transition from slash-and-burn (khoriya) farming to permanent agroforestry in the middle hills of Nepal; an analysis of costs, benefits and farmers' adoption.

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Transition from slash -and -burn (*Khoriya*) farming to permanent agroforestry in the Middle hills of Nepal; An analysis of costs, benefits and farmers' adoption

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Declaration

I, Rigendra Khadka, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature………………………………..

Date……………………………………

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Part I: Extended Summary

Abstract

Slash-and-burn farming, locally known as Khoriya farming, has been one of the farming systems prevailing in the middle hills of Nepal. Reduced fallow period in this kind of agriculture is considered as the major economic downturn of the cultivators and environmental hazards in the area. Despite of these negative consequences, farmers are practicing Khoriya farming because of lack of alternative, poverty and government's negligence over the issue. Against the backdrop, MDI-Nepal (Manahari Development Institute), a non-government organization, started agroforestry program for Khoriya farmers in Makwanpur district of Nepal. The aim of this paper was to analyze the costs and benefits and the adoption of introduced agroforestry system and the traditional Khoriya farming prevailing in the area. Net present value (NPV), benefit- cost ratio (B-C ratio) and return to labor were the major financial indicators to analyze the costs and benefits of two systems to farmers. Binary logistic regression model was used to analyze the effects of various factors on agroforestry adoption by Khoriya farming households. Moreover, farmers' perceptions over advantages and disadvantages of agroforestry and motivational factors for adoption were also studied. The data of the study came from household survey with randomly selected 218 farmers (109 with agroforestry and 109 with Khoriya farming) and two focus group discussions in four VDCs (Village Development Committee) of Makwanpur district in Nepal.

Results of the farm income analysis showed that agroforestry system was financially profitable than the traditional Khoriya farming in the area. All three indicators of financial analysis; NPV (Net present value), B-C (Benefit-cost ratio) ratio and return to labor was higher in agroforestry system than Khoriya farming. The binary logistic regression predicted that education level of the household head, extension services, presence of active labor in household, average off- farm income were positively related to the adoption of agroforestry among Khoriya farmers. Younger farmers who were nearer to market centers were the early adopters of the agroforestry system. Similarly, the selection of species was the crucial motivational factors to adopt agroforestry system in contrary lack of capital and complex management system in view of farmers were the most limiting factors for the adoption of introduced agroforestry system in the area. Findings of the study suggest that the introduced agroforestry can improve the economic status of slash-and-burn farmers and ecological stability of the area only if establishment costs are subsidized and land tenure problems are solved.

Introduction:

Majority of hill population in Nepal still depends on the farming for livelihood support. However, sustainability of the farming has been a challenge for policy makers and development agencies. The land degradation problem induced by intensive farming on steep land, deforestation and natural phenomenon pose the food and livelihood security of local farming communities in fragile condition in the middle hills of Nepal (Shrestha et al., 2004). Different forms of intensive to semi-intensive land-use systems have been in practice in the hills of Nepal. Among them, slash –and- burn- farming, which is also called shifting cultivation, is also practiced in middle hills of Nepal. According to Regmi et al., (2005), this form of agriculture is practiced by ethnic people in hilly areas of 20 districts in Nepal. And, locally this form of farming is called *Khoriya* farming (Aryal and Kerkhoff, 2008, Dhakal, 2000). Under *Khoriya* farming generally steep to gentle steep land is cultivated using slash-and- burn techniques. Patches of forest land are first cleared off and subsequent burning of dried vegetation is done before sowing maize or leguminous crops. After one or two cycles of crops the land is abandoned for few years. In the mean time, farmers go for other patches of land to clear the vegetation for cultivation purpose. According to Brady, (1996) this form of cultivation which needs moving from one plot to another by destroying the forest land is called slash-and-burn agriculture.

There has been lack of considerable research in the hills of Nepal whether or not the *Khoriya* farming is responsible for land slide, soil erosion and deforestation. Sharma and Khatri-Chettri, (1995) found that this form of cultivation reduces the vegetative cover from the field which is responsible for soil erosion in the hills. But, many researchers have pointed that the *Khoriya* farmers are mostly food unsecure, marginalized and often they have to rely on wild and uncultivated plants for subsistence (Aryal et al., 2009, Kerkhoff and Sharma, 2006, Regmi et al., 2005). During monsoon period landslide and downstream siltation are the common features in the hills of shifting cultivation areas in Central Nepal. Several studies on shifting cultivation areas of Bangladesh have shown that shifting cultivation practice with reduced fallow period increases the soil erosion which jeopardizes the livelihood of the cultivators (Borggaard et al., 2003, Gafur et al., 2003, Rasul and Thapa, 2006). In practice, the fallow period of Khoriya farming in Nepal is reduced from 10-15 years in the past to 2-3 years now (Aryal and Kerkhoff, 2008, Dhakal, 2000, Sharma and Khatri-Chettri, 1995).

Many government and non-government organizations are trying to promote suitable agricultural technology that can promote sustainability of farming in middle hills of Nepal. But, communities are continuing the *Khoriya* farming because of lack of technical knowhow about the alternatives. Against this background, MDI-Nepal (Manahari Development Institute), a non-government organization, started an agroforestry project in the *Khoriya* farming areas of Makwanpur district. The aim of the project was to improve livelihood of farmers and mitigating the adverse environmental effects associated with farming. The project initiated plantation of commercial agroforestry species to enhance the farm income of the Khoriya farmers. Major agroforestry species were banana (*Musa acuminata*), pineapple (*Ananas comosus*), ipil-ipil (*Leucaena ssp*.), *Bakaino* (*Melia azederach*) and brome grass (*Bromus inermis*).

Different studies in Nepal have shown that agroforestry can increase the sustainability of hill farming system (Amatya and Newman, 1993, Carson, 1992, Garforth et al., 1999, Neupane and Thapa, 2001). However, all these studies, except Neupane and Thapa, (2001), are focused on the soil fertility management and erosion control under subsistence hill farming system rather than the costs and benefits of the technology to farmers. And, the hill farmers were not interested to adopt any agriculture technology which sole objective was to control erosion or improve soil fertility unless that provided income to households (Acharya et al., 2008). So, it is one of the important considerations that the introduced technology should have better financial return to farmers to make the technology adoptable among farmers. Research in shifting cultivation areas of Bangladesh found that agroforestry provided better alternative both ecologically and economically to shifting cultivation (Rasul and Thapa, 2006, Rahman et al., 2007). Studies by others Brown, (2006), Brady, (1996), Adesina et al., (2000), Fischer and Vasseur, (2000) also documented the promise of agroforestry as an alternative to slash-and – burn agriculture in different parts of the world. Even though *Khoriya* farmers are resource poor, they are concerned with the input costs and output benefits attached with the agroforestry system initiated by the project. Profitability of available alternative, farmers' socio-economic condition and risk and uncertainty of farming system may affect the decision of *Khoriya* farmers whether or not to accept the available alternatives. Because of land tenure security, market price competition of the products and high transaction costs, shifting cultivators may prefer to continue their traditional practice no matter how the agroforestry is profitable (Rasul and Thapa, 2006). No matter how the agroforestry system has potential of improving ecological and economical sustainability, its benefits are not visible until the large scale adoption by farmers (Raintree, 1983) . And, many factors affect the decision of Khoriya farmers whether or not to adopt the introduced agrofroestry. Farmers' preference, resource endowments, market incentives, biophysical factors and risk and uncertainty are the most determining factors for agroforestry adoption found by different researchers (Pattanayak et al., 2003, Pattanayak and Mercer, 1996). In shifting cultivation areas of Bangladesh, institutional support including land tenure, extension support, credit facilities and market access enabled farmers to adopt ecologically and economically appropriate agroforestry (Rasul and Thapa, 2006 b, Thapa and Rasul, 2005) .

The *Khoriya* farming system is somehow different than the subsistence hill farming in Nepal because the *Khoriya* farming has been declared as illegal and farmers have no tenancy right of these *Khoriya* lands after the nationalization of forest in 1957 (Regmi, 1978). Despite of the tenancy right issue farmers in mid-hills of Nepal have been practicing the *Khoriya* farming for generations. Under such scenario, even though farmers are aware of the negative environmental effects and degradation of land resource, they are continuing the *Khoriya* farming on marginal land because everybody can extract the resource but nobody is responsible for the care of the common property as stated by (Fox, 1993). So, it is necessary to evaluate the introduced agroforestry for *Khoriya* farmers in terms of profitability, adoptability and farmers' perceptions over constraints and opportunities. Agroforestry in the area may be adoptable if farmers perceive it as suitable as their socio-economic conditions and available alternatives to them in local condition. So, it seems to be justifiable to assess the costs and benefits of introduced agroforestry system in the area and factors affecting the adoption by *Khoriya* farmers.

Objectives of the study:

The overall objective of the study was to evaluate the profitability of agroforestry system against the traditional slash-and-burn (*Khoriya*) farming and to analyze the factors affecting the adoption of agroforestry by *Khoriya* farmers. The specific objectives of the study were as follows

1. Evaluation of financial performance and profitability of promoted agroforestry –based farming system against existing slash- and -burn based (*Khoriya*) farming system in the project areas.
2. Analysis of farmers' perceptions over constraints and benefits of agroforestry system.
3. Analysis of the factors affecting the adoption of agroforestry by *Khoriya* farmers.

Materials and method:

The study was conducted in 4 VDCs (Village Development Committee) of Makwanpur district in Middle hill of Nepal. In the area MDI-Nepal started the agroforestry project for *Khoriya* farmers in 2004 with the support of UNDP/GEF/SGP-Nepal (United Nations Development Program, Global Environment Fund, and Small Grant Project). The data was collected in January, 2010 using structured questionnaire and two focus group discussions.

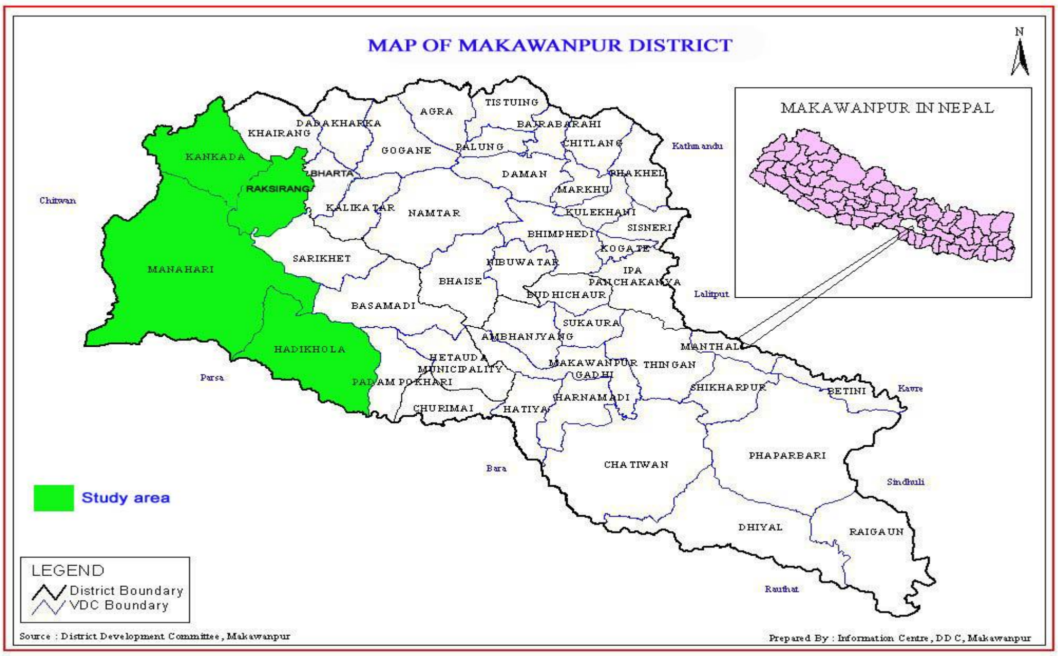

Fig 1: Site of the study

Secondary information was obtained from the project reports before selection of villages and households after then one reconnaissance field visit was conducted to finalize the villages for study. It was found that agroforestry was practiced in *Khoriya* land by 914 farmers in 13 villages of the project area. Out of these 914 farmers a sample size of 109 households from 13 villages, which constituted approximately 12 % of the total agroforestry farmers in each village, was randomly selected using lottery method. Then after, equal numbers of farmers cultivating *Khoriya* only were selected using the same method. The final size of the sample was 218 households including 109 agroforestry practicing and 109 *Khoriya* farming. Then the households were labeled as 'farmers with agroforestry' and 'Khoriya farmers' to analyze the costs, benefits and the farmers' adoption. Socio-economic data of the households, inputs used and output produced in agroforestry and Khoriya farming, farmer's perceptions over benefits and constraints of agroforesty, different extension services received and motivating and limiting factors for agroforestry cultivation were collected within these two categories of farmers to analyze the factors affecting agroforestry adoption and its costs and benefits to *Khoriya* farmers.

