncertainty. According to utility maximisation, farmer i will, thus, only chooses a particular alternative j if $U_{ij} > U_{ik}$ for all k [?] j.

A common formulation of equations (1) and (2) is as follows, assuming V ( ) is a linear function of x_i , observed factors to the farmer's utility:

$$U_{\mathrm{ij}} = x_i\beta_j + \varepsilon_{\mathrm{ij}} \dots\dots\dots\dots\dots (3)$$

$$U_{\mathrm{ik}} = x_i\beta_k + \varepsilon_{\mathrm{ik}} \dots\dots\dots\dots\dots (4)$$

Then, if we denote $Y_i = j$ and the farmer's choice of alternative j , it can be written that

$$\text{Prob } [Y_i = j\,|x\ ] = Prob\ [U_{\mathrm{ij}} > U_{\mathrm{ik}}]$$

$$= Prob[x_i\beta_j + \varepsilon_{\mathrm{ij}} - x_i\beta_k - \varepsilon_{\mathrm{ik}} > 0\,|x\ ] = Prob\ [x_i\,(\beta_j - \beta_k) + \varepsilon_{\mathrm{ij}} - \varepsilon_{\mathrm{ik}} > 0\,|x\ ] = Prob\ [x_i\beta + \epsilon > 0\,|x\ ]$$

Where,

β is a vector of unknown coefficients that can be explained as the net impacts of a vector of explanatory variables influencing the choice of farming practice and ϵ is a random error term.

Assuming that ϵ for all alternatives is independent and identically distributed (i.i.d) conditional onx_i , with the Type I extreme value distribution, the probability that a farmer will choose alternative j is given by Equation (5):

$$\text{Prob } (Y = j) = \frac{e^{\beta_j x_i}}{\sum_{k=1}^{3} e^{\beta_k x_\text{i}}} \dots\dots\dots\dots\dots (5)$$

Equation 5 is the MNL model (Greene 2003). The MNL model significantly requires to hold the assumption of independence of irrelevant alternatives (IIA) in order to obtain unbiased and consistent parameter estimates. The IIA assumption necessitates that the probability of adopting a farming practice by a given farmer requires independence from the probability of selecting another farming practice.

The numerator is the utility (i.e., net benefit) from choice 'j' and the denominator is the sum of utilities of all alternative choices. The probability of selecting a specific farming practice is equal to the probability of that specific alternative being higher than or equal to, the utilities of all other alternatives in the set of farming practices. The parameters of this model can be estimated using maximum likelihood methods. However, the parameter estimates of the MNL model merely show the direction of the impact of the explanatory variables on the dependent variable. The real extent of changes or probabilities is not represented by the estimates. Moreover, parameter estimates are hard to interpret since they are derived from non-linear estimates (Greene, 2003). Therefore, the MNL model parameters are transferred to relative risk ratios (RRR). This RRR measures the effects on the relative odds of one outcome being selected relative to the baseline outcome for a unit change in any of the explanatory variables.

2.4 Test of multicollinearity

The model was tested for multicollinearity using the variance inflation factor (VIF). The VIFs for all variables are less than 10 (1.09– 2.03), which indicates that multicollinearity is not a serious problem in this model. Finally, the model was tested for the validity of the IIA assumptions by using the Hausman test for IIA. The test failed to reject the null hypothesis of independence of the farming practices, suggesting that the multinomial logit MNL specification is appropriate to model these practices of smallholder farmers (ranged from -4.63 to 40.73, with probability values ranging from 0.85 to 1.00).

The estimation of the MNL model for this study was undertaken by selecting CAS as the reference state or base category. The odds of two other farming systems namely AFS and ACS to be adopted by farmers with respect to the CAS are estimated in this study. Since the CAS is the base category, most predictor variables will have a positive impact on the adoption of the tree-based farming practices i.e. one unit increase in the predictor variable will increase the likelihood of AFS and ACS adoption.