For financial analysis benefit –cost (B/C) ratio, return to labor and NPV (Net Present Value) were examined with and without including household labor opportunity cost. Sensitivity analysis was done to analyze the profitability of agroforestry system under changed discount rate and decreased market price of the agroforestry production. For calculation of NPV a 5 year time horizon was set out because in farmers experience the agroforestry species in the area need to be replaced after 5 years and within this period 2 cycles of Khoriya cultivation can be completed. For discount rate 6.5 % was used which is the central bank discount rate in Nepal (Theodora, 2010). The outputs produced during the year 2009 were included for analysis of yearly return from agroforestry and Khoria farming. The output produced in Khoriya farming were cereal, legume crops and Khar (long grass used for roofing material for houses). For agroforestry, yield of fruits and fodders were converted into monetary value by multiplying the amount produced by respective average farm gate prices. The value of fodders and grasses were determined on the basis of Bhari (local marketing unit in the area) and their respective prices in the villages. The cost of inputs and outputs were verified during two focus group discussions.

To analyze the factors affecting agroforestry adoption by Khoriya farmers, binary logistic regression model was employed. It describes the relationship between a dependant variable and a set of independent variables and predicts the factors affecting the adoption or non-adoption of agroforestry. The logistic regression model has been used by majority of agroforestry adoption studies to analyze dichotomous adoption decisions in which the dependent variable is binary ; 1 if adopts, 0 otherwise (Mercer, 2004). For factors affecting the adoption different independent variables were hypothesized on the basis of previous agroforestry adoption studies and the socio-economic condition of the farmers in the area (Table 1). SPSS (statistical package for social science) was used to analyze the data obtained from household survey. Mean (using independent samples t-test) and percentage (using cross-tabulation, chi-square tests) were compared between 'farmers with agroforestry' and 'farmers with Khoriya only' to know the characteristics of sample households and the differences between adopters and non-adopters. Bivariate correlation was also performed to know the correlation between independent variables.

Table 1: Indicators used for the study

Indicators for cost and benefit analysis	Description
Net present value (Rs/ha)	Including HH opportunity cost and not including HH opportunity cost
B/ C ratio (Rs/ha)	Including HH opportunity cost and not including HH opportunity cost
Return to labor(Rs/M-Day)	Provides labor unit opportunity cost used in an enterprise. (Total farming income / total labor unit requirement).
Independent variables hypothesized for adoption study	
AGE	Age of the household head in years
EDUCATION	Years of schooling of the household head
ACTIVELABOR	Members in household aged between 16-59
LAND	Total land of household in hector

LANDTYPE	1 if the household owns Khoriya as well as other type of land; 0 if the HH owns only Khoriya Land
LIVESTOCK	Total numbers of livestock Unit(TLU) with household
OFFINCOME	Average annual off-farm income of household in Rs.
FOODSUFF	Number of months in a year that household has food sufficiency from own production
EXTENSION	Extension index measures the different extension support that household received
DISTANCE	Hours of walking distance of Khoriya land from market center or highway
ABUNDANCE	1 if the HH easily finds new forest land for cultivation;0 if the HH cannot find or difficult to find new forest land

Results and discussion:

The independent samples t-test showed that mean education (numbers of years of schooling) of the household head, household food sufficiency months in a year from own production and household average annual off-farm income was significantly higher ($p<0.1$) in households with agroforestry than households with Khoriya only. While the mean age of the household head was significantly lower ($p<0.1$) in the households with agroforestry project than Khoriya only (paper I).

Results of the farm income analysis showed that agroforestry system provided higher gross benefit than Khoriya farming. Agroforestry system showed better result for all three criteria NPV, B-C ratio and return to labor. NPV, including and not including household labor, was much higher in agroforestry system than Khoriya farming. Similarly return to labor was almost 60% higher in agroforestry system. The B-C ratio in Khoriya farming including household labor opportunity cost was less than 1 indicates the system was not financially profitable when labor opportunity cost was considered (paper I).

Result of the sensitivity analysis showed that agroforestry was profitable than Khoriya farming up to 40% decrease in product price and increase in discount rate as compared to present market price (paper I).

The result of the farmers' perceptions on advantages of introduced agroforestry showed that households with agroforestry exhibited faster and higher economic return as first most important advantage , easy to sell agroforestry product as second most important and reduces the chances of land slide as third important benefits. However, households with Khoriya perceived that increase livestock productivity as first, easily available planting materials as second and reduces the chances of land slide as third most important benefits of introduced agroforestry (paper I).

The prevailing Khoriya farming system in the study area was unsustainable in terms of farming income and land-use practice. Farmers often had to rely on wild and uncultivated fruits because of severe food insecurity in the area. Land slide and downstream siltation were the major environmental problems of the Khoriya farming in farmers' experience. The fallow period was drastically reduced because of unavailability of more *Khoriya* land for new cultivators. The agroforestry system was found more profitable than the traditional farming practice in terms of NPV, B/C ratio and return to labor. In these steep lands annual cropping of cereal seems to be irrelevant. Labor was abundant in the area because of lack of alternative employment opportunities to farming. Hence, farmers having low off- farm income and extension services continued the *Khoriya* farming despite of being aware that agroforestry was quite economically and ecologically better than the *Khoriya* farming. Because the agroforestry system demanded more capital than the *Khoriya* farming during establishment phase while *Khoriya* farming provided subsistence income despite of any investment.

The binary logistic regression analysis showed that out of 11 hypothesized factors, 5 factors namely; education level of the household head, active labor availability in the family, extension index , off-farm income and food sufficiency from own production were positively related to the agroforestry adoption. Increasing the level of these factors among *Khoriya* farmers will significantly enhance the adoption of agroforestry. In contrary age of the household head and distance to market were negatively related to the adoption. Farmers having land nearer to market centers or highway were more likely to adopt agroforestry than

Khoriya farming. Similarly younger farmers were likely to adopt agroforestry practice compare to older farmers (paper II).

Most farmers reported that the higher and quicker income from agroforestry species and difficulty to find *Khoriya* land around as the major motivational factors for agroforestry adoption. The population pressure in shifting cultivation areas has been considered as one of driving forces to reduce the fallow period in *Khoriya* farming system. Similarly farmers reported four limiting factors for agroforestry adoption. Of these, difficult to manage agroforestry after plantation and lack of capital during establishment were the two major factors. Agroforestry need special management knowledge which is often difficult for the resource poor and inexperience *Khoriya* farmers without proper extension support.

Conclusions:

The introduced agroforestry for Khoriya farmers provided higher net present value (NPV), benefit-cost ratio and return to labor than the *Khoriya* farming system prevailing in the area. So, the agroforestry is more profitable than Khoriya farming and also not risky when the product price decreases. The agroforestry species are preferred by the Khoriya farmers.

Education level of the farmers, active labor in the family, off-farm income of the household , food sufficiency months from own production in a year and extension support are positively related to the adoption of agroforestry among Khoriya cultivators. Similarly, the selection of species is one of the crucial motivational factors to adopt agroforestry system in contrary lack of capital and complex management system in view of farmers were the limiting factors for the adoption of introduced agroforestry system in the Khoriya.

Although the study was conducted in small geographical area and may not be applicable in wider context , the findings of the study suggests that agroforestry can give desirable economic return and bring ecologically stability in Khoriya farming areas of middle hills in Nepal. But the following considerations are important for future expansion.

- The land tenure of the Khoriya plots should be clearly defined by the forest department.
- An establishment subsidy should be provided to Khoriya farmers.
- Sufficient knowledge about the agroforestry species should be provided to farmers through technical and management training before plantation.

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Part II:

Research paper I:

Agroforestry for Slash-and–burn (Khoriya) farmers in the middle hills of Nepal: An analysis of costs, benefits and farmers' perceptions

Abstract

Slash-and –burn, locally known as Khoriya farming, has been the mainstay of many ethnic people in the central middle hills of Nepal. The negative consequences, low productivity and land degradation, from slash-and- burn farming under reduced fallow period have been documented by many researchers. To improve the situation MDI-Nepal (Manahari Development Institute- Nepal) introduced an agroforestry system for Khoriya farmers in four VDCs (Village Development Committee) of Makwanpur district in Middle hill of Nepal. The aim of this paper was to analyze the costs and benefits of introduced agroforestry system and the traditional Khoriya farming prevailing in the area to the farmers. A field survey was conducted covering 218 farmers, of which 109 were cultivating introduced agroforestry in their Khoriya land. Net present value (NPV), Benefit- Cost ratio (B-C ratio) and return to labor were the major financial indicators to analyze the costs and benefits of two systems to farmers. Sensitivity analysis was done to know the profitability of introduced agroforestry and Khoriya systems under different risk and uncertainties. Furthermore, farmers perceptions over benefits and constrained received from agroforestry system were also analyzed to know the competitiveness of the system in farmers' view.

The results showed that the agroforestry system was better than Khoriya farming in all three economic indicators; NPV, B-C ratio and return to labor. And, the agroforestry was even profitable to farmers up to 40% decrease in product price and up to 40 % increased discount rate. In farmers view, quick and more return from agroforestry was the most important advantage and harbor insects and pests was the most important disadvantage of the agroforestry system However, the Khoriya farming also provided considerable B-C ratio if household labor opportunity cost was not considered. So, farmers are continuing the Khoriya farming because of lack of alternative employment opportunities in the area.

Introduction:

Majority of hill population in Nepal still depends on the farming for the livelihood support. However, poverty and environmental degradation like soil erosion, land slide and downstream siltation are the common outcomes of farming in middle hills of Nepal. The land degradation problem induced by the intensive farming on steep land, deforestation and natural phenomenon threatens the food and livelihood security of the local farming communities in the middle hills of Nepal (Shrestha et al., 2004). Slash- and -burn farming which is also called shifting cultivation is still practiced in Nepal although it is believed that (Rasul and Thapa, 2003) this form of farming system has been almost entirely replaced by sedentary agriculture. Locally such farming system is known as *Khoria Kheti* and it is practiced mostly by indigenous tribal communities (Aryal and Kerkhoff, 2008, Dhakal, 2000). Literally, *Khoriya* means the steep slopes where cultivation is done following slash- and -burn practices. Shifting cultivation system which needs moving from one plot to another , or slash –and –burn , referring to the means of destroying the forest land (Brady, 1996). This form of agriculture involves the growing of crops on a plot of land and then letting it fallow for several years. During the fallow period various plants and trees will grow naturally on fallow land. In Nepal , *Khoriya* farming is still practiced in the hilly areas of 20 districts with the involvement of ethnic minorities like Chepang, Magar, Tamang, Sherpa and Rai (Regmi et al., 2005, Dhakal, 2000). The practice of Khoriya farming starts in winter with land clearing and burning. During April-May Maize is planted after the onset of monsoon rain. Then after, intercropping of one or two leguminous crops like black gram, cowpea, beans, rice bean and horse gram with maize or millet with maize is followed. Most of the *Khoriya* farmers prefer rice bean and horse gram as intercrop. Harvesting of maize takes place in late August and leguminous crops and millet in late October to mid November. Then the land is fallowed for 2-3 years. The Khoriya farming is generally practiced in areas with more than 30 degree slopes where the cultivation of other permanent cereal crops is not possible (Aryal and Kerkhoff, 2008, Dhakal, 2000). So, the *Khoriya* farmers are the poorest and the areas are mostly food deficit.

It is assumed that the shifting cultivation system was sustainable at times when the population density was low, market access was limited and there was abundant forest land available for cultivation. However, due to increase in population, intensification of agriculture with available market and nationalization of forest, in most parts of Asia, fallow period is reduced drastically in shifting cultivation land use systems (Rasul and Thapa, 2006). Different studies have shown that sloping uplands with slash -and -burn farming practices are in higher ecological risk consequently threatening the livelihood of people in these areas. Shifting cultivation with reduced fallow is considered ecologically and economically unsustainable and is jeopardizing the livelihood of people depending on it (Borggaard et al., 2003). Decreased fallow period due to population pressure in shifting cultivation areas has led to food insecurity among its practitioners, accelerates deforestation and increases biodiversity loss (Gafur et al., 2003, Rasul, 2003 b) . The loss of soil materials from shifting cultivation plots in the first year of cultivation was 6 times higher than the plots with perennial vegetation or fallow in the watersheds of Chittagong Hill Tracts of Bangladesh (Gafur et al., 2003). In the context of global warming the burning of forest products from slash-and –burn farming is one of the contributors of greenhouse gases (Brady, 1996) . There is lack of information in Nepal about the *Khoriya* farming system and its effects on farmer's livelihood and environment. Sharma and Khatri-Chettri, (1995) found that this form of cultivation reduces the vegetative cover from the field which is responsible for soil erosion in the hills of Nepal. *Khoriya* farmers are the poorest of the poor and who belongs to the group having less than 1US$/ per day income (Kerkhoff and Sharma, 2006). *Khoriya* farmers are mostly food unsecure, marginalized and often they have to rely on wild and uncultivated plants for subsistence (Aryal et al., 2009). Practically, the *Khoriya* farming prevailing in Nepal is quite unsustainable and is unable to support livelihood of people (UNDP/GEF/SGP, 2008). In practice, the fallow period of *Khoriya* farming in Nepal is reduced from 10-15 years in the past to 2-3 years now (Sharma and Khatri-Chettri, 1995, Aryal and Kerkhoff, 2008, Dhakal, 2000).

With this background, in 2004 MDI-Nepal (Manahari Development Institute) started controlling the slash- and –burn farming through promotion of fruit and fodder based agroforestry system in *Khoria* cultivation areas of Makwanpur district in Nepal under financial support of UNDP/GEF small grant Project (United Nations Development Project / Global Environment Facility). The overall goal of the agroforestry intervention in *Khoriya* was to achieve improved and sustainable livelihood of people through increased household income. The most common fruit species used for agroforestry development were banana (*Musa acuminata*) and pineapple (*Ananas comosus*) while ipil-ipil (*Leucaena ssp*.), *Bakaino* (*Melia azederach*) and brome grass (*Bromus inermis*) were the fodder trees.

Several studies have shown that agroforestry has the potential of improving sustainability of farming. Agroforestry is a collective name for land use systems and technologies where woody perennials are deliberately used on the same land-management units as agricultural crops and animals and stems. There are both ecological and economical interactions between woody and non-woody components (Nair, 1993). Agroforestry planted in contour hedgerows in sloping lands increase sustainability of livelihood assets of people (Lal, 1990, Young, 1997). Agroforestry can be an alternative to shifting cultivation land use systems because of its economic and ecological viability over shifting cultivation (Rasul and Thapa, 2006, Rahman et al., 2007, Naath et al., 2005). But these findings were observed in the Chittogang Hill tracts of Bangladesh where shifting cultivation was the main land-use system. In case of Nepal also many researchers have found that agroforestry has potential of improving economic and ecological sustainability of the subsistence hill farming system (Carson, 1992, Neupane and Thapa, 2001, Garforth et al., 1999, Amatya and Newman, 1993). However, all these studies, except (Neupane and Thapa, 2001), are focused on the soil fertility management and erosion control under subsistence hill farming system rather than the costs and benefits of the technology to farmers. And, the hill farmers were not interested to adopt any agriculture technology which sole objective is to control erosion or improve soil fertility unless it provides income to households (Acharya et al., 2008). So, it is one of the important considerations that the introduced agroforestry should have better financial return to farmers to make it adoptable among farmers.

The findings of research in one area and country cannot be interpreted as same level for another area because of difference in bio-physical nature of the area and socio-economic condition of people involved (Rasul and Thapa, 2003). So, it is necessary to study the costs and benefits of introduced agroforestry in the *Khoriya* farming areas. Profitability of agroforestry system should be analyzed in terms of costs- benefit, positive net present value and the relation between agroforestry and alternatives available to farmers (Current et al., 1995). No matter how the agroforestry system is beneficial to farmers and the local ecosystem its benefits would not be visible until they are adopted at farm level and have some impact on farmer's economy and local environment. Like any other agricultural technology, adoption of introduced agroforestry in the area considerably depends on the economic benefits accruing to famers (Neupane et al., 2002). However, decisions to adopt a land- use option could also involve fulfillment of non-economical needs. So, farmer's perceptions of benefit they receive from farming are also equally important because they affect their decision making over long term adoption of the technology (Kliebenstein et al., 1980). The objectives of the study were;

- Evaluation of financial performance and profitability of promoted agroforestry –based farming system against existing slash- and –burn (*Khoriya*) based farming system in the project areas.
- Analysis of farmers' perceptions over constraints and benefits received from farming of two agricultural systems.

Research methods:

Selection of study area and households:

Four project VDCs (Village Development Committee) of Makwanpur district Manahari, Handikhola, Raksirang and Kankada were selected as the study areas. Makawanpur district of Nepal, a typical middle hill district, occupies a total land area of 242,600 ha with less than 15% cultivable land (MDI-Nepal, 2007). These four VDCs lie in the Northern Makwanpur where *Khoriya* faming is widely practiced by Tamang and Chepang ethnic communities. In study VDCs the agroforestry project was introduced by MDI-Nepal since 2004. In these four project VDCs 7941 households are residing with majority of Tamang (46%) followed by Brahmin 21% and Chepang 18% (UNDP/GEF/SGP, 2008).

Households for the study were selected at two stages. First, villages with agroforestry intervention were selected with the help of previous project household survey reports. The study of project report found that a total of 914 previous *Khoriya* farmers started the agroforestry-based system in 13 clusters of four VDCs. This was followed by the identification of farmers practicing agroforestry-based farming system and farmers continuing with the traditional *Khoriya* farming in each cluster of the four VDCs through a reconnaissance field visit. The cluster selection was based on the motive to select adopter (households cultivating agroforestry-based farming system introduced by project) and non-adopter households (household without agroforestry-based system and still practicing *Khoriya* farming) living in the same villages. Then after, households were labeled as ‘with agroforestry’ and ‘with *Khoriya*’ based on the farming system they have on practice.

Table 2: Villages and households selection

VDC	Clusters (Villages)	Selected HH (Total 218)	
		HH With agroforesry (109)	HH with Khoriya (109)
Raksirang	Niguretar, Churidanda,	23	23
Manahari	Faribang, Balbhanjyang, Polaghari, Rupachuri	25	25
Handikhola	Runchedanda, Hattibyaune, Chapal, Chuharphaka	33	33
Kankada	Silinge, Deviatar, Einatar	28	28

Second, a random sample of 218 households, using lottery method, comprising 109 agroforestry and equal numbers of *Khoriya* were selected for survey. This represented 12% sample of agroforestry farming households in each of the four VDCs. The numbers of *Khoria* farming households were selected as equal number as agroforestry farming households from each VDC.

Data collection:

Data were collected during January 2010 using enumerators living in the study VDCs. Information on the salient features of introduced agroforestry and shifting cultivation system in the area, land use pattern, household farming input and output, and farmers’ perceptions over constraints and benefits they received from agroforestry systems were collected through household survey and two focus group discussions. A structured questionnaire was used for data collection. Two focus group discussions were conducted with 10 farmers from each of the four VDCs, 2 agro-vet traders of the area, one fruit wholesaler and three project staffs. In each focus group discussion there were 25 participants including 20 farmers from two VDCs. Input and output cost obtained during interview with farmers and farmers’ perceptions over constraints and benefits of the agroforestry system were re-discussed and verified in the focus group discussion.

Analysis of farm income of agroforestry and *Khoriya* farming system was based on the data on input used and output produced on total land of the farmers and later this was converted on per hector basis.

Estimation of financial cost and benefits:

The cost and benefit analysis of *Khoriya* and agroforestry system requires production and investment data of two systems. The key variables considered for the estimation of production were inputs (e.g. labor, seed, planting materials, fertilizers and pesticide used) and outputs produced from both systems (e.g. fruits, cereals, bi-products harvested and grasses and fodders produced). The value of land was considered same for both system and neglected from calculation because the market for land is marginalised in the area and farmers have no registered land for *Khoriya* farming.

The outputs produced during the year 2009 were included for analysis of yearly return from agroforestry and *Khoria* farming. The production data for *Khoriya* farming were cereal , legume crops and *khar* (long grass used for roofing material for houses) .For agroforestry, yield of fruits like banana and pineapple were converted into monetary value by multiplying the amount produced by respective average farm gate prices. The value of fodder and grasses were determined on the basis of *bhari* (local marketing unit in the area) and their respective prices in the village. Production cycle of Khoriya cultivation and agroforestry differ considerably. In the study area agroforestry included fruit trees like banana, pineapple and fodders *Leucaena ssp*., brome grass and *Melia azederach*. The introduced agroforestry started to yield after 18 months period but the yield of banana and pineapple considerably lowered and need re -plantation after 4-5 years period in the local condition.

The Khoriya cultivation, however, needs one year cycle to have the harvest like maize, legumes and grasses. Then the land is rested for two years. So, to make the cost-benefit analysis comparable, a 5–year time horizon was considered during which 2 cycles of Khoriya cultivation, with 2-3 years of fallow, and one cycle of banana and pineapple plantation were completed. But the fodder trees give continued production even after 5 years so the values of these trees were expected as additional benefits. When agroforestry is compared with annual cropping system such tree products are considered as creation of capital even after the project period (Rahman et al., 2007).

The major input item included for study used was labor for field preparation, planting, weeding and harvesting needed for agroforestry and *Khoriya* cultivation. The labor cost is determined by 1- labor unit which is equivalent to 1 Man/day. Generally 1 labor unit is equivalent to Rs 150 per day in the area. For animal labor 1 pair of bullock per day is equivalent to 2,5 man /days under local condition. The valuation of labor requirement is based on the labor used by a crop from establishment to harvesting in a year. For the first year, both the labor and non- labor cost for agroforestry was higher because farmers needed extra manpower for plantation and costs for saplings. However, after second year the labor cost was calculated by subtracting the manpower used for plantation and non-labor cost was calculated by subtracting the sapling cost. In case of Khoriya farming the labor and non-labor cost was calculated as same for all the years.

A discount rate of 6.5 % was used for discounting which is the central bank discount rate of Nepal (Theodora, 2010).

Evaluation of financial cost, benefits and profitability:

In the study by Current et al., (1995) profitability of agroforestry practice relative to farmer's alternative system was analyzed in terms of cost- benefit, positive net present value and sensitivity analysis to determine the range of conditions such as input or output prices and productivity levels. Returns to land, benefit-cost ratio and return to labor and sensitivity analysis were the criteria for evaluation of financial performance and profitability of introduced agroforestry against shifting cultivation in shifting cultivation areas of Bangladesh (Rasul and Thapa, 2006). Likewise a study by Rahman et al., (2007) in the same area used cost-benefit ratio, internal rate of return , payback period and net present value to analyze the economic benefits of agroforestry system over shifting cultivation. In Middle hill condition of Nepal, benefit-cost ratio and net return were used as indicators to study the impact of agroforestry intervention on farm income under the subsistence hill farming system (Neupane and Thapa, 2001a). Hence, in this study net Present Value (NPV), benefit-cost (B-C) ratio and return to labor were used as indicators for the analysis of financial performance of agroforestry and Khoriya farming systems.

Net Present Value:

Net present value (NPV), which determines the present value of net benefits by discounting the cash flow of benefits and costs back to the base year, of agroforestry and *Khoriya* farming system, was calculated by the following formula (Dixon and Hufschmidt, 1986) . Higher and positive net present value of the system is considered as financially attractive.

$$\text{NPV} = \frac{\sum_{t=1}^{n}(B_t - C_t)}{(1+r)^t}$$

Where,

B_t= the benefit of production by a cultivation practice over the years t.

C_t = the production costs incurred by a cultivation practice over the years t.

t= the time period

r= discount rate

Benefit –cost (B/C) ratio:

Farmers are often concerned about the costs and benefits of a farming system to reach a conclusion whether or not to adopt the system continuously. So, the profitability analysis of the agro forestry –based farming system versus *Khoriya* cultivation was based on the cost benefit analysis. The benefit- cost ratio was calculated based on the economic formula , (Dixon and Hufschmidt, 1986) and it is based considered that land use with higher ratio is more profitable. A benefit-cost ratio lower than 1 means the land use is not profitable in terms of economic return.

$$\text{B/C ratio} = \frac{\sum_{t=1}^{n}\left(B_t/(1+\mathrm{r})^t\right)}{\sum_{t=1}^{n}(C_t/(1+\mathrm{r})^t)}$$

Return to labor:

Return to labor was calculated by subtracting material costs from the gross benefit and dividing the outcome by the total man-days needed by the farming system in a year. The calculation of return to labor for smallholder households is particularly important because they seek to maximize it if alternative employment are available (Rasul and Thapa, 2006). This is used to compare the farming benefits of both systems.

Sensitivity analysis:

Farmers in subsistence agriculture system like slash- and -burn are not always highly concerned about the costs and benefits while making decisions on adoption of new technology but may rather be concerned about the risk and uncertainties associated with them (Rasul and Thapa, 2006). In the study area farmers were deriving their livelihood primarily from cultivating *Khoriya* land. So, farmers may be reluctant to adopt agroforestry because of many risks and uncertainties associated with it. If all farmers adopt agroforestry there may be chances of market competition of the agroforestry product which can reduce the price. Labor opportunity cost is another uncertainty. If farmers find attractive off-farm employment, they may be reluctant to adopt agroforestry which demands more labor force than *Khoriya* farming. Farmers are very much conscious about the present income because of high poverty and food insecurity in the area. So, they can discount the future income on very high discount rate.

Shifting cultivators are always worried about the investment and return from it because of high level of present poverty (Rasul and Thapa, 2006). To find the profitability of agroforestry under such possibilities sensitivity analysis was done assuming that agroforestry product price will fall up to 50 % lower than present market price and farmers may discount the future income up to 90 % because of very high level of poverty in the area. In the analysis all the three indicators ; NPV , B-C ratio and return to labor with household labor opportunity cost was included because it was assumed that more alternative employment opportunities would be available for labor in future.