2.5 Variables used in the model

The dependent variable in the empirical estimation is the choice of a farming option from the three farming practices. The choice of explanatory variables is based on data availability and literature. The explanatory variables for this study include socio-economic, biophysical and institutional characteristics including gender (sex of household heads), age and education of the household head; household size (15 to 60 years); off-farm income; landholding size; risk-taking attitude; level of awareness; livestock herd size; extension services; home to nearest government forest distance, irrigation facility; availability of transport means; membership with farmers' groups and agricultural organizations, and types of household (native or migrated) (Table 1). Some variables were not included in the model such as farmers' perception of agroforestry, slope gradient, and access to the credit facility. The variable 'farmers' perception on agroforestry' was dropped off the model because several studies showed that this variable had no relationship with adoption (Alavalapati et al., 1995; Anley et al., 2007; Carlson et al., 1994; Thangata and Alavalapati, 2003) and there is a methodological challenge measuring it (Roberts et al., 1999). The second variable 'slope gradient' was not applicable because the study area has little altitudinal variation across the sampled households. The third variable 'access to credit facility' was not included because the financial institutions in the study area are reluctant to release loans for agroforestry.

3 Results

3.1 Sample characteristics

On average, the household heads were 44 years old, with AFS farmers being the youngest (Table 2). In terms of education, 15% of household heads were illiterate. The average family size was 7 which is above the national average i.e. 4.9 (CBS, 2012). The majority of households (57%) were male-headed. AFS adopting households were more male-headed (65%) compared to the other two farming systems (55% for both ACS and CAS). Farmers had both off-farm and on-farm income sources. Of total respondents, 46% of households had both off-farm and on-farm sources of income while the rest were dependent only on on-farm income for their livelihoods. Overall, 44% of the sample households had a private source of irrigation. Specifically, 62% of AFS farmers had access to the irrigation facility while only 46% and 35% of farmers from ACS and CAS respectively possessed this facility. The study area consisted of both native and migrated farmers. More farmers (56%) were migrated in the study area. 58% of farmers were native in the AFS category while there were only 40% and 41% native farmers in ACS and CAS respectively.

Out of eleven variables (continuous) tested, five variables i.e. education, landholding size, livestock herd size, extension service, and availability of transport means are significantly different in their mean values (Table 2). The mean values of three variables i.e. household head's age, household size (economically active) and crop diversity were significantly different for CAS and ACS. The statistics suggest that the households with large holdings and bigger livestock herd size that are headed by a young and educated male family member receiving more extension services tend to adopt the tree-based farming (Table 2).

3.2 Association, relative risk and significance of explanatory variables with regards to the choice of farming systems:

The parameter estimates (association) and relative risk ratios (RRR) of the MNL model for AFS and ACS with CAS as a reference group are reported in Table 3. The coefficients show the direction of explanatory variables, while the RRR shows the likelihood of adoption/dis-adoption of AFS and ACS by farmers with respect to CAS. The model was significant at the 1% level. The log-likelihood ratio (LR) test shows that the estimated model, including the constant and the set of explanatory variables, fits the data better compared with those containing the constant only. In other words, there is a significant relationship between the likelihood of adoption/dis-adoption of agroforestry systems and the explanatory variables included in the model. The result suggests that these variables contribute significantly as a group to the explanation of the agroforestry adoption behaviour of the sample farmers, although several coefficients and RRR were not significant individually.

Except for the variables 'irrigation facility' and 'origin' (types of household), all other variables had expected signs. 'Irrigation facility' was found to be positively associated with the adoption of AFS and ACS but not significant for ACS. 'Origin' was found to be negatively associated with the adoption of ACS only, which means a migrated farmer is more likely to prefer ACS to CAS. Out of fifteen variables tested, twelve variables were significant in the case of AFS while there were only five variables significantly affecting the adoption of ACS. Our result suggests that the likelihood of adopting AFS would increase by a unit of 1.323 if the household head were a male. Similarly, the AFS was 2.9 times more likely to be adopted by households having off-farm income sources. Having a private source of irrigation would increase the likelihood of AFS adoption by 1.73.

There are some variables with negative signs indicating that these variables decreased the likelihood of adopting AFS and ACS with respect to CAS. If a farmer were risk-averse, the likelihood of adopting AFS would decrease by 89%. In other words, a risk-averse farmer is less likely to adopt an agroforestry system. Similarly, having own source of transport would decrease the likelihood of AFS and ACS adoption by 50% and 16% respectively compared to CAS.

4. Discussion

The results of the MNL model suggest that out of fifteen variables, twelve variables for AFS and four variables for ACS had significant effects on adoption decision with respect to CAS while the three variables i.e. education, age of household head, and origin had no significant effect. The negative sign for the variable, age of household head suggests that young farmers are more likely to adopt agroforestry systems. In other words, the likelihood of adopting an agroforestry system decreases with the increasing age of farmers. This may be because young people are less risk-averse and have longer planning horizons to justify investments in tree-based practices (Adesina et al., 2000). Education (years of schooling) has a positive influence on the adoption of both AFS and ACS. Education may lead to a better understanding of the new technology when reviewing the different extension materials (Adesina and Chianu, 2002).

Seven variables have significant effects in the case of AFS adoption. The significant and positive sign for the variable, 'sex of household head' implies that male-headed households were more likely to adopt an AFS practice compared to their female-headed neighbours. This is expected because the rural society of Nepal is male-dominated, and most household decisions are made by male members of the family (Tiwari et al., 2008). Existing literature has also shown that gender plays a crucial role in decision making when it comes to the adoption of new practices. For example, in studies carried out in Cameroon and Nigeria, it was found that male farmers were more likely to use alley farming than women (Adesina et al., 2000; Adesina and Chianu, 2002; Fabiyi et al., 1991). In Nepalese mid-hills also, a positive association between male-headed households and the adoption of agroforestry practice was found (Neupane et al., 2002). The sign of the coefficient of the variable 'household size' (economically active) indicates that the likelihood of adopting AFS decreases with the increased household size. In other words, the chance of adopting agroforestry is higher when the household size is relatively low. This holds true because tree-based farming is a less labour-intensive practice in the long-run (Cockfield, 2005), but other agriculture practices are labour demanding for smallholders (Rai et al., 2018). A recent study by Cedamon et al. (2018) from Nepal's mid-hills also reinforces our findings. They argue that the emerging remittance economy of the country has increased the outmigration of Nepalese youths resulting in a short supply of labour force, which made the Nepalese farmers practice less labour-intensive cultivation practice such as agroforestry.

The results also suggest that large farmers are more likely to adopt the tree-based farming practice. Land-holding size was found to be the most determining factor of agroforestry adoption in the study area. This may be because larger-scale farmers are more likely to make higher investments in new land management practices such as agroforestry. They can take high risks and can survive crop failure resulting from unfavourable conditions such as insect and pest outbreaks, hailstone, and excess rail fall (Amsalu and De Graaff, 2007). Besides, larger farms offer farmers more flexibility in their decision making, more opportunity to new practices on a trial basis and more ability to deal with risk (Nowak, 1987). Having a private source of irrigation is positively associated with the farmers' decision of AFS adoption over conventional agriculture. A similar result was found in a study carried out in Himachal, India by Sood and Mitchell (2009) and in Burkina Faso by Ayuk (1997).

The results also suggest that households with off-farm income sources are more likely to adopt the tree-based farming system such as AFS compared to their neighbours having agriculture as a major source of income. The reason may be that the off-farm income helps farmers take a risk as it may serve as a safety net in case of crop failure resulting from sudden natural calamities and other unexpected events. Adopting a tree-based farming practice is a risk because farmers have to wait a long time to get the return on their investment. Until the tree crop harvest from the time of establishment, there would be a considerable loss in farm production, which a farmer with no off-farm income is hardly able to bear/face the loss. Similar results were found in the Gunnungkidul region, Indonesia that the farmers having off-farm income sources were more likely to adopt a tree management practice than those with no off-farm income (Sabastian et al., 2014).

Similarly, 'livestock herd size' was found to positively influence a farmer's decision about adopting the tree-based farming system. It suggests that an increase in livestock herd size results in the increased likelihood of adopting AFS. In Nepal, trees are grown in the farmland for fodder, fuelwood and timber. Fodder is a good source of livestock feed in the study area. Trees provide green fodder during the dry season of the year, which is very important for the milking livestock to maintain milk production throughout the year. Table 2 reports that the tree densities and livestock herd size of the farming systems are statistically different. AFS farmers raised a higher number of trees and larger livestock herd compared to the ACS farmers. In the mid-hills of Nepal, the number of livestock was the most significant determinant of agroforestry adoption (Neupane et al., 2002).