Analysis of farmers' perceptions:

Farmers' perceptions over benefits and constraints accrued from agroforestry-based system were also analyzed. For analysis 6 possible benefits and constraints of agroforestry in the area were selected from discussion with project staffs and farmers during reconnaissance field survey and included in the household survey questionnaire. The respondents were asked to rank three most important criteria in order of importance in their views and experiences. According to (Ayuk, 1997), farmers' perceptions generally differ from one to another according to the benefits and constraints they received from farming; a benefit perceived by one farmer as most important may be least important for another farmer. The most important factor in view of farmers was given 5 points, second most important was given 3 points and third ranking was given 1 point value. Then a formula was set to calculate ranking of famers' perceptions following , (Ayuk, 1997).

$RW_i = \sum W_j F_j$

W_j represents the assigned weight of the responses of the jth farmer

F_j represents the frequency of the response across n farmers.

RW_i is the relative weight of the i_{th} response.

For each response RW_i will be calculated and all RW_i will be compared to know the relative importance of the factors.

Data analysis:

The households were grouped into two categories 'with agroforestry' and 'with Khoriya only' for analysis. Data analysis was done in SPSS (Statistical packages for Social Sciences version 17) program. Mean comparison of households (independent T-test) with agroforestry and *Khoriya* were conducted under two groups of households to know the marked differences. NPV, B-C ratio, return to labor and sensitivity analysis was done using Microsoft Excel formulas.

Results and discussion:

The key socio-economic characteristics of households with agroforestry project and *Khoriya* only were comparable and presented in table 3.

Table 3: Key characteristic of the sample households

Key characteristics	Both	HH with Agroforestry (n=109)	HH With *Khoriya* (n=109)	Sig. (2- tailed t test)
Age of the HH head	49	48	50	O.01*
Education of the HH head	3	5	2	0.001*
Family size	6	6	6	0.299
Active family members in HH (age between, 16-60)	5	5	4	0.001*
Total land(ha)	0.331	0.433	0.233	0.001*
Total Khoriya land (ha)	0.243	0.286	0.201	0.001*
Total livestock unit(TLU)	3.58	3.57	3.59	0.951
Food sufficiency Months in a year from own production	7	8	5	0.01*
Avg. annual off-farm income(Rs)	29520	34717	24323	0.001*

* at 1% level of Significance

The result from the independent T-test showed that the mean age of the household head with Khoriya farmers was higher but the education (years of schooling) was lower. Household food sufficiency months in a year from own production and household average annual off-farm income were significantly higher with agroforestry households than Khoriya only. The mean comparison revealed that households with agroforestry had more economically active family members and higher land property than Khoriya farmers. All of the above mean differences were significant at 1% level. But the mean family size and livestock holdings were not significantly different among these two groups of households. The detailed statistics of the households' socio-economic characteristics are presented in appendix 4 and 5.

The results provided quite similar results as of many agroforestry adoption studies. Many agroforestry adoption studies in the tropics found that younger and more educated farmers are often the early adopters of agroforestry technology which requires more complex knowledge and willingness to take risk than their traditional occupation (Alavalapathi et al., 1995, Adesina et al., 2000). Similarly, household resource endowments like more land, higher off-farm income and food sufficient households have more chances of agroforesty adoption than the resource poor farmers because the better -off farmers can get credit facilities easily and can withstand the waiting period of agroforestry product (Pattanayak et al., 2003, Mercer, 2004). Agroforestry system is rather labor demanding so households with more active labor in the family have the more chances of adoption agroforestry (Nkamleu and Manyong, 2005).

Table 4: Analysis of farm income of* Khoriya *and agroforestry system

Indicators	Agroforestry	*Khoriya* farming
Gross income(Rs/ha)	186,466	37,407
Total Cost (Rs/ha)	55,515	29,602
Total labor cost (Rs/ha)	42,055	25,608
Total non-labor cost (Rs/ha)	13,459	3,994
Net financial benefits(NPV) (Rs/ha)		
With opportunity cost of HH labor	130,951	11,796
Without opportunity cost of HH labor	173,007	33,411
Return to labor (Rs/Man-day)	571	337
B-C ratio (Rs/ha)		
With opportunity cost of HH labor	2.36	0.40*
Without opportunity cost of HH labor	9.73	8.37

***** The B-C ratio below 1 indicates that the farming system is not financially profitable.

1 US $ equivalents to appox. 74 Nepalese Rupees.

HH- Household

Results of the farm income analysis showed that agroforestry system provided much higher gross benefit than *Khoriya* farming (Table 4). But, the costs were not considered under gross benefit. Further analysis of B-C ratio and NPV need to be taken to compare financial performance of the two systems, as they take into account both cost and revenue. Labor cost remained the major cost component for *Khoriya* farming and agroforestry system. So, the NPV and B-C ratio were calculated under both conditions; including household labor opportunity cost and not including household labor opportunity cost.

Agroforestry system showed better result for all three criteria NPV, B-C ratio and return to labor. NPV, including household labor, was 130,951 Rs/ha in agroforestry as compared to 11,796 Rs/ha in shifting cultivation. NPV, not including household labor, was much higher (173,001 Rs/ ha) in agroforestry system than *Khoriya* farming (Rs/ha 33411). Similarly return to labor was almost 60% higher in agroforestry system. The B-C ratio in *Khoriya* farming including household labor opportunity cost was less than 1 indicating that the system was not financially profitable land use system (Table 4) when labor opportunity cost was considered.

The B-C ratio without HH labor opportunity cost was more or less similar in both systems (table 4). This may be due to the fact that in *Khoriya* farming system used relatively low levels of inputs as compared to agroforestry. Agroforestry needs saplings, seed as well as fertilizer so demands higher non- labor cost during establishment stage. Farmers generally used much higher material cost for the agroforestry establishment. A higher B-C ratio in shifting cultivation system than agroforestry while not including labor opportunity cost was also found in the studies by Rasul and Thapa, (2006), Rahman et al., (2007) in shifting cultivation areas of Bangladesh. And ,a higher internal rate of return (IRR) in shifting cultivation system than agroforestry during initial stage of agroforestry was found by Rahman et al., (2007) in the same area. Small farmers' decision to adopt land- use system depends largely on net amount of income (NPV) they earn from farming rather than exact amount of input-output ratio (Thapa and Weber, 1994).Then , the labor opportunity cost may not be considered important by farmers because of lack of alternative income opportunities round the year in the study area. This may be the answer of the question why the farmers are continuing such low return agricultural practices despite the agroforestry project demonstrated a relatively better option of income from farming.

Table 5: Sensitivity analysis of agroforestry including HH labor opportunity cost

Sensitivity to decrease in price of product				Sensitivity to change in discount rate			
price fall	NPV	B-C ratio	Return to labor	discount rate	NPV	B-C ratio	Return to labor
0 %	130951	2.36	776	0 %	169847	2.74	971
5 %	121626	2.19	734	6.5%	130951	2.36	776
10 %	112304	2.02	692	10 %	114473	2.18	692
15 %	102982	1.86	650	20 %	79308	1.73	512
20 %	93657	1.69	608	30 %	56010	1.38	391
25 %	84334	1.52	567	40 %	40027	1.10	306
30 %	75013	1.35	525	50 %	28741	0.86	246
35 %	65687	1.18	483	60 %	20576	0.67	199
40 %	56365	1.02	441	70 %	14547	0.51	164

45 %	47040	0.85	399	80 %	10016	0.38	137
50 %	37718	0.68	357	90 %	6563	0.27	116

Results of the analysis (Table 5) showed that agroforestry can provide better result than *Khoriya* farming in all three indicators, NPV, B-C ratio and return to labor, up to the 40% decrease in product price. In case of change in discount rate, agroforestry can give better result on if the discount rate is increased up to 40 %. The results are similar to the study in Chittagong hill tracts of Bangladesh (Rasul and Thapa, 2006, Rahman et al., 2007) ; both studies found better result of agroforestry than shifting cultivation under decrease in yield, product price and increased discount rate.

However, in *Khoriya* farming the price fall of the commodity can further decrease the NPV and B-C ratio. More than 30 % decrease in price give negative NPV and B-C ratio (Table 5).

Table 6: Sensitivity analysis of Khoriya farming including HH labor opportunity cost

Sensitivity to decrease in price of product				Sensitivity to change in discount rate			
price fall	NPV	B-C ratio	Return to labor	discount rate	NPV	B-C ratio	Return to labor
0 %	11796	0.40	334	0 %	13746	0.39	389
5 %	9925	0.34	315	6.5%	11796	0.40	334
10 %	8056	0.27	297	10 %	9409	0.39	309
15 %	5740	0.19	273	20 %	9042	0.40	256
20 %	4315	0.15	259	30 %	7693	0.38	215
25 %	2444	0.08	241	40 %	6698	0.38	189
30 %	573	0.02	221	50 %	5939	0.37	168
35 %	-1296	-0.04	203	60 %	5344	0.37	151
40 %	-3167	-0.11	184	70 %	4865	0.36	137
45 %	-5037	-0.17	165	80 %	4463	0.36	126
50 %	-6906	-0.23	147	90 %	4144	0.35	117

Environmental costs and benefits:

Due to the lack of previous research and technical documentation of the soil erosion and gas emission during biomass burning in the area the environmental costs and benefits of *Khoriya* farming and agroforestry could not be quantified and not included in the costs and benefits analysis. These excluded intangible costs and benefits of these two systems are mainly soil erosion, effects on soil fertility and nutrient depletion and amount of green house gasses released through biomass burning from these two land -use systems. However different study of soil erosion in Nepal have shown that agroforestry provided better benefits than the *Khoriya* farming system in Middle hills of Nepal. Contour hedgerows using nitrogen-fixing plant species has benefit of reducing soil erosion in the sloping lands of middle hills of Nepal (Murray and Ya, 2004). Agroforestry system has many ecological services and environmental benefits (Jose, 2009); potential to increase the sustainability of subsistence hill farming by minimizing the soil erosion (Young, 1997, Lal, 1990, Lal, 1989) ; improving soil quality and farmers' income (Neupane and Thapa, 2001, Pattanayak and Mercer, 1996). In contrast , shifting cultivation reduces vegetative cover from the field and increases rate of soil erosion (Sharma and Khatri-Chettri, 1995). Loss of natural forest vegetation from hill slopes due to cultivation purpose was one of the major causes of low soil organic carbon (SOC) content in the Middle hills of Nepal (Sitaula et al., 2004). Besides, slash-and –burn farming may be one of the major factors of greenhouse gas emission through forest fire in tropics (Goldammer, 1988). Moreover, agroforestry has also potential of reducing emission of green house gases through controlling deforestation and forest fire (Goldammer, 1988) and sequestering carbon through above and below ground biomasses (Nair et al., 2009).

Farmers' perceptions on agroforestry:

From the above analysis of costs and benefits agroforestry provided better farm income than the *Khoriya* farming and it was also not risky up to decrease in 40 % price reduction. Under local condition it was obvious that farmers with agroforestry project have higher income and more security in terms of food security situation. But despite of project's effort, a large numbers of *Khoriya* farmers have not adopted the agroforestry. Hence, it poses an important question; why the adoption of agroforestry was not satisfactory in the area? Several factors play a vital role in the adoption of agroforestry. Farmers' positive perceptions and attitude were important determinants of agroforestry adoption (Sood and Mitchell, 2004). The results of the farmers' perceptions of advantages and disadvantages of project introduced agroforestry are presented in (Table 7). It can be seen that households with agroforestry perceived the quick and more economic return as the most important advantage of agroforestry. However, households with Khoriya perceived that the most important advantage of agrofrestry was to increase livestock productivity. The species used in agroforestry like banana, pineapple started to give outcome after 16-20 months of plantation. So, farmers perceived the agroforestry was able to generate quicker income than other fruit species in the locality.

Table 7: Farmers' perceptions of agroforestry system

Advantages of agroforestry	Farmers with agroforestry		Farmers with *Khoriya* only	
	Scaled score [1]	Ranking	Scaled score[1]	Ranking
Provides quick and more income	394	1st	80	
Reduces the chance of land slide	126	3rd	191	3rd
Improves soil fertility	84		148	
Increases livestock productivity	85		247	1st
Planting materials are easily available	107		197	2nd
Easier to sell agroforestry products	185	2nd	126	
Disadvantages of agroforestry				
Harbors more insects and pests	147	3rd	232	1st
Needs more capital and land during establishment	108		229	2nd
Agroforestry species are not suitable for local condition	20		72	
Needs more management and labor	68		97	
Hampers tillage operations	306	1st	116	3rd
Increases the chances of competition between crops	288	2nd	89	

Easy to sell agroforestry product was the second most important advantages in view of farmers with agroforestry project while easily availability of planting materials was the second most important advantage of agroforestry for farmers with *Khoriya* only. The species were easily available in the local area and the marketing of agroforestry product was not so difficult for the farmers. Both households perceived that agroforestry reduces the chances of land slide as third important advantage. Households with agroforestry ranked hampers tillage operations as top most disadvantages of agroforestry but farmers with *Khoriya* only ranked harbors insects and pest as top most disadvantages. Increases the chances of competition between crops was ranked as the second most important disadvantages of agrofrestry by households with agroforestry while needs more capital during initial stage ranked second by households with Khoriya only. The agroforestry establishment demanded much more capital investment than *Khoriya* farming during establishment stage. The agroforestry combined various species of fruit and fodder which may harbor different kinds of insects and pests and increase competition within species for water, nutrients and space.