Extension service has also positive impacts on adopting tree-based farming systems. Farmers having frequent access to extension services are more likely to adopt AFS compared to the farmers with a less or minimum number of extension services. The result was not unexpected because contact with the extension workers and receiving relevant training allow farmers to learn more about the new practices and helps them build up the confidence to adopt such technologies. Extension workers help to clarify if any doubts that farmers may have regarding the new practices and motivate them to adopt them. This finding corroborates the existing literature (Adesina and Chianu, 2002; Ison and Russell, 2007; Lohr and Park, 1994; Paudel and Thapa, 2004).

The result also suggests that farmers living farther from the government managed forest are more likely to adopt tree-based farming systems than those living close to the forest. When farmers easily get their daily needs of fuelwood, fodder, timber and food fulfilled from the nearby forest, they are reluctant to tree planting on their farmland (Rai et al., 2017). On the contrary, the distant farmers have to spend more time in the collection of these products from the forest and therefore they are inclined to tree planting on their farms.

5. Conclusions

The results of this study suggest that agroforestry practice could be an appropriate strategy in the context of changing climate and economy in the farm-based economy. First, an agroforestry practice demands less labour compared to conventional agriculture practice. Adopting agroforestry may help to maintain the rural economy since, the young population is out-migrating, and the rural area is facing a short supply of labour. Besides, the agroforestry system is preferred by households having an off-farm income source. This suits the existing rural context as rural economy is in the transition towards monetized transactions due to outmigration for employment.

Agroforestry is a good source of fuelwood and fodder for livestock. Livestock raising is an integral part of Nepalese farming. The general assumption is that the farmers who live far from the forest tend to raise trees on their farmlands. Our finding reinforced this assumption. The reason for the distant farmers tending towards agroforestry adoption is that they would otherwise have to allocate a huge amount of time mostly every day for fuelwood and fodder collection from the forest. Not only the time saving, it has also contributed to forest conservation by reducing pressure on the forest.

The results also suggest that agroforestry is not a favourable option for smallholders as it is more likely to be adopted by large farmers. Collective farming through a cooperative approach might be a positive and practical step to engage smallholders in agroforestry promotion. As agroforestry gained attention in the international climate change policy, it could be an attractive option as a part of the mitigation strategy. The study clearly indicates that access to information may contribute to promote agroforestry practice, which requires intensive extension services.

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Conflict of Interest

There is no conflict of interest to declare.

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Tables

Table 1: Description of the explanatory variables specified in the multinomial logistic model

Variables	Description	Type of me
Education	Years of formal education of household head	Years
Age	Age of the household head	Years
Sex	Sex of the household head	1 if male, 0
Household size	Number of family members between 15 to 60 years	Years
Off-farm income	Farmer has any off-farm source of income	1 if yes, 0 o
Landholding size	Total cultivated area	Katha*
Livestock herd size	Total number of cattle and buffaloes kept by a surveyed household	Numbers
Extension service	Total number of training received and visits by extension workers in the last five years	Numbers
HF_distance	Distance from home to nearest government forest	Kilometres
Transport	Means of transport possessed by the surveyed household	1 if a farme
Irrigation facility	Farm has any source of irrigation	1 if yes, 0 o
Membership	Member of farmers' group and organization	1 if yes, 0 o
Origin	Farmer is native	1 if yes, 0 o
Risk taking attitude	Farmer is risk-averse, risk-neutral and risk loving	1 if risk lovi
Awareness	Farmer is aware of environmental benefits of an agroforestry practice	1 if yes, 0 o

* katha = a unit of area measurement (30 katha = one hectare)