But these disadvantages were not important in light of enhanced income, easy market access to product and easy to establish the agroforestry system as perceived by most of the adopters and not adopters. However, the adoption was not satisfactory and numbers of factors played a vital role as barriers for future extension. If labor opportunity cost was not considered the *Khoriya* farming would have provided profitable B-C ratio. Farmers were not considering the labor as important in the area because of lack of alternative employment. And most farmers were poor so they could not support the initial establishment cost of agroforestry and the waiting period to harvest agroforestry product. So, farmers without off farm income continued the *Khoriya* farming because it provided them subsistence without or very little initial investment. Farmers not adopting agroforestry also pointed the management problems associated with agroforestry system after plantation.

Conclusions and recommendations:

The agroforestry system provided higher farming income to *Khoriya* farmers as compared to their traditional system. The agroforestry system was also profitable up to 40 % decrease in market price. Farmers perceived many substantial benefits of introduced agroforestry system like easy to get planting materials, easy to sell harvest and the reduced chances of land slide in the area.

It is clear from the costs and benefits analysis and farmers' perceptions that the introduced agroforestry system can bring win-win situation; better environment and secured livelihood. But, development agencies should consider few institutional and extension problems for future expansion. According to the above findings and discussion some recommendations can be considered for future expansion of the agroforestry for *Khoriya* farmers.

- The land tenure of the *Khoriya* plots should be clearly defined by the forest department before t plantation of agroforestry species.
- An establishment subsidy should be provided to *Khoriya* farmers so that everyone can establish the agroforestry.
- Sufficient knowledge about the agroforestry species should be provided to farmers through technical and management training before plantation.

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Part III

Research Paper II:

Factors affecting the adoption of introduced agroforestry practice by slash- and -burn (*Khoriya*) farmers in the Mid- hills of Nepal.

Abstract

The sustainability of hill farming system has been the major challenge of many government and non-governmental organizations in Nepal. If farmers adopt economically and environmentally sound agriculture practices in the hills, may lead to sustainable agriculture. Agroforestry has been considered as one such agriculture practice. Several studies have been conducted to investigate the factors affecting the adoption of agroforestry in the hill farming system. However, only few study has been conducted on the adoption of agroforestry in the slash-and-burn (Khoriya *) farming areas in Nepal. This study was conducted to analyze the effects of various factors on agroforestry adoption by Khoriya farming households in four VDCs (Village Development Committee) of Makwanpur district in Nepal. The results of the study were more or less similar to other agroforestry adoption studies. The binary logistic regression analysis showed that out of 11 hypothesized factors the education level of the household head, active labor availability in the family, extension index and off-farm income were positively related to the agroforestry adoption. In contrary age of the household head and distance to market affected the adoption negatively. Most farmers reported that the higher and quicker income from agroforestry species and difficulty in find* Khoriya *land around as the major motivational factors for agroforestry adoption. Similarly farmers reported difficulty to manage agroforestry after plantation and lack of capital during establishment were the two major limiting factors for agroforestry adoption. Agroforestry needs special management knowledge which is often difficult for the resource poor and inexperienced* Khoriaya *farmers without proper extension services.*

Introduction:

Sustainability of hill farming has been one of the major challenges for government as well as non-government organizations in Nepal. The land degradation problem induced by the intensive farming on steep land, deforestation and natural phenomenon pose the food and livelihood security of the local farming communities in fragile condition in the middle hills of Nepal (Shrestha et al., 2004). Sustainability can be achieved if the farmers adopt ecologically, economically and socially suitable practices. It is the farmer and his socio-economic condition that determines the decision to adopt land-use option available in his locality. However, often marginal farmers are forced to adopt the low returning and ecologically unsustainable agriculture practices because of lack of options such as technical knowhow and management skills needed for new agriculture technology. In the hills of Nepal many ethnic people have been practicing the low return and ecologically fragile *Khoriya* farming despite the fact that they were aware of the many negative aspects of this kind of farming system. Shifting cultivation with abundant fallow period is sufficient to maintain natural stage of soil and it neither exploit the excessive nutrients from soil nor induces erosion and it is ecologically stable forms of agroforestry (Raintree and Warner, 1986). However, due to increase in population, intensification of agriculture with available market and nationalization of forest land, in most parts of Asia, fallow period is reduced drastically in shifting cultivation land use system (Rasul and Thapa, 2006). In case of Nepal the fallow period in slash- and- burn farming system is reduced from 15-20 years to 2-3 years because of state-led land tenure policies (Dhakal, 2000). Decreased fallow in shifting cultivation system has led to food insecurity among its practitioners, accelerates deforestation and increases biodiversity loss (Rasul and Thapa, 2003, Gafur et al., 2003, Palm et al., 1996).

Under *Khoriya* cultivation generally steep to gentle slopes are cultivated using slash- and - burn practices. The system starts during December-January with slashing of the vegetation on a land plot and letting it to dry for few weeks then burning of dried branches and leaves. After the burning, farmers sow maize crop in March-April as a main crop which is followed by intercropping of leguminous crops like horse gram, black gram and millet during monsoon in June-July. Maize crop is harvested in August and the leguminous crops are in October-November. Then after, the land plot is left abandoned for 2 to 3 years. The *Khoriya* land plots are dominant in an altitude range from 350 m to 1800 m from the mean sea level (UNDP/GEF/SGP, 2008). Almost all *khoriya* land do not possesses irrigation facility and remain rain fed. The *khoriya* farmers also keep livestock such as goat, poultry and cattle to fulfill tillage requirement and manure. A large portion of households have only *Khoriya* land as their sole land property while others have other terraced as well as irrigated land. Most of these *Khoriya* lands lack basic tenancy right because they fall under government land. Tenancy right is managed by community as *customary* right. Household first claim to the piece of land and cultivates first will be the owner of that land and it continues for generations. The *Khoriya* plots are generally ranged from less than 20 degree to 60 degree slopes (MDI-Nepal, 2007).

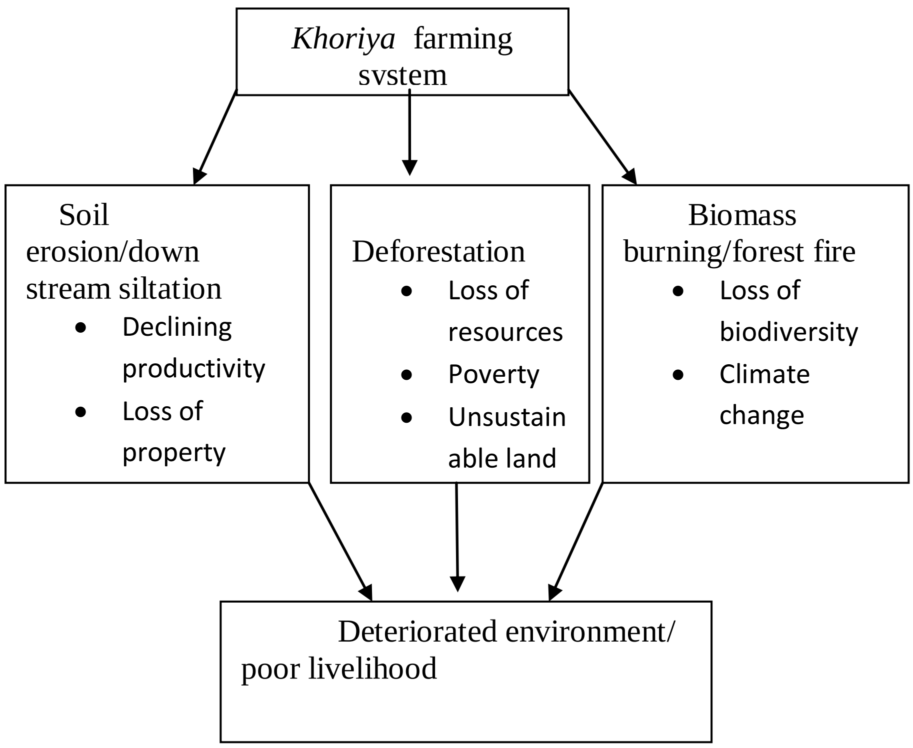

Fig. 2: Possible problems of Khoriya *farming in Nepal*

Aiming to improve livelihood of *Khoriya* farmers, MDI-Nepal (Manahari Development Institute) started promotion of fruits and fodder based agroforestry system in slash and burn farming areas of Manahari watershed in Makwanpur district of Nepal. The project attempted to control the adverse effects of slash-and-burn practice prevailing in the area through promotion of permanent fruit and fodder based agroforestry in Khoriya plots of farmers. The most common species used for agroforestry system were banana (*Musa acuminata*), pineapple (*Ananas comosus*), ipil-ipil (Leucaena ssp.), *bakaino* (*Melia* *azederach*) and brome grass (*Bromus inermis*). The agroforestry species are planted on contour lines using SALT (Sloping land agricultural technology) on the steep plots. The project supported farmers by providing necessary technical knowledge to plant the species on contour hedgerows.

As the agroforestry refers to the holistic approach of combining trees, crops and livestock in a land –use system. Agroforestry plays a significant role in maintaining sustainability in the hill farming system (Carson, 1992). Agroforestry in sloping lands can reduce soil erosion and increase soil fertility status thus the overall increase sustainability of livelihood assets of people (Young, 1997, Lal, 1990). Agroforestry has the potential of providing food, fodder and fuel wood which are the basic needs of subsistence farmers (Amatya and Newman, 1993). The slash -and -burn farming areas are rain fed areas and researchers have shown that development of fruit trees in such uplands, Chittagong Hill tracts of Bangladesh, found to be the attractive alternative for sustainable development of upland community (Rasul and Thapa, 2006, Rahman et al., 2007, Naath et al., 2005). In subsistence hill farming system of Nepal agroforestry adoption have contributed to increased farm income and soil fertility (Neupane and Thapa, 2001). Agroforestry species can be planted as contour hedgerows which can increase the nitrogen and organic matter content of soils, increase species diversity, and provide direct benefits to farmers in sloping and shifting cultivation areas (Aryal et al., 2007) of Nepal. Households in Dhading district of Nepal have well recognized the role of agroforestry in increasing farm income, tree species diversity and women's time saving for collection of fuel wood and fodder (Regmi, 2003). It is obvious that under subsistence hill farming system agroforestry can play a vital role for livelihood support of hill farmers however agroforestry research and promotion has never gained high priority in Nepalese state agriculture and forestry plans. Agroforestry has a wide range of species and adoption of these species depends on the suitability of selected species under local environment and socio-economic condition. Tree species selected only for soil conservation and not to provide quick income have very little adoption rate among subsistence hill farmers in Nepal (Acharya et al., 2008).

No matter how the agroforestry species are suitable to enhance economic and ecological sustainability it will not be effective to farmers without large scale adoption (Raintree, 1983). Although agroforestry increases the farm income and enriches soil fertility, adoption of agroforestry among small holders in subsistence hill farming is either too low or lasts only as long as it is supported externally (Neupane et al., 2002). This may be because of lack of research and development of appropriate system of agroforestry suitable for hill and subsistence farmers of Nepal. There were very limited numbers of research in the Nepalese context regarding agroforestry adoption. But, for the shifting cultivators in Nepal there were no any reliable research evidences as to which agroforestry model and species are appropriate for the area and farmers to enhance the economic and ecological sustainability. So, the main objective of this study was to analyze the effects of various factors on agroforestry adoption by Khoriya farming households, regarding agroforestry project initiated by the MDI-Nepal in four VDCs of Makwanpur district in Nepal. Outcomes of the study is considered as the reference for government and development agencies for further extension of the agroforestry technology in other slash- and -burn farming areas of Nepal.

Conceptual framework:

The adoption theory developed by Rogers, (1983), Rogers and Shoemaker, (1971) describes that adoption is a mental process from first hearing about the technology to making final decision whether to adopt this technology or reject. According to the theory farmers generally go through four different stages; awareness, interest, evaluation and adoption. During adoption process of a new agriculture technology and at each stage social, economic, physical and other factors play as constraints and opportunities for adoption of the technology. Economic models describe adoption as farm level decisions and the degree of use of the new technology by farmers in long-run when the farmers have full knowledge about the technology (Feder et al., 1985).

Like any other agricultural technology agroforestry adoption is also influenced by several factors. Farmers' preference, resource endowments, market incentives, biophysical factors and risk and uncertainty are the most determining factors for agroforestry adoption found by different research in the tropical agriculture (Pattanayak et al., 2003, Pattanayak and Mercer, 1996). The long waiting period for benefits and knowledge required for agroforesty system often provides barriers for adoption (Mercer, 2004). Factors like land availability, household labor, income and agricultural inputs to begin new agricultural technology are positively correlated with adoption (Adesina and Chianu, 2002, Bannister and Nair, 2003, Thangata and Alavalapathi, 2003). In shifting cultivation areas of Bangladesh, institutional support including land tenure, extension support, credit facilities and market access enabled farmers to adopt ecologically and economically appropriate agroforestry system(Rasul and Thapa, 2006 b, Thapa and Rasul, 2005).