Table 2: Characteristics of sample households in the study area

Variables	Mean values of the variables	Mean values of the variables	Mean valu
	CAS (n = 162)	ACS (n = 60)	AFS (n =
Years of schooling (Education)	5.0 (3.6)[a]	6.3 (3.7)[b]	9.6 (4.0)[c]
Age of household head	46.6 (13.2)[a]	43.6 (9.9)	39.4 (10.0
Sex of household head	0.55 (0.50)	0.56 (0.50)	0.64 (0.48
Household size	4.7 (2.1)[a]	4.4 (1.9)	3.9 (1.3)[b]
Off-farm income	0.32 (0.50)	0.49 (0.50)	0.75 (0.43
Landholding size	23.8 (21.1)[a]	34.7 (25.4)[b]	74.3 (36.7
Livestock herd size	2.9 (1.9)[a]	3.7 (2.6)[b]	6.7 (2.8)[c]
Extension service	0.80 (1.1)[a]	3.2 (2.2)[b]	5.5 (1.7)[c]
Distance from home to nearest government forest	4.2 (2.7)[a]	9.0 (5.6)[b]	9.3 (5.5)[b]
Transport (tractor, bullock cart)	0.6 (0.51)	0.4 (0.51)	0.3 (0.48)
Irrigation	0.35 (0.48)	0.46 (0.50)	0.63 (0.49
Membership	0.25 (0.43)	0.51 (0.50)	0.73 (0.45
Origin	0.41(0.49)	0.40 (0.49)	0.58 (0.50
Risk taking attitude	2.4 (0.80)	1.71 (0.77)	1.52 (0.74
Awareness	0.28 (0.45)	0.51 (0.50)	0.69 (0.47
Tree density (no of trees/hectare)	0	101(38)[a]	245 (49)[b]
No. of agricultural crops grown in a year	7.0 (2.0)[a]	8.0 (2.0)	10.0 (3.0)

Note: Figure in the parenthesis is the standard deviation. Means in a row with different superscripts are significant at 0.05 level. CAS: Conventional agricultural system; ACS: Alley cropping system and AFS: Agroforest system

Table 3: Parameter estimates and RRR of a multinomial logistic model for AFS and ACS

Variable	AFS (n = 48)	AFS (n = 48)	AFS (n = 48)	ACS (n = 60)	ACS (n = 60)	ACS (n = 60)
	Coefficient	RRR	*P* level	Coefficient	RRR	*P* level
Years of schooling (education)	0.159	1.172	0.247	0.114	1.121	0.194
Age of household head	-0.048	0.953	0.315	-0.008	1.008	0.753
Sex of household head	1.842	1.323**	0.044	0.202	0.823	0.714
Working household members	-0.618	0.539**	0.041	-0.078	0.925	0.580
Off-farm income	2.192	2.954**	0.023	0.770	1.159	0.262
Landholding size	0.123	3.130***	0.000	0.095	1.099***	0.003
Livestock herd size	0.555	1.742***	0.003	0.178	1.195	0.179
Extension service	1.064	2.910***	0.000	0.529	1.697***	0.003
Distance from home to nearest government forest	0.376	1.457***	0.001	0.322	1.380***	0.000
Transport	-0.682	0.506***	0.005	-0.172	0.842*	0.086
Irrigation	1.907	1.732**	0.042	0.302	0.352	0.571
Membership	1.831	1.242**	0.038	1.349	1.122**	0.019
Origin	1.215	3.371	0.188	-0.336	0.714	0.551
Risk averse [a]	-2.134	0.118**	0.041	-1.208	0.299	0.123
Risk neutral [a]	-1.049	0.350	0.326	-0.384	0.681	0.577
Awareness	1.650	1.208*	0.058	0.821	2.273	0.122
Constant	-10.110	0.00004***	0.004	-5.213	0.0054***	0.002
Diagnostics						
Base category	CAS (n = 162)	CAS (n = 162)	CAS (n = 162)			
Number of observations	270	270	270			
LR chi-square	373.13***	373.13***	373.13***			
Log likelihood	-93.45	-93.45	-93.45			
Pseudo R^2	0.67	0.67	0.67			

[a] risk loving is the reference category. AFS: Agroforest system, ACS: Alley cropping system, CAS: Conventional agricultural system. RRR: Relative risk ratio· $^{*}p < 0.10$, $^{**}\ p < 0.05$ and $^{***}p < 0.01$

Figure 1 Study area