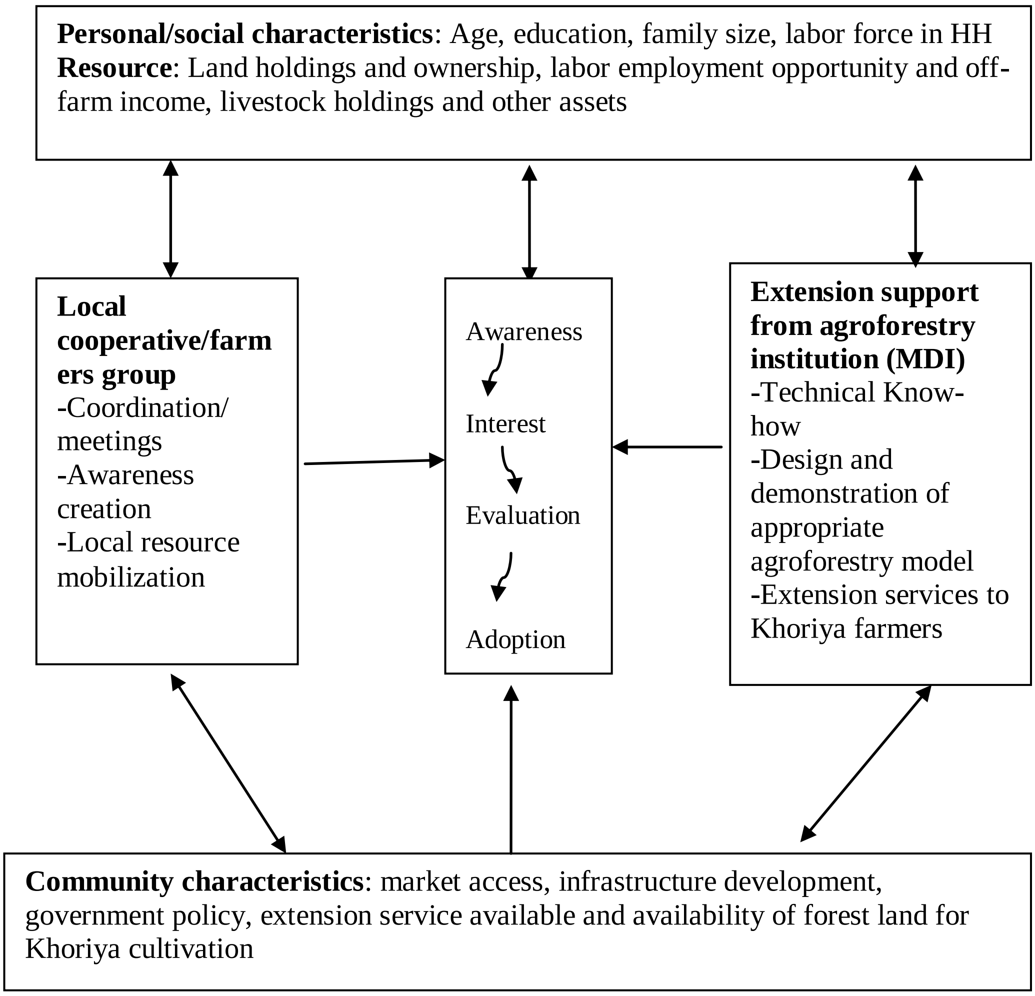

Fig:3 Framework for agroforesty adoption by Khoria farmers: adopted from (Neupane et al., 2002, Alavalapathi et al., 1995)

Under subsistence hill farming system male membership in local NGO, female education level, livestock population and farmer's positive perception towards agroforestry were the factors affecting positively agroforestry adoption (Neupane et al., 2002). But these indicators cannot be expected as same factors influencing the agroforestry adoption among shifting cultivators in the Middle Hills of Nepal. It is important to know the relationship between different socio-economic and institutional factors and agroforestry adoption by *Khoriya* farmers. It is assumed that *Khoriya* farmers will compare the profitability and suitability of introduced agroforestry in the area with the available land use system and future risk and uncertainty. Numbers of social, personal, community and institutional factors will impact on their adoption decision.

Research method:

Selection of study area and households:

Four project VDCs (Village Development Committee) of Makwanpur district Manahari, Handikhola, Raksirang and Kankada were selected as the study areas. Makawanpur district of Nepal, a typical middle hill district, occupies a total land area of 242,600 ha with less than 15% cultivable land (MDI-Nepal, 2007). These four VDCs lie in the Northern Makwanpur where Khoriya farming is widely practiced by Tamang and Chepang ethnic communities. In these four project VDCs 7941 households are residing with majority of Tamang (46%) followed by Brahmin (21%) and Chepang (18%) (UNDP GEF SGP, 2008).

A survey from MDI- Nepal in study VDCs showed that 57% of Khoriya plots have had slope range of 31-40 degree and 28 % has 21-30 degree. These study VDCs are either connected with highway or at close distance from it. The East-West highway has crossed Manahari VDC from Southern sector and Handikhola lies in association of the highway. Raksirang and Kankada have however no direct connection to highway but lies in 1-5 hours walking distance from highway.

Households for the study were selected at two stages. First, villages with agroforestry intervention were identified and selected with the help of previous project household survey reports. The study of project report found that a total of 914 previous Khoriya farmers started the agroforestry-based system in 13 clusters of four VDCs. This was followed by the identification of farmers practicing agroforestry-based farming system and farmers continuing with the traditional Khoriya farming in each cluster of the four VDCs through a reconnaissance field visit. The cluster selection was based on the motive to select adopter (households cultivating agroforestry-based farming system introduced by project) and non-adopter households (household without agroforestry-based system and still practicing Khoriya farming) living in the same villages. Then after, households were labeled as 'adopter' and 'non-adopter' based on the farming system they have on practice.

Table 8: Villages and households selection

VDC	Clusters (Villages)	Selected HH (Total 218)	
		Adopters (109)	Non-adopters (109)
Raksirang	Niguretar, Churidanda,	23	23
Manahari	Faribang, Balbhanjyang, Polaghari, Rupachuri	25	25
Handikhola	Runchedanda, Hattibyaune, Chapal, Chuharphaka	33	33
Kankada	Silinge, Deviatar, Einatar	28	28

HH- Household

Second, a random sample of 218 households, using lottery method, comprising 109 adopters and equal numbers of non-adopter were selected for survey. This represented 12% sample of agroforestry adopting households in each of the four VDCs. The numbers of non-adopter project households were selected as equal number as adopter households from each VDC.

Data collection:

Data were collected during January 2010 using 3 local enumerators from study VDCs. A reconnaissance field visit was conducted prior to household selection and interview. A structured questionnaire was prepared and pre-tested for quantitative information. Information about the personal characteristics of household head, family size, resource endowments, and institutional support received and perceptions of household head regarding *Khoriya* and introduced agroforestry on different intercultural operations were collected from the household survey. The household head was supposed to be the decision maker of the adoption of agroforestry in the area and interviewed to collect information on different personal, social, economic and institutional aspects on *Khoriya* farming and agroforestry adoption. Two focus group discussions were conducted with 10 farmers from each four VDCs, 2 agro-vet traders of the area, one fruit wholesaler and three project staffs to verify the data collected from household survey.

Households were grouped into two categories, adopters and non-adopters, to study the impacts of different factors on adoption of agroforestry. The adopter households have planted the project introduced agroforestry in the *Khoriya* land and have also fetched income from sale of agroforestry product. On the other hand, the non-adopter households have not planted agroforestry in their *Khoriya* land and are practicing the traditional farming system.

Data analysis method:

Quantitative data obtained through household survey was processed using Statistical Package for Social Sciences (SPSS). Two sample t-rests were conducted to compare mean differences of households, Chi-square tests were applied to analyze categorical data, correlation was used to check the inter dependence among independent variables influencing agroforestry adoption. And finally binary logistic regression was applied to investigate the degree and direction of relationship between adoption of agroforestry by *Khoriya* farmers and the independent variables affecting the adoption. The dependant variable, adoption of agroforestry in the *Khoriya* land, was defined in terms of a dichotomous or binary variable. The variable was assigned 1 if the household has planted agroforestry and fetched income and if not then assigned 0. Before put in the logit model explanatory (Independent variables) are checked if they are highly correlated or not. The correlation matrix presented on (Table 10) shows that multi-Co linearity may not be problem for the variables used in the model.

Logistic regression model is used to describe the relationship between an outcome (dependant or response) variable and a set of independent (explanatory or predictor) variable, if the outcome variable is binary or dichotomous, has only two groups; adopters and non-adopters and the explanatory variables are continuous, categorical and dummy (Hosmer and Lemeshow, 2004, Long and Freese, 2006). The logistic regression model has been used by majority of agroforestry adoption studies to analyze dichotomous adoption decisions in which the dependent variable is binary ;1 if adopts, 0 otherwise (Mercer, 2004).

Then the model is specified as follows (Agresti, 1996):

$$\ln(P_x/(1-P_x)) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots\ldots\ldots\ldots\ldots\ldots \beta_k X_{ki}$$

Where,

Subscript i is the i^{th} observation in the sample.

P_x is the probability that a farmer adopts the agroforestry.

1-P is the probability of non-adoption by a farmer.

β is the intercept term and β_1 $\beta_2 \ldots \beta_k$ are the coefficients of the explanatory variables $X_1, X_2 \ldots\ldots X_k$.

In this model, the positive or negative sign of the coefficient β indicates the direction of the relationship between independent variables (X) and the dependant variable (Dossa et al., 2008). The odds ratio $\{P_i / (1-P_i)\}$ and predicted probability of the independent variables indicates the influence of these variables on the likelihood of adoption if other variables remain same (Tiwari et al., 2008). So, farmers with higher positive or negative and significant estimated values for independent variables are more likely to adopt agroforestry practice.

Dependent variable:

The dependent variable for the study for factors affecting agroforestry adoption by Khoriya farmers indicates whether or not a household has adopted project introduced agroforestry in his *Khoriya* land. The adoption of agroforestry in *Khoriya* was defined as a binary variable with a value ‘’1’’ for those farmers who have adopted project introduced agrofrestry in their *Khoriya* and fetched income from the agroforestry system. And a value of ‘’0 ‘’ was assigned if the farmer has not adopted agroforestry in his *Khoriya* land and practiced *Khoriya*.

Explanatory variables and expected influence on Adoption:

As defined in the agroforestry adoption framework (Fig 2) the adoption of agroforestry by *Khoriya* farmers is the outcome of influence of numbers of different factors like Personal/ social characteristics of household, resource ownership, external support or institutional factors and community characteristics. These influencing factors for whether or not to adopt the agroforestry practice by *Khoriya* farmers are described as explanatory variables (Table 9).

AGE is the variable that represents the age of the household head in years. Like previous studies in agroforestry adoption by subsistence farmers, it was hypothesized that farmers with young age had greater likelihood of adopting new agricultural technology or likelihood of being early adopters (Alavalapathi et al., 1995, Adesina et al., 2000). It was assumed that in local conditions farmers with young age had relatively high degree of risk taking capacity. So, we expect that age is negatively associated with agroforestry adoption

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EDUCATION is the variable that represents the number of years of schooling of the household head. Education is considered as change agent for technology adoption because it enhances capacity for creativity and innovation (Adesina et al., 2000) . Furthermore, education levels may affect livelihood choices of rural households (Mercer, 2004). So, it was hypothesized that higher the schooling of household head, higher would be the chances of agroforestry adoption, thus a positive association between adoption and education was expected.

ACIVELABOR is the variable that measures the total numbers of active labor (aged between 16 to 60) in the household. Instead of total members in the family, used by many agroforestry adoption studies, only members who are aged between 16 to 60 and can support farming are taken as active labor for study. Family labor is the only source of labor supply in the area and agroforestry practice demands more labor (Nkamleu and Manyong, 2005) . It was presumed that households with higher active labor in the family are likely to adopt more labor intensive agroforestry system. Thus, a positive association of this variable with agroforestry adoption was hypothesized.

LAND is a variable which represents the total land holdings of the farmer. Landholding is considered as one of the major assets of smallholders and found to be positively significant in most of the agroforestry adoption studies (Pattanayak et al., 2003). So, a positive relation with adoption of agroforestry was assumed.

LANDTYPE is a dummy variable which indexes the type of land the farmer owns in terms of land security. As there are two types of land with *Khoriya* farmers in the study area; Khoriya land without land ownership certificate and other land with land ownership certificate. If the farmer owns both secure and unsecure (*Khoriya* and other) land then it was valued 1 and if the farmers owns *Khoriya* only the 0. Farmers with unsecure land tenure are reluctant to adopt sustainable agriculture practices like agroforestry in shifting cultivation areas because they lack institutional support necessary for it and are not sure how long they would be allowed to use the land without any kind of usufruct right (Thapa and Rasul, 2005). Farmers without tenancy right faced problems to get formal credit and input required for improved land use practices as a result they are often forced to adopt traditional land use practices despite of willingness to change (Rasul, 2003 b, Rasul et al., 2004). (Pattanayak et al., 2003) also found that landowners are more likely to adopt agroforestry than tenants. So, it was presumed that farmers with higher proportion of other type of land along with *Khoriy*a land are likely to adopt agroforestry.

LIVESTOCK is the variable that measures the total livestock units with the farmers. The number of livestock kept by the households was found to be the most important determinant of agroforestry adoption in the subsistence hill farming of Nepal (Neupane et al., 2002). The *Khoriya* farming more or less represents the subsistence hill farming system in Nepal. So, the positive relation of agroforestry adoption with the total livestock units was assumed.

OFFINCOME is a variable that measures the farmers' average annual off-farm income. Farmers with high off-farm income can invest the capital needed for agroforestry management during establishment phase. Agroforestry is rather capital demanding as compared to *Khoriya* farming during establishment (Rasul and Thapa, 2006) which may not be affordable to farmers without off-farm income. Likewise, having non-agricultural incomes may allow farmers to meet costs for seeds, seedlings, materials for nursery and hiring of labor (Adesina et al., 2000). So, it was hypothesized that a positive relation between agroforestry adoption and average off- farm income of the farmer.

FOODSUFF is a variable that measures the food sufficiency months in a year that households acquired from own production. Like off-farm income, food sufficiency also determines the households' well-being. Food shortage households cannot wait long for the farm income, but agroforestry species planted in the area started to give income after 18 months. Better-off households are always better situated to take advantage of new innovations with uncertainprospects (Mercer, 2004). So, it was hypothesized that households with higher food sufficiency months in a year from own production likely to adopt agroforestry.

EXTENSION is the variable that measures numbers of different extension support that a household received from the project. An extension index for each household was calculated based on the farmers quantitative response to numbers of different extension services received by farmers (Appendix 4) following (Neupane et al., 2002). Extension agents work as catalyst by flowing knowledge and resources to bring the desired attitude necessary for agroforestry adoption (Alavalapathi et al., 1995). Hence, farmers with more extension support and contacts with extension workers are likely to adopt the new agroforestry practice despite of more comprehensive knowledge and capital required for the management.

Table 9: Description and summary statistics (mean and percentage) of variables used in the binary logistic model

Variables	Description	Adopters N=109	Non-adopters N=109	significance
[1]AGE (X_1)	Age of the HH head in years	48	50	0.003[b]
[1]EDUCATION (X_2)	Years of schooling of the HH head	4	2	0.001[a]
[1]ACTIVELABOR (X_3)	Members in HH aged between 16-59	5	4	0.01[a]
[1]Land (X_4)	Total land of HH in Ha	0.433	0.233	0.01[a]
[2]LANDTYPE (X_5)	1 if the HH owns Khoriya as well as other type of land; 0 if the HH owns only Khoriya Land	34% 69%	66% 31%	0.04[b]
[1]LIVESTOCK (X_6)	Total numbers of livestock Unit(TLU) with HH	3.57	3.59	0.951
[1]OFFINCOME (X_7)	Average annual off-farm income of HH in Rs.	34717	24323	0.01[a]
[1]FOODSUFF (X_8)	Number of months in a year that HH has food sufficiency from own production	8	5	0.01[a]
[1]EXTENSION (X_9)	Extension index measures the numbers of different extension support received	2.74	0.88	0.003[b]
[1]DISTANCE (X_{10})	Hours of walking distance of *Khoriya* land from market center or highway	1	2	0.01[a]
[2]ABUNDANCE (X_{11})	1 if the HH easily finds new forest land for cultivation; 0 if the HH cannot find or difficult to find new forest land	41% 55 %	59 % 45.5 %	0.74

[1] Continuous variable and use t-test

[2] Dummy variable and use x^{2}-test

[a] at 1 % level of significance

[b] at 5 % level of significance

DISTANCE is a variable which measures the distance of *Khoriya* land to market centers or highway in hours of walking. One of the prime objectives of agroforestry intervention among *Khoriya* farmers in the area was to increase the farm income of *Khoriya* farmers. So, the agroforestry species were selected to produce commodities that could get market easily in the nearby cities. Under such condition distance variable may capture the price effect and which is correlated with the adoption of agroforestry system (Pattanayak et al., 2003). Farmers with long walking distance may be reluctant to adopt such agroforestry species because they have to invest more time and money for transportation of the product to the market center because carrying on the back is the only option of transportation in the area. So, it was assumed that distance is negatively related with adoption.

ABUNDANCE is a dummy variable which takes value 1 if a farmer says that more forest land is available for *Khoriya* farming otherwise 0. The population pressure exerts pressure on availability of land plots for rotation in shifting cultivation land use system which influence the decision of farmers whether to continue or go for sedentary agriculture system (Rasul and Thapa, 2003, Raintree and Warner, 1986). If there is easy availability of forest land for *Khoriya* farming farmers are less likely to adopt other alternative practices because for the local people the *Khoriy*a practice has been the tradition from generation. Abundance of *Khoriya* land therefore assumed as negatively associated with the agrofroesty adoption.

Table 10: Correlation matrix for independent variable (explanatory) used in the Logit model

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
X_1	1										
X_2	-.269	1									
X_3	.188	-.209	1								
X_4	.025	.280	.355	1							
X_5	-.024	-.138	-.282	-.503	1						
X_6	.120	-.006	.031	.285	-.188	1					
X_7	.042	.140	.091	.233	-.111	-.002	1				
X_8	.243	.318	.235	.454	-.226	.002	.165	1			
X_9	.235	.372	.237	.321	.212	.025	.275	.393	1		
X_{10}	.070	-.155	-.134	-.269	.-276	.168	0.251	-.244	-.377	1	
X_{11}	.042	-.051	-.047	.038	-.033	.128	-.011	-.043	-.127	.051	1

Results and discussion:

The result of the study is presented in two sections; the first section presents the household characteristics and econometric analysis (binary logistic model) of factors affecting agroforestry adoption by *Khoriya* farmers and the second section will discuss the motivating factors of agroforestry adoption.

Household characteristics/ adoption:

The results of household characteristics (table 9) showed that the socio-economic condition (off-farm income, total land, HH food sufficiency and active labor in the family) significantly different between adopters and non-adopters of agroforestry system. The age of the household head was significantly lower among adopter .But the education was higher among the household head of the adopters. Similarly adopter households received more extension services and geographically advantaged in road access as compare to non-adopter households.

The binary regression model (Table 11) predicted that out of 11 explanatory variables used in the model, 5 variables were significant at 1 % level, 1 variable at 5 % level and 1 variable at 10 % level, with all possessing the hypothesized signs. Among the positive sign variables education, active labor and extension index were significant at 1 % level while off-farm income is significant at 5 % level and total land at 10 % level. The binarly logistic result showed

Table 11: Analysis of factors affecting agroforestry adoption by Khoriya famers (Logit model)

Variables	B	S.E	Sig.	Exp(B)
AGE	-0.343	0.131	0.009[a]	0.710
EDUCATION	1.547	0.414	0.000[a]	4.696
ACTIVELABOR	1.649	0.549	0.003[a]	5.200
LIVESTOCK	0.039	0.232	0.867	1.040
OFFINCOME	0.000	0.000	0.040[b]	1.000
FOODSUFF	0.309	0.270	0.253	1.361
EXTENSION	1.759	0.495	0.000[a]	5.805

DISTANCE	-3.427	1.023	0.001[a]	0.032
ABUNDANCY	1.306	1.209	0.280	3.691
TOTALLAND	10.436	5.891	0.077[c]	0.014
LANDTYPE	0.847	1.338	0.527	2.333
CONSTANT	-.576	4.694	0.902	.562

Hosmor and Lemeshow test: Chi-square=5.84,d.f=1,sig.=0.65,-2Log likelihood =39.56,Cox & Snell r^2=0.70, nagelkerke r^2=0.93, overall percentage of right predictions=97.2, sample size = 218

X^2 test: [a] significant at 1%,[b] significant at 5%

That education, active labor in the family, extension services to farmers, total land holdings and higher off-farm income positively influenced the agroforestry adoption among *Khoriya* farmers. And, age of the household head and distance to market negatively influence the agroforestry adoption in the area.

Farmers with higher schooling years were the early adopters of the agroforestry practice in the area. As per the hypothesis higher schooling year acted as catalyst (Adesina et al., 2000) to receive information and extension service and positively affected the agroforestry adoption. *Khoriya* farmers who were in frequent contact with extension agencies got trainings and exposure visits, involved in the saving and credit groups and co-operatives than farmers with no or less contact with extension agencies.. The same result was found in different studies in shifting cultivation areas of Bangladesh (Rasul and Thapa, 2006 b, Rasul and Thapa, 2007, Rasul et al., 2004). The *Khoriya* farmers were marginal and could not adopt the complex and capital demanding agroforestry in the start. They need support with trainings, exposures, credit and sapling support during establishment phase. So, farmers receiving institutional and extension service shifted from *Khoriya* farming to agroforestry practice.

Labor force in the family played significant role in agroforestry adoption among *Khoriya* farmers. Agroforestry is rather labor demanding system during establishment phase. And, family labor was the only source of labor for cultivation in the area. So, it was obvious that poor farmers could not hire the labor if they need for agroforestry. Under such condition it played a vital role for adoption of the agroforestry.

Similarly, farmers with higher off-farm income in the area adopted the introduced agroforestry. This finding was similar with other agroforestry adoption studies (Rasul and Thapa, 2006, Adesina et al., 2000). In these studies farmers with higher non-agricultural income adopted agroforestry because the income helped them to purchase the seedlings, fertilizers and other agri-input needed for the agroforestry. Although, project provided the saplings and other institutional support for the *Khoriya* farmers, the agrofrestry species provided the outcome only after 18 months period. And farmers with low off farm income were not capable of adopting agroforestry because of its longer gestation period than Khoriya farming which had only 6 months waiting time.

Unlike other agroforesty adoption studies in middle hill of Nepal (Neupane et al., 2002), livestock had the positive sign but not significantly affecting the agroforestry adoption among Khoriya farming. The agroforesty species was especially targeted for cash income through sale of agroforestry products so may not relevant to the livestock holdings of the *Khoriya* farmers. Similarly household's food sufficiency period in a year and land holdings both have positive relation with the adoption but did not significantly related to the agroforestry adoption in the area. Land security and availability of *Khoriya* plot were also not significant with the agroforestry adoption in the area. Generally, it was hypothesized that farmers with *Khoriya* land as well as other land were more likely to adopt the agroforestry than farmers with *Khoriya* only because of usufruct right issue attached with the land. However, other studies on agroforestry adoption in shifting cultivation areas, (Thapa and Rasul, 2005, Brown, 2006) ,found that land tenure security was the fundamental barrier of agroforestry adoption. The land ownership always plays a vital role among shifting cultivators whether to adopt permanent agriculture or not because they are not sure how long they would be allowed to use the land without any kind of usufruct right (Thapa, 1998, Rasul and Thapa, 2006 b). So, farmers are not interested in the technology like agroforestry which requires investment for the long future. However, in the study the project introduced major agroforestry species like banana and pineapple which are not considered for long term period. In farmers experience these species need to be completely replaced by new ones after 5-6 years period. Despite of tenancy right problem most households started agroforestry because they expected higher and quick income from the agroforestry in comparison of *Khoriya* farming.

Following the hypothesis age and distance variables are negatively significant. That means farmers who were close to market centers or highway and younger in age were more likely to adopt the agroforestry initiated by MDI-Nepal in the area. Distance to market was found negatively significant in more than 70 % of agroforestry adoption studies while included in the study (Pattanayak et al., 2003). Agroforestry adoption needs extra investment by farmers and this was only possible if farmers feel that they have market access and can get fair prices of the product (Thapa and Rasul, 2005). Younger age farmers have relatively higher risk taking capacity so are likely to adopt new and complex agroforestry technology like agroforestry (Alavalapathi et al., 1995). Similar result was also found by (Neupane et al., 2002) in subsistence hill farming system of Nepal.

Motivating factors for agroforestry adoption:

Farmers reported four motivational factors and limiting factors for agroforestry adoption in the area (Table 12). Most farmers reported that the higher and quicker income from agroforestry species and difficulty to find *Khoriya* land around as the major motivational factors for agroforestry adoption. The population pressure in shifting cultivation areas has been considered as one of the major driving forces to shift the farmers from shifting cultivation land use system to permanent agricultural land use system because of reduced fallow and unavailability of new land (Rasul and Thapa, 2003, Raintree and Warner, 1986).

Table 12: Determining factors for adoption in farmers perception

Motivational factors for agroforestry adoption	Farmers' response (%)
Agroforestry gives higher income than *Khoriya*	43
Difficult to find *Khoriya* land around	32
Government prohibited *Khoriya* farming	7
Khoriya farming has many negative effects on environment	18
Limiting factors for agrofrestry adoption	
Do not have enough money for establishment	30
Difficult to manage after plantation	42
Do not have tenancy right of *Khoriya*	20
Agroforestry gives very late return	8

In the same way alternative land-use with market access, institutional support and extension services enabled shifting cultivators to adopt environmentally sustainable agroforestry practices (Thapa and Rasul, 2005). Similarly farmers reported four limiting factors for agroforestry adoption. Of these, difficult to manage agroforestry after plantation and lack of capital during establishment were the major factors. As discussed earlier, agroforestry needs special management knowledge which is often difficult for the resource poor and inexperienced *Khoriaya* farmers.

Conclusions:

Human capital characteristics such as farmer's age, education and labor availability in the household played significant role in the adoption of agroforestry . Contrary to the previous studies of agroforestry adoption among the shifting cultivators, availability of *Khoriya* land and land tenure security were not related with the agroforestry adoption. This may be because the agroforestry system introduced for *Khoriya* fetched more return than *Khoriya* farming and more availability of new *Khoriya* plots was becoming difficult to farmers. Despite the problems of land tenure security, *Khoriya* farmers were convinced by the attractive income and easily manageable agroforestry species. The resource poor Khoriya farmers however were reluctant to adopt the agroforestry because of lack of capital for establishment and the complex management problems associated with the technology.

The findings of this study have important policy implications for the adoption of agroforestry by *Khoriya* farmers. Numbers of factors should be considered for further expansion of an agroforestry program for *Khoriya* farmers. Selection of appropriate species, extension and institutional support and development of effective marketing infrastructures are the crucial factors.

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Appendices

Appendix 1: Calculation of extension index

Items included	HH With agroforestry (yes = 1, No= 0)	HH Without agroforestry (yes =1, No = 0)
	Mean	**Mean**
1. Did you get technical training	0.60	0.19
2.Did you get agroforestry management raining	0.58	0.18
3. Did you get subsidy on sapling	0.56	0.23
4. Did you get credit facility	0.68	0.32

Extension index = 1+2+3+4

Appendix 2: Household survey questionnaire

Section A

Household socio- economic information

Village	
Household no (sample no)	
Date of interview	
Name of the farmer / household head (M/F)	
Checked date	
Responsible person	

M- Male, F-Female

1. General information about the household head

Age	
Education (Years of schooling	
Marital Status (M/ S)	
Total family members in household	

M- Married, Single

2. Household demographic information

Name of the family member	Sex	Age	Education (years of schooling)

3. Household Landholding

Total land (Ropani)	
Total Khoriya land (have no land ownership certificate)	
Other land (Land ownership certificate)	
Irrigated	
Rainfed (No irrigation facility)	

4. Road and market access

Land type	Distance from Market center / Road head (Hours of walking)
Khoriya land	
Other than Khoriya land	

5. Livestock Unit of the household

Livestock type	Total numbers
Goat/ Sheep	
Cow/ ox	
Buffalo	
Pig/ Swine	
Poultry	
If other specify…	

6. Food sufficiency months in a year from own production.

7. How do you manage subsistence of your family other than farming?

Type of off- farm business	No. of family members engaged	Tentative income monthly (Discuss with farmer and write tentative income)
Wage labor		
Selling of firewood		
Small retail business		
If other (specify)		
Total income yearly		

8. Do you or your family member have membership on one or many of the following organizations in the village?

A. Saving and credit group **B.** Farmers cooperative **C.** Agroforestry user group **D.** Specify if any other……………..

9. Do you have access to credit?

A. Yes B. No

10. If yes, where do you get credit?

A. Saving and credit group **B.** Farmers cooperative **C.** Agroforestry user group **D.** From local person **E**. Bank and financial institutions **F**. specify if any other………………..

11. What is the rate of interest?

………………………………

12. If no, why did not you get credit?

…………………………………………..

13. What are the conditions required to access the credit?

………………………………………………………

14. Do you buy farm inputs?

A. Yes B. No

14. If yes, where do you buy?

…………………………………………..

15. If no, why do not you buy?

16. Do you practice Khoriya Farming?

Yes/ No

If the farmer practices Khoriya then continues with question 17 if not practicing currently and cultivating agroforestry go to question no 25.

17. Cropping pattern of your Khoriya land

List the cereals, legumes or other crops grown in last year (In order from January to December)	List the name of the fodder and fruit trees grown

18. Do you remember since when you are practicing Khoriya?

19. How many years do you keep the Khoriya fallow?

20. Why did you start to practice shifting cultivation?

……………………………………

21. Why did not you practice agroforestry as in your neighboring village or home?

(Select one of the following)

A Do not have enough money for agroforestry establishment

B. It will be difficult to manage agroforestry after plantation

C. Do not have tenancy right of the Khoriya

D. Agroforestry gives very late return

22. What do you think about the agroforestry?

Ranking the farmers view as

Most important= 5

Moderately important= 3

Least important=1

Advantages of agroforestry	Most important	Moderately important	Least important
Provides quick and more income			
Reduces the chance of land slide			
Improves soil fertility			
Increases livestock productivity			
Planting materials are easily available			
Easier to sell agroforestry products			
Disadvantages of agroforestry			
Harbors more insects and pests			
Needs more capital and land during establishment			
Agroforestry species are not suitable for local condition			
Needs more management and labor			
Hampers tillage operations			
Increases the chances of competition between crops			

23. Do you think any other benefits and constraints of Khoriya farming?

24. Extension services available

Items included	**Yes**	**No**
1. Did you get agroforestry technical training?		
2. Did you get agroforestry		

management training?		
3. Did you get subsidy on sapling?		
4. Did you get credit facility?		

Yes -1

No- 0

25. List the agroforestry species in your Khoriya land

List the name of the fodder and fruit trees grown	Area (Ropani

26. When did you start to grow agroforestry tree in your Khoriya land?

27. Why did you start to grow agroforesty in your land?

A. Agroforestry gives higher income than Khoriya farming

B. Difficult to find Khoriya land around

C. Government prohibited Khoriya farming

D. Khoriya farming has many negative environmental effects

28. Did you get following services before planting agroforestry?

Items included	**Yes**	**No**
1. Did you get agroforestry technical training?		
2. Did you get agroforestry management training?		
3. Did you get subsidy on sapling?		
4. Did you get credit facility?		

Yes- 1, No-0

29. Did you ever practice shifting cultivation?

A. Yes B. No

30. If yes, when did you leave this practice?

……………………………………..

31. What is your perception about agroforestry you have planted on the following categories?

Ranking the farmers view as

Most important= 5

Moderately important= 3

Least important=1

Advantages of agroforestry	Most important	Moderately important	Least important
Provides quick and more income			
Reduces the chance of land slide			
Improves soil fertility			
Increases livestock productivity			
Planting materials are easily available			
Easier to sell agroforestry products			
Disadvantages of agroforestry			
Harbors more insects and pests			
Needs more capital and land during establishment			
Agroforestry species are not suitable for local condition			
Needs more management and labor			
Hampers tillage operations			
Increases the chances of competition between crops			

32. Do you think any other benefits and constraints of the agroforestry adoptetd?

Benefits

1………………………….

2…………………………

3…………………………

Constraints

1………………………

2………………………

3………………………

33. Where do you sell your agroforestry product?

34. How do you sell the product?

Section B

Financial analysis of agroforestry and Khoriya

Agroforestry system

Banana –Pineapple- Fodder trees system

	Total land	**Qty**	**Unit**	**Rate**	**Total**	**Remarks**
Cost s						
1**.Establishment cost** (A+B+C						
A. Input cost						
Banana suckers						
Pineapple suckers						
Fodder saplings						
FYM (farm yard manure)						
Chemical fertilizers if used only						
Urea						
DAP						
Potash						
Chemicals if used						
Equipments used						

B. Labor cost						
Sucker transportation						
Pit digging and planting						
Fertilizer application						
2.Yearly cost						
D. Labor cost						
Earthing up labor						
Removing of sucker/thinning/trashing/ propping/mulching						
Chemicals and fertilizers application						
Harvesting labor						
Fixed cost including machine and equipment						
E. Non-labor cost						
FYM						
Fertilizers						
Chemicals						
Equipments						
Incomes						
1.fruits / fodders yield						
Yield of Banana						
Yield of Pineapple						
Brome grass						
Ipil-Ipil, Bakaino						
2.Yiled of suckers						
Banana						
Pineapple						

Khoriya farming system

	Total land	**Qty**	**Unit**	**Rate**	**Total**	**Remarks**
Costs						
Non-labor costs						
1.seeds						
Maize seed						
Horsegram seed						
Millet seeds						
2.Fertilizer						
FYM						
Chemical						
Labor cost						
Field preparation						
sowing						
weeding						
harvesting and transportation						

4.Bullock						
Field preparation						
4.Agriequipments cost						
Income						
1.Crop yield						
Yield of maize						
Yield of legume						
Yield of millet						
2.By-product yield						

Appendix 3: Questionnaire for group discussions

1. What is the unit price in the market and village of the following items?

Items	Unit	Rate
Man/ Day	Per day	
Bullock/Day	Per day	
Maize	Kg	
Millet	Kg	
Horse gram	Kg	
Banana	Ghari	
Pineapple	Kg	
Grass	Bhari	
Fym	Doko	
Fertilizers (Urea, DAP, Potash)	kg	
Banana sucker	Gota	
Pineapple sucker	Gota	
Fodders saplings (Ipil, bakaino, ..)	Gota	

2. How do you manage the tenancy right of your Khoriya?

3. What are the negative and positive aspects of Khoriya farming in your locality?

Discuss on the items included on the household survey questionnaire

4. What are the advantages and disadvantages of introduced agroforestry in your area?

Discuss on the items included on the household survey questionnaire

5. Do you think the species of the agroforestry are best suited for your area?

6. Where do most of you go when you need credit?

7. What is the interest rate of the credit in the village and market?

8. How are you managing the marketing of agroforestry product?

9. What should be done to improve the marketing of agroforestry product?

10. What do you need in future to shift permanently from Khoriya farming to agroforestry?

Appendix 4: Group statistics for independent samples t-test

	ADOPTION	N	Mean	Std. Deviation	Std. Error Mean
age	no adoption	109	50.3394	4.37421	.41897
	adoption	109	47.8440	5.98327	.57309
education	no adoption	109	2.0642	1.73352	.16604
	adoption	109	4.8899	2.67824	.25653
active labor	no adoption	109	4.1927	1.16648	.11173
	adoption	109	5.1468	1.95707	.18745
total land	no adoption	109	.2331	.09968	.00955
	adoption	109	.4332	.22177	.02124
Total livestock unit	no adoption	109	3.5979	2.32553	.22275
	adoption	109	3.5788	2.23295	.21388
Avg. annual offfarm income	no adoption	109	24323.9450	16506.47673	1581.03373
	adoption	109	34717.8899	8558.66066	819.77102
Food sufficiency months in a year	no adoption	109	5.4495	1.54851	.14832
	adoption	109	8.0642	2.50657	.24009
Extension index	no adoption	109	.88	.868	.083
	adoption	109	2.74	1.272	.122
distance to market	no adoption	109	2.3761	1.09535	.10492
	adoption	109	1.2752	.50683	.04855
total khoriya land	no adoption	109	.2011	.08614	.00825
	adoption	109	.2861	.12192	.01168
family size	no adoption	109	6.4312	1.64636	.15769
	adoption	109	6.1927	1.73460	.16614

Appendix 5: Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
age	218	38.00	65.00	49.0917	5.37624
education	218	.00	12.00	3.4771	2.65912
family size	218	3.00	12.00	6.3119	1.69138
active labor	218	2.00	10.00	4.6697	1.67692
total land	218	.07	1.06	.3331	.19870
total khoriya land	218	.02	.66	.2436	.11360
Total livestock unit	218	.00	9.34	3.5883	2.27447
Avg. annual offfarm income	218	17000.00	190000.00	29520.9174	14113.59743
Food sufficiency months in a year	218	2.00	12.00	6.7569	2.45711
distance to market	218	1.00	4.00	1.8257	1.01459
Valid N (listwise)	218				

Appendix 6: Financial calculation

Items	Year 1	Year 2	Year 3	Year 4	**year 5**
Agroforestry					
Non –labor cost	8435	1722	1722	1722	1722
Labor cost	33378	3331	3331	3331	3331
Annual total cost	41813	5053	5053	5053	5053
Gross return	0	57968	57968	57968	57968
NVV of non-labor cost	13 459,37				
NVV of labor cost	42 055,71				
NPV of cost	55 515,08				
NPV of gross return	186 466,38				
Net Benefits (NPV)					
including HH labor opportunity cost	130 951,30				
not including HH labor opportunity cost	173 007,01				
return to labour	570,98				
B/C ratio					
with household labor opportunity cost	2,36				
Without household labor opportunity cost	9,73				
total man-day	303,00				
Khoriya farming					
Non-labor cost	2327	0	0	2327	0

labor cost	14921	0	0	14921	0
Total cost	17248	0	0	17248	0
Gross return	21794	0	0	21794	0
NVV of non-labor cost	3 993,81				
NVV of labor cost	25 608,77				
NPV of cost	29 602,57				
NPV of gross return	37 404,83				
Net Benefits (NPV)					
NPV of Benefit including HH labor opportunity cost	11 796,06				
NPV of Benefit not including HH labor opportunity cost	33 411,02				
return to labour	337,49				
B/C ratio					
with household labor opportunity cost	0,40				
Without household labor opportunity cost	8,37				
total man-days	99				

Financial calculation is based on Rupeess/ ha

1 US dollar is equivalent to approx. 74 Rupees